Studies on Characteristics of Pastoral Cattle Production in Adamawa State, Guinea Savannah Zone of Nigeria

By

Ibrahim Hayatu Kubkomawa, B. Tech., M. Tech. (FUT, Yola)

Reg No. 20114769498

A Thesis Submitted to the Postgraduate School, Federal University of Technology Owerri, Imo State, Nigeria

In Partial Fulfillment of the Requirements for the Award of The Degree of Doctor of Philosophy (PhD) in Animal Management

April, 2016

CERTIFICATION

This thesis entitled **"Studies on Characteristics of Pastoral Cattle Production in Adamawa State, Guinea Savannah Zone of Nigeria"** submitted by Ibrahim Hayatu Kubkomawa meets the regulations governing the award of the degree Doctor of Philosophy (PhD) of the Federal University of Technology, Owerri and has been examined by:

------------------------------	24/5/2016
Prof. I. C. Okoli	Date
Principal Supervisor	
------------------------------	23/05/2016
Prof. A. B. I. Udedibie	Date
Co-supervisor	
------------------------------	23-05-2016
Prof. U. E. Ogundu	Date
Co-supervisor	
------------------------------	24.05.2016
Dr. E. B. Etuk	Date
HOD, AST	
------------------------------	24/05/16
Prof. B. O. Esonu	Date
Dean, SAAT	
------------------------------	------------------------
Prof., Engr. K. B. Oyoh	Date
Dean, PG School	
------------------------------	05.04.2016
Dr. D.I. U. Kalla	Date
External examiner	

DEDICATION

This thesis is dedicated to my family and the entire Lala Community in Nigeria and the Diaspora.

ACKNOWLEDGEMENTS

I hereby sincerely express my profound gratitude and unreserved appreciation to my team of supervisors, Prof. I. C. Okoli, Prof. A. B. I. Udedibie and Prof. U. E. Ogundu for their open-mindedness, selflessness, constructive criticism, true mentorship and commitment towards the actualization of this research work.

My sincere gratitude also goes to the Dean, SAAT and my HOD, Prof. B. O. Esonu and Dr. E. B. Etuk respectively. I also thank Prof. O. O. Emenalom, Prof. N. J. Okeudo, Prof. G. A. Anyanwu, Prof. M. C. Uchegbu, Dr. C. T. Ezeokeke, Dr. C. S. Durunna and other academic and non academic staff of the department for their all time encouragement, support and counseling throughout my stay in the university. I also appreciate all my Dean Post Graduate School, Prof., Engr. K. B. Oyoh and all the staff of Postgraduate School and the Postgraduate hostel for their enduring tolerance, genuine love, understanding and cooperation during the course of my study and to ensure the timely completion of this research work.

I also wish to express my unreserved appreciation to my sponsor, the Federal Polytechnic, Mubi, Adamawa State, Nigeria, associates, collaborators and researchers such as Dr. M. A. Tizhe, Dr. S. M. Adamu, Dr. J. N. Shua, Mr. Sarki Iya, Mr. A. Midiga, Mr. A. Zakaria and other academic and non academic staff of the Department of Animal Health and Production Technology, Federal Polytechnic Mubi, Adamawa State, Nigeria for their constant support, prayers, best wishes and encouragement during the study period.

I wish to say a big thank you to my crew of Deeper Life Campus Fellowship (DLCF) Pastors; Prof. J. N. Maduako of the Department of Agricultural Engineering, Prof. Kenneth Nnadi, Department of Maritime Management, Federal University of Technology Owerri, Mr. and Mrs. Felix Eleagu of the Federal Government Girls College Owerri, Mr. and Mrs. Kenneth Amanze of the Alvan Ikoku College of Education, Owerri, Mr. and Mrs. Lanre Olayemi, Mr. and Mrs. Offer Gwandi of the Federal Polytechnic Mubi, and the entire DLCF family in Nigeria and the Diaspora for their all time prayers and spiritual nourishment throughout the programme.

I also appreciate the effort and contributions of my brother Mr. E. K. Micah Dingai, Hon. Japhet Kefas, Mr. Ardimas Nuhuruwa, Sister Biriskila Ibrahim Kubkomawa, Sister Rose Ibrahim Kubkomawa, Sister Elmina Benson Timawus, Sister Felicia Ibrahim, Sister Kaunatu Biyantu Atiko, Sister Rifkatu Ahmed, Brother Daniel K. Jalo of the Department of Community and Public Health, Novana University Amai, Delta State, Sister Annah Haruna Kwargashe and Sister Joy Felix Eleagu of the Federal Government Girls College, Owerri, Imo State, Nigeria. I say a big thank you to you all.

Finally, my greatest thanks go to Almighty God, to Him be the Glory for giving me abundant grace, zeal, patience, strength, wisdom, sound mental health and understanding to undergo this advanced graduate programme and also for seeing me to a successful completion of this project.

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ABSTRACT

The main objective of the study is to characterize aspects of pastoral cattle production in Adamawa state, guinea savannah zone of Nigeria in order to understand the socio-cultural conditions of key stake holders, the common cattle breeds, available feed resources and morpho-physiological conditions of cattle grazing in the zone. The study was divided into two phases to elucidate production characteristics at the pastoralists and semi sedentary levels of production in three Local Government Areas (LGAs) of the state namely, Mubi north, Gombi and Jada. Pastoralists' production component of the study was carried out with the aid of questionnaire, oral interview and field observations on 300 respondents spread across the three study LGAs, while the semi-sedentary component was carried out on one purposively identified cattle farm in each of three LGAs. Morpho-physiological parameters studied included body condition score (BCS), rectal temperature (RT), respiratory rate (RR), pulse rate (PT), hematological and serum biochemistry were determined. Most preferred dry season feed resources and water consumed by the animals were analyzed for the nutrient compositions and quality respectively. Data generated were subjected to descriptive statistics and interactions of different study parameters were also determined. Pastoral cattle production in Adamawa state was predominated by highly experienced (80 – 85%), married (75 - 88%), Fulani (95 – 65%) male (75 – 90%), Muslims (75 – 80%) aged mostly 31 – 40 years (48 – 55%) and having limited western education. White Fulani breed (50.00%) are most common in Gombi LGA, while Red Bororo (53.00%) and Adamawa Gudali (50.00%) were most predominant in Mubi North and Jada LGAs respectively. Most of the pastoralist (40 – 50%) maintained herd size of 41 to 50 heads and reared cattle for multiple purposes such as breeding, milk, meat and traction. Farmers practiced uncontrolled breeding, with bull to cow ratio of 1:10 (75.00% at Mubi north LGA). First mating (50 – 60%) was done between 4 and 5 years, while age at first calving was mostly (73 -75%) was mostly 5 – 7 years indicating serious reproductive life wastage. Most pastoralists (55 – 65%) use ethno-veterinary practices to enhance cattle reproductive performance. Calving rates (75 – 85%) were more during late rainy season (LRS), while (90.00%) depended on natural pastures for feeding their cattle. Cattle grazed 21 grasses and 19 legumes during the wet periods, while 12 crop residues, 7 by-products and 10 browse plants were offered during dry periods as supplements. Most of the pastoralists (70.00 - 90.00%) depended solely on natural flowing streams and rivers for the supply of water to their cattle. The major production constraints (43.33%) identified was diminishing natural resources characterized by shrinking land and vegetal resources.

Methods for reducing poor morphometric effects of lean feed resources were forage conservation as hay, supplementation with tree fodder, migration and splitting of herds. BCS was significantly ($p<0.05$) better in Adamawa Gudali, semi-sedentary production and during LRS, while RT, RR and PR were significantly ($p < 0.05$) different across LGAs. RBC counts were normal but male values were significantly ($p < 0.005$) higher than the female values. Similarly, PCV, Hb and WBC were within normal range for cattle although significant ($p<0.05$) differences were observed across LGAs. Male AST, ALT and ALP values were also significantly different from female values although within normal range. Interactions of breed or management effects with morpho-physiological parameters were also significant ($p<0.05$) for PR, RBC count, PCV, MCV, MCH, MCHC, AST and ALT, with these interactions being more significant in Adamawa Gudali and Red Bororo in most cases. Pasture resources were more abundant during the LRS and EDS, while crop residues/browse resources predominated during the other seasons. It was concluded that Adamawa Gudali out-performed the other breeds on many parameters followed by Red Bororo, reflecting their earlier adaptation to the study area. The semi-sedentary production system generated better performance results than the pastoral system. The major constraints to pastoral cattle production in the study area were seasonal feed and water shortages, shrinking pasture lands, desertification linked to changes in the production environment, with resultant insecurity and poor animal performance. Appropriate government agencies should formulate policies to address the static socio-cultural conditions of pastoralists in Nigeria that resists adoption of agricultural technologies adapted to the realities of a modern world.

Keywords: Pastoralism, cattle breed, pasture, guinea savannah, Nigeria

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Cattle production and breeding in Nigeria is predominantly controlled by pastoralists who constitute a major socio-economic group in the country (Nori & Davies, 2007; Moutari, 2008). These nomads own more than 93% of the country's estimated 15.3 million cattle population (Umar, 2007; Umar, Alamu, & Adeniji, 2008; Tibi & Aphunu, 2010). Pastoralist livestock industry is therefore, the country's reservoir of animals for slaughter, milk, manure production as well as draft power (RIM, 1992; Parton, Morgan, Wang & Gross, 2007; Kubkomawa, Helen, Timon, Kabir, & Neils, 2011b). The industry also contributed 19% in 1983 and 1984, 10% in 1998 and 6% in 2004 and 2005 to agricultural production and 3.2 - 4% to overall GDP of the country (FAO, 1999; CBN, 1999; Mbanasor, 2000; Ifeanyi & Olayode, 2008).

Cattle are produced predominantly in the northern Nigeria where savannah grass pastures are found in abundance, especially the semi-arid zone characterized by low rainfall regimes and humidity (Fricke, 1993; RIM, 1992). The region also has abundance of crop residues and fodder to supplement for the dry season feeding of cattle. Prescribed bush burning is carried out at certain periods of the year to control parasites and allow for the re-generation of fresh forage for livestock (Fricke, 1993). The pastoralist cattle production system that evolved over the centuries in the zone is based on grazing animals on natural communal pastures and complementary use of fodder and crop residues (Muhammad & Ardo, 2010; Nweze, Ekwe, Alaku, & Omeje, 2012). The system has been defined as an adaptation to the hash and variable physical and environmental conditions of marginal range lands with a view to harnessing the otherwise un-utilizable biomass for production of livestock (Niamir, 1991). There is therefore, a transhumance or seasonal cyclic movement of animals and farming families in synchrony to the rain fall regimes that drives biomass availability (Moran, 2006; WISP, 2007; Okoli & Kalla, 2008). It is however constrained by threats of animal diseases; insecurity, conflict and increasing shortages of forage and water resources for livestock (Muhammad & Ardo, 2010). Pastoralist livestock management is therefore, becoming increasingly difficult in northern Nigeria due to lack of access to enough land in the wake of rapid population growth and agricultural expansion which result in competitive demand for land resources (Nori & Davies, 2007). The current land use pattern and natural resource development and conservation in Nigeria show that pastoralism is at cross-roads with uncertain future. Livestock development and empowerment of pastoralists is plagued by a number of problems which may include, among many others, diminishing land space for grazing and stock movement; deterioration of existing range lands with low biomass yields; scarcities of water; poor carrying capacities of available land; concentration of endemic diseases and parasites; low literacy rates and physical isolation of pastoralists; environmental constraints; absence of functional extension services; distorted agricultural development policies as well as an enduring disconnect between government and aspirations of the pastoralists (Okoli & Kalla, 2008; Muhammad & Ardo, 2010).

To the south of this pastoralist zone is the guinea savannah zone that has more abundant rain fall, biomass resources and permanent water sources. However, this and the rest of the rain forest zones further south are notoriously infested with tsetse fly, the vector of trypanosomiasis and other humidity related diseases and have therefore prevented the sustenance of pastoralist cattle production for ages (Ikede & Taiwo, 1985; Anosike, Opara, Okoli, Kyakya & Okoli, 2003). These southern zones are home to major crop production activities in the country.

However, recent prolonged droughts, resulting in shortage of forage and water resources, more efficient control of tsetse fly down south, the wide spread availability of veterinary medicines and the increasing use of crossbred cattle have led to increased migration of the pastoralists and their animals into the guinea savannah and forest zones of Nigeria (Bassett & Turner, 2006). In addition, changes in the political economy of regional livestock markets and ownership have contributed to movements of pastoralists to the south even though they are faced with conflicts of various degrees with indigenous crop producers (Blench, 2010; Nyong, 2010). Thus, the humid tropical rain forest zone of southern Nigeria has become a haven for some pastoralists and their livestock (Blench, 1994; Okoli, Enyinnia, Elijah, Omede, & Unamba-Opara, 2012). Such conflicts with crop farmers threatens pastoral access to shared material resources, thus, impacting on the sustainability of pastoralism in the forest zones (Tonah, 2006; Ofuoku & Isife, 2009; Okoli, Kubkomawa, Ugwu, Unamba-Opara, & Okoli, 2014). Current approaches to preventing these conflicts show that controlled reproduction in animals within the carrying capacity of available land and appropriate sensitization of key stakeholders are critical (Okoli *et al*., 2012 & 2014).

The northern zones therefore, remain the major environment for cattle production in Nigeria. The breeds of cattle produced in the region are the indigenous Zebu cattle such as White Fulani (Bunaji), Red Bororo (Rahaji), Sokoto Gudali (Bokoloji) and Adamawa Gudali (RIM, 1992; Umar, 2007; Addass, 2011; Kubkomawa, Tizhe, Neils, Igwebuike, Nafarnda, & Uberu, 2011a). Cattle are highly valued livestock in these northern zones, where they contribute to the local economy and food security (Moutari, 2008). Cattle are kept mostly for beef, milk, manure, hide and skins as well as for draught power to plough farm lands (Tukur & Maigandi, 1999; Kubkomawa *et al*., 2011b). They also serve other socio cultural functions such as payment of bride price, transportation of goods and people, employment, prestige and symbol of economic status (Walker & Salt, 2006; Klein, Harte & Zhao, 2007).

The feed resources of pastoralist cattle consists mainly of grasses, legumes, browses, and cereal crop residues indigenous to the production zones and have been reported to be of low yield and quality (Shiawoya & Tsado, 2011; Nweze *et al*., 2012). Good quality forage is available in adequate amounts to support reasonable level of cattle production from early to late rainy seasons, while at other times, pasture and range plants decline in quantity and quality (Moutari, 2008). During the dry season period, available natural pastures are low in protein, nitrogen, sulphur, vitamins and other nutrients, while fibre is high with dry matter content of more than 30% (Bonsi *et al.*, 1991; Hughes, Jennings, Mlambo, & Lallo, 2011). Considerable quantities of crop residues and agro-industrial by-products are also generated every year. However, because of improper management, they are usually lost, wasted or underutilized.

There is a relationship between body condition scores (BCS) of grazing animals and feed availability (Waltner, Mcnamara, & Hillers, 1993). Malnutrition, old age and sickness are major causes of low body condition scores in cattle which affect every area of production (Drennan & Berry, 2006). Older cattle have less fat over their backs, while bulls have higher BCS compared to cows (Joe, 2010). A cow's reproductive performance is closely associated with her body energy reserves; for example, a low feeding level at service can reduce reproductive efficiency (Clay *et al*., 2002). Similarly, cows with low body condition scores have reduced fertility rates, milk yield, late postpartum estrus and low weaning weights (Clay, Jason, & Ron, 2002). Body condition scores improve with nutrient availability (Waltner *et al*., 1993; DEFRA, 2001) and because of this; it usually serves as a more reliable indicator of nutritional status of animals than body weights (Waltner *et al*., 1993). The general purpose of condition scoring is however to achieve a balance between economic and efficient feeding, good management, market weights and welfare (Waltner *et al*., 1993). Addass, Midau, and Butswat (2010) investigated physiological consequences of season, breed, body condition score and age on epididymal sperm reserve of bulls and showed that reserves were highest during late rainy season in Red Bororo bulls of 4 years old at BCS 5 which corresponded with the period of feed availability in Mubi, Adamawa state, Nigeria. According to Assan (2012), genetic makeup also plays vital role in reproduction efficiencies, weaning weights and body condition scores in cattle. Higher body condition scores precede higher dressing out percentage with good quality meat which also attracts greater market values.

Production without access to market is a problem for many livestock producers in Nigeria (Mubi, Michika, & Midau, 2012). Pastoral populations in northern Nigeria lack reliable marketing outlets that could provide the full benefits of indigenous cattle resources, to be captured by both pastoralists and consumers in the region and beyond. Market prices of cattle in Nigeria are determined by visual evaluation which in-cooperates elements of BCS, ages, sexes, breeds, live weights and grade (Okoli *et al*., 2005; Adugna, 2006; Tibi & Aphunu, 2010; Mukasa, Ojo, Adepoju, & Dabo, 2012).

According to Hughes *et al*. (2011) traditional methods of reducing morphometric effects of lean feed resources period remain forage conservation either as hay or as silage during times of abundance to off-set pasture deficit during the dry season. This may serve as a suitable strategy to alleviate the effects of inadequate pasture during the dry season, while supplementing inadequate pasture with tree fodder provides another cost-effective alternative (Adegbola, 1998). However, there is a significant shortfall in supply of the forage particularly when required for longer periods. Concentrate supplementation has also been traditionally seen as a reliable strategy; however, cost and availability of local concentrate sources is a major deterrent (Hughes *et al*., 2011). Use of crop residues and agricultural by-products as intervention feeding materials is also commonly practiced (Ibrahim, Uwude, Aliu, & Ogunsui, 1983). Movement of animals and splitting of herds have also been used by pastoralists to reduce morphometric effects of lean feed resources period (Ezeomah, 1987; Mathias-Mundy & McCorkle, 1989).

The continual increase in the price of veterinary drugs coupled with their prolonged absences from the state-owned veterinary drug stores has continued to sustain the use of ethno-veterinary practices for handling different livestock diseases and parasites (Okoli, Tamboura, & Hounranghe-Adote, 2010; Moreki, Tshireletso, & Okoli, 2012). Such ethno-veterinary practices in-cooperate medicinal plants, which have been widely used for centuries as a primary source of prevention and control to livestock diseases and parasites (Hoareau & DaSilva, 1999). In West Africa, including Nigeria, farmers use traditional methods of curing livestock diseases and parasites because they are readily available and at cheaper rates (McGraw & Eloff, 2008; Chah, Igbokwe, & Chah, 2009; Okoli *et al*., 2010).

1.2 Problem Statement

The major challenge to pastoralist's cattle producers in the dry areas of northern Nigeria is the changing environment, characterized by shrinking land due to expansion in arable farming; land excavations for construction; industrialization and mining activities, which have resulted in shortage of natural forage lands for livestock grazing (Shiawoya & Tsado, 2011). The shrinking pastoral land with the opportunities for pastoral people to make a viable living has put the industry in a crisis (Hesse & MacGregor, 2006; Okoli & Kalla, 2008; Ofuoku & Kife, 2009). Political and economic factors are combining to replace pastoral grazing land with other allegedly more beneficial land uses (Hesse & MacGregor, 2006). The eroding feeding resource is also linked to changes in economy, inappropriate aid, conversion of range lands and mixed farming systems for crop production and game parks (Hesse & MacGregor, 2006). Diminishing genetic resources is also evident because of product focused selection, changes in knowledge, changes in technology, intensification, lack of storage facilities and conservation and indiscriminate crossbreeding of animals and plants in many tropical environments (FAO, 1995; Spore, 2005; Kubkomawa *et al*., 2011a). The idea that modern or imported breeds are better has led to continuing loss of knowledge about traditional livestock husbandry and to the erosion of domestic animal diversity (FAO, 1999). Wars and other forms of socio-political problems have also led to livestock owners moving their stock out of their usual area, thus, increasing the possibility of mixing with other breeds thereby potentially losing a location-specific breed (Hansen, 1992). In addition, natural disasters such as flood, drought, famine, desertification, global warming, livestock diseases and parasites have in numerous cases resulted to breeds of cattle dying out (Spore, 2005).

The traditional pastoralist system in Nigeria has become highly vulnerable because of heightened insecurity situations, while resilience and adaptation options are almost exhausted without any new place to go to because of conflicts with crop producers in the northern guinea savannah and southern rain forest havens (Tenuche & Ifatimehin, 2009; Okpi, 2010; Nyong, 2010). Pastoralism decline in Nigeria is thus a vicious circle: pastoral land use is undervalued, and either ignored or appropriated for alternative uses, thus, making pastoralism less viable and ripe for persistent neglect or appropriation for alternative uses (Hesse & MacGregor, 2006). Decline in the economic viability of pastoral production system as presently structured has also paved way for the adoption of modern production systems coupled with the intensification of livestock production that rely on veterinary services and improved feeding condition (Spore, 2005). Some levels of sedentary system may be the only solution to the current situation. However, the essential components of the traditional system needed to drive this, such as the best breeds and feed resources as measured by morpho-physiological scores of the animals across seasons need to be researched.

In designing such critical studies, the questions that may need to be asked include;

1. What are the socio-cultural characteristics of the key stake holders in cattle production in the zone?
2. What are the current breeds and characteristics of cattle in the pastoralist zone of Northern Nigeria?
3. What are the current feed resources available to the cattle grazing the zone?
4. What are the effects of seasons on cattle production characteristics in the zone?
5. What are the likely improvement and sedentarization strategies to be employed?

1.3 Study Objectives

The main objective of the study is to characterize aspects of pastoral cattle production in Adamawa state in the guinea savannah zone of Nigeria. The specific objectives include:

1. To determine the socio-cultural characteristics of the key pastoralist stake holders in Adamawa State, Nigeria.
2. To characterize the common cattle breeds in Adamawa state, north-eastern Nigeria
3. To identify and rank the common cattle feed resources available during wet and dry seasons in the study area
4. To determine the morpho-physiological conditions of cattle grazing the study area across different seasons.
5. To determine the chemical compositions of the most preferred dry season feed resources

1.4 Justification of the Study

There is limited up to date literature on the current cattle production characteristics in a changing environment like the guinea savannah zones of northern Nigeria. This study therefore generated information that could be used by farmers to optimize feeding practices during different seasons of the year, especially during the lean feed resource periods. The study relates breed and physiological adaptations of different cattle breeds to performance across different seasons.

As pastoral practice continue to contend with its uncertain future in most tropical environments like the study location, important data generated from this study could form part of guiding principles for government policy formulations on pastoralism. It could also contribute to the actual decision frame works of immediate local authorities on the management of pastoral animals feeding resources. These may include cattle breeding scheme to provide better breeding stock to cattle farmers, intervention strategies for feed resources provision such as fodder banking and grazing reserve development.

The need for re-settlement of pastoralists in Nigeria should be based on societal awareness of the detrimental effects of extensive livestock production system. Therefore, improvements on pastoral systems without the loss of traditional values (re-evaluation of little-productive land, environmental conservation) requires a good knowledge of current production characteristics, strengths and weaknesses at the herd level within the frame work of the overall farming sector. The present study also provided baselines for future in-depth investigation into adaptable strategies for sedentary cattle farming in Nigeria.

CHAPTER TWO

LITERATURE REVIEW

2.1 Cattle Production in West Africa and Nigeria

A large percentage of rural people in West Africa are involved in livestock production, which includes the rearing and marketing of cattle (Oyesola & Olujide, 2000). Over 80% of the West African livestock population, especially cattle are in traditional herds and remain the most prominent of all domesticated animals in West Africa (Tewe, 1995). They are mostly owned by pastoral ethnic groups, such as the Fulani - Hausa, Kanuri, and Tuareg, generally inhabiting the northern grasslands and sahelian regions or dry areas (Ikeme, 1990; Bâ, 1994; Tamboura *et al*., 1998). Pastoralists are thought to have arrived Nigeria around the thirteenth or fourteenth century, migrating east from the Senegambia region (Blench, 1994). Pastoralism therefore, is an age old system of livestock husbandry which entails grazing of animals on communal natural pastures and range lands as practiced in the northern ecological zones of Nigeria (Nuru, 1988).

According to Akpa, Alphonsus and Abdulkareem (2012), the historical mobile pastoralism or transhumance is the dominant system of ruminant production in Nigeria. For a long time, it involved movement of herdsmen, families and the herds from place to place, with the availability of fodder, water and animal health as determining factors. The movement of the Fulani over the years has led to a pastoral calendar in which the location and the grazing habits of the Fulani herds can be predicted. They move southwards during the dry season to search for grazing land where the prevailing climate still support vegetation growth even in the dry season. At the onsets of rains, they move northwards to escape tsetse fly infestation during the rainy season in the South (Payne, 1993). According to Akpa *et al*. (2012), the Fulani movement varies according to individual circumstances, dictated by the seasonal distribution of grass and water. Mobility is necessary because pastoral resources are non-static and access to them requires movement. By extensive spatial grazing, the pastoralists optimize spatial resource use, allow the soil to rejuvenate, and prevent permanent land damage (Payne, 1993).

These indigenous cattle, although hardy and well adapted to the environment, grow slowly and are low in productivity. Most pastoral cattle in the same ecological region are genotypically identical. Mono-species herding and species specialization are the result of a long history of inbreeding among the pastoralist in Nigeria. The failure of the exotic species to adapt to the environment, their susceptibility to diseases and their demand for large space and special care discourage the pastoralist from species diversification. Having raised cattle for centuries, the Nigerian pastoralists have evolved a herding system that withstands time, weather, social change and government intervention.

Society's awareness of the detrimental effects of this extensive livestock system has gradually changed methods and aims of researchers and even in research institutes, trying to focus on the improvement and sustainability of the systems instead of just increasing the productivity (Sorensen & Kristensen, 1992). Therefore, the improvement of this extensive and/or semi extensive systems without the loss of their traditional values requires a good knowledge of their characteristics and of their strengths and weaknesses at the farm level and within the frame work of the overall farming sector (Rubino & Haenlein, 1996).

However, Social, political and economic marginalization remain central to majority of contemporary analyses on pastoralist societies across the world, with investment into pastoralist development generally regarded as 'disproportionate' to its potential role in national economies (Rass, 2006; Davies & Hatfield, 2006). Despite attempts to promote greater policy and development innovations to address pastoralist issues, pastoralism is still perceived in a negative light by national governments and global policy actors alike (Barrow *et al.*, 2007; Nori, Taylor & Sensi, 2008). With policy approaches ranging from sedentarisation to the promotion of political inclusion, ongoing issues regarding service provision, land rights and political marginalization consistently feature as limitations to pastoralist livelihoods in the twenty-first century (Davies & Hatfield, 2006; Nori *et al*., 2008).

2.1.1 Present pastoral situation in Nigeria

Currently, cattle production in Nigeria lends itself to small, medium and large (industrial) production (Ikpi, 1992). According to Sonaiya (2000), families employ various but largely extensive management systems to take advantage of common village resources to produce cattle. Nigeria's Fulani pastoralists are thought to number around 12 million, accounting for a quarter of sub-Saharan Africa's 50 million pastoralist people (Rass, 2006; Ibrahim, 2012).

However, Iro (1995) reported that several attempts to bring Nigeria's Fulani into the fold of so-called progressive society has failed, leaving the Fulani at the mercy of the weather and faulty government actions that impoverish rather than promote the welfare of the pastoral producers. The need to critically engage pastoralist communities and understand their current and potential contribution to society; not just to the agriculture sector but to the wider national and regional economic performance and security in an increasingly globalized world remains imperative. For example, given the right inputs, pastoralism offers an opportunity to expand livestock production for regional markets, sustainably manage rangeland ecosystems increasingly affected by climate change and stabilize conflicting geopolitical interests, especially the growing uptake of arms by pastoralist youths (OECD, 2013).

Again, the importance of studies that highlight the informal governance mechanisms and decision-making processes that are rooted in the day-to-day, ground level realities in pastoralist communities cannot be overemphasized (Jones, 2011). Recently, tensions between Nigeria's pastoralist Fulani and settled indigenous farmers have intensified, with dwindling natural resources and land availability greatly contributing to the ongoing, escalating conflict in the north of the country (Jabbar, Reynolds & Francis, 1995; Okoruwa, Jabbar & Akinwumi, 1996. This is because pastoralism, despite its dominance in the northern region, the traditional pattern of transhumance has been affected in recent years by a number of factors such as the drought in the Sahel and the increased arable farming in the semi-arid and sub-humid zones (Jabbar *et al.,* 1995; Okoruwa *et al*., 1996). These factors are responsible for continued displacement of pastorals out of their traditional territories in the drier northern areas to the sub-humid and humid zones where they now exploit pasture, water and crop residues. Over time, seasonal transhumance is gradually disappearing giving way to the process of sedentarization. The urgent requirement to engage with, rather than isolate, Nigeria's pastoralists from various socioeconomic and environmental management strategies is therefore fundamental to peace and agricultural productivity in the country. This again according to Jones (2011) requires a greater understanding of formal and informal governance mechanisms and their relative impact on the Fulani pastoralists.

There have been several pastoral development interventions in Nigeria over the years, geared towards education, sedentarisation and improved livestock health and productivity (Oxby, 1984; Waters-Bayer & Bayer, 1994; Ibrahim, 2012). They have had little impact however, since the conditions of pastoralists remain largely unchanged. This high rate of failure can be attributed to misconceptions of decision-makers regarding pastoralist natural resource management via informal governance systems, with policy analysts usually underestimating the potential for self-organization in the pastoral communities (Nori *et al*., 2008; Ostrom, 2009; Jones, 2011; Ibrahim, 2012). The ongoing pastoralism debate therefore resembles that which occurs in various other social-ecological systems (SES) governed by traditional societies, where simple blueprint policies do not work (Ostrom, 2009). Identifying and analyzing the self-governance mechanisms of local communities has been acknowledged by Ostrom (2009) as the major challenge in diagnosing why some SESs are sustainable whereas others are not. The ability of the pastoralists to organize themselves has been highlighted as key to enabling pastoralists to gain a stake in the policy process, particularly concerning land rights (Nori *et al*., 2008). Understanding the mechanisms of pastoralist self-organization and informal governance structures, particularly in light of insufficient resource inputs from state authorities, therefore remains a critical component of the pastoralist development process.

2.1.2 Pastoral resources management and control

Accounts of Fulani pastoralists moving southwards into Nigeria's sub-humid ‘Middle Belt’ zone appeared as early as the 1820s; however, tsetse flies and the associated trypanosomiasis necessitated a return northwards into the semi-arid zone during the rainy season (Blench, 1994). This gradual southern movement has been attributed to the creation of dairy markets by Hausa traders and the relative security of the British colonial period, when violence related to the trans-Saharan slave trade was curtailed (Blench, 1994; Waters-Bayer & Bayer, 1994). Migration was also seen as a way to avoid the hated jangali (cattle tax) imposed by the British (Waters-Bayer & Bayer, 1994), with the introduction of trypanocidal drugs further enabling pastoralist cattle herds to access the high-quality grazing land in the southern sub-humid zone (Blench, 1994).

There has also been movement in the opposite direction leading to northwards expansion of agricultural cultivation into the semi-arid zone that occurred from the 1960s, alongside a general increase in the amount of land under cultivation in the region. The resulting gradual disintegration of the *burtali* (official stock migration routes) allowed indigenous farmers to claim ownership rights to fertile land and waterways which Fulani cattle had been grazing for over two centuries (Blench, 1994). The 1978 Nigerian Land Use Decree which gave complete authority to the state and local governments to assign and lease land exacerbated the situation. The relative ease with which settled farmers could obtain the ‘certificate of occupancy’ demonstrating land ownership, due to their ‘indigene status’ and higher literacy levels, left the Fulani in Nigeria ‘permanently on the outside of land tenure’ (Ezeomah, 1985). Contributing to the complexity regarding land ownership is the observed reluctance of the Fulani to buy land even when the opportunity exists. Many pastoralist groups, whose social structure functions around common land use, meet the idea of ‘outright ownership’ of natural resources with suspicion. Cases exist where Fulani households have been leasing the land their houses are built on for decades (HRW, 2013). Several mechanisms for addressing the growing issues of land use in northern and central Nigeria have included the mapping and demarcation of cattle routes and the ongoing promotion of grazing reserve establishment (Buhari, 2009; IRIN, 2009; Adebowale, 2014). However, despite numerous attempts by both government and international organizations to improve the land rights situation, rising tensions in northern Nigeria have resulted in devastating violence over the last 20 years (HRW, 2013). North central and north eastern Nigeria have been the worst hit, with over 100,000 deaths since 2010 (HRW, 2013). Although largely attributed in the press to religious conflict between the indigenous Christians and non-indigenous Muslims (HRW, 2001), there are many who believe that tensions are purely economic in nature (Abbass, 2010). Therefore, there are increasing calls on the government to take concrete legislative steps to address all the contending issues exacerbating the conflict between pastoralists and crop producers (Adebayo & Olaniyi, 2008; Ibrahim, 2012; PARE, 2012). Again, Majekodunmi (2012) reported that the current levels of tribal, religious and political polarization are overwhelming any efforts to promote peace in central and north eastern Nigeria, with the view that any hope of government intervention or fair reviews of land tenure and natural resource use laws are currently not feasible.

The Nigerian Grazing Reserve Act of 1964 was passed as an initial attempt to improve Fulani access to grazing land for their cattle, simultaneously encouraging sedentarization in order to address existing conflicts between farming and grazing communities and improve provision of essential amenities to pastoralist families (Ibrahim, 2012). In a broader sense, it was expected that the policy would help address some of the wider constraints facing livestock development in Nigeria at the time, such as disease control and market supply (Ingawa, Tarawali & von Kaufmann, 1989). In a more recent attempt to protect pastoralism, the National Agricultural Policy of 1988 declared that a minimum of 10% of the national territory, equivalent to 9.8 million acres, would be allocated for the development of grazing reserves. However, this policy has not been enforced to date, with only 2.82 million hectares having been acquired in 313 reserves (CIEL, 2006; Ibrahim, 2012).

Additionally, only about 24 of these reserves have been formally gazetted by the government, meaning that occupants of the remaining non-gazetted reserves do not have the rights to services such as road access and water provision, as set out in the grazing reserve laws. Whilst establishing grazing reserves could certainly help alleviate the ongoing land resource conflicts, their increased promotion according to Majekodunmi (2012) may be seen as an admission by government that all efforts towards peaceful coexistence of farmers and herders has failed, thus fostering stereotypes and further suspicion amongst the Fulani and indigenous ethnic groups.

2.2 The Importance of Cattle

2.2.1: Economic and cultural importance

Nigeria is one of the leading countries in cattle production in sub-Saharan Africa for example, in 2008 Tibi and Aphunu (2010) reported that the country had over 14.73 million cattle consisting of 1.47 million milking cows and 13.26 million beef cattle. Less than 1% of this population is managed commercially, while about 99% is managed traditionally. Under the traditional system, there is the use of indigenous methods in all aspect of cattle production including health management (Mafimisebi, Oguntade, Fajeminsin & Ayelari, 2012). This tilt towards traditional management continues to have grave implications for commercialization of the production of cattle and cattle products and their prices in Nigeria (Abubakar & Garba, 2004).

Cattle singly contribute about 12.7% of the agricultural Gross Domestic Product (GDP) in Nigeria (CBN, 1999). The cattle industry provides a means of livelihood for a significant proportion of pastoral households and participants in the cattle value chain in the sub-humid and semi-arid ecological zones of Nigeria (Adegeye, 1995; Okunmadewa, 1999; FAO, 2006). Thus, thousands of Nigerians make daily living from the sale, transport, processing and marketing of pastoral livestock products, including meat, milk, skins and draught power. Some research findings revealed that the Nigerian cattle industry generates USD 6.8 billion of a potential USD 20 billion annually (Bénard, Bonnet & Guivert, 2010). The cattle industry also contributed 3.2 to 4% to overall GDP of the country (FAO, 1999; CBN, 1999; Mbanasor, 2000; Ifeanyi & Olayode, 2008). Although, there are many sources of animal protein in Nigeria, several studies have shown that cattle and their products are the predominant and the most commonly consumed animal protein sources. Thus, cattle are highly valued livestock in Nigeria and are kept for beef, hides and milk or for traction (Tukur & Maigandi, 1999). Among pastoralist however, cattle are kept as a status symbol and cultural medium, while in other cultures it also plays major role in marriages, weddings, sacrifices, and funerals (Tibi & Aphunu, 2010). From the foregoing, it is obvious why cattle production and marketing are notable employment and income-generating livelihood activities for many Nigerians.

Further more, cattle are sources of raw materials such as bones, wool, fur, hides and skin, milk etc. for the production of clothing and leather products such as foot wears like shoes, belt, bags, shawl and milk products such as yoghurt, butter and cheese. Oxen are also used as draught animals for transportation and land cultivation (Payne & Wilson, 1999; Kubkomawa *et al*., 2011b). Cattle are very important source of farm power in Nigeria and in different parts of the world, since it is accessible to peasant farmers who cannot afford costly mechanized farm power (Jahake, 1992). Draught animal power is widely used for cultivation, transportation, water lifting and powering food processing equipment and has enhanced the volume of crop production in areas of use (Kubkomawa *et al.*, 2011b; Babayemi, Abu, & Opakunbi, 2014). For example, according to FAO (1996), where cattle are used to graze the vegetation under plantations of coconut, oil palm and rubber in Malaysia, it dramatically reduces the cost of weed control sometimes by as much as forty percent. Again, according to FAO (1997), cow dung is highly valued for cooking and heating in many countries. For example, 25 kg of fresh cow dung could be used to produce one cubic meter of biogas, which can be used to provide energy for light, heat or motive power. Cattle also serve as means of foreign exchange earnings, for instance, beef, milk, hides, skin and other by-products are exported to earn foreign currency (Payne & Wilson, 1999). In Nigeria, cattle are kept at subsistence level by a farmer and usually serve as the first step out of poverty by rural dwellers. Thus, to the traditional arable farmer, cattle offer security of continued food supply during periods of crop failure.

Other cultural and economic contributions of cattle include the prestige inherent in their ownership and their place in custom, religion and festive occasions. Recently cattle have been used as experimental animals such that much of what is known today about milk fat synthesis and the physiological mechanism that is involved, relate to the ruminant on account of its convenience in research. Cattle also assist in the economic utilization of non-marketable crop resources, adding to them. These animals are able to survive on fallow lands and others that are not good for arable crop farming thereby maximizing the use of the available land resource. They are also used as gifts or for payment of bride price in traditional rites which serves as family wealth (Payne & Wilson, 1999).

Cattle as well as other animals provide organic manure which improves soil fertility. Farm manure which consists of animal fecal materials is used to fertilize farm lands.

Manure itself is a valuable fertilizer containing 8 kg of nitrogen, 4 kg of phosphorus and 16 kg of potassium to the tone (FAO, 1999). Adding manure to the soil not only fertilizes it but also improves its structure and water retention capacity. Bulls can also be used as game animals and may be source of prestige to farmers kept at recreational parks for tourism activities. It represents the position of the owner and the family in the society. Overall, cattle are seen as a measure of status of the owner in the society, as mobile banks by nomads, as insurance against crop failure by mixed farm producers and as items of religious worship and marriages by various groups of traditionalists (Payne & Wilson, 1999).

2.2.2 Cattle products and by-products

Cattle have been used as a major animal protein sources in many cultures with its by-products representing 66.0% of its live weights and 11.4% of the gross income (Liu, 2009). About 99% of global cattle are utilized for meat and other products such as hides and skins which are processed into leather before being used (Liu, 2009; AFRIS, 2010). Animal hides have also been used for shelter, clothing and as containers since prehistoric times. Hides and skins are generally one of the most valuable by-products from animals.

Animal fats are important by–products of meat packaging industry. The major edible animal fats are lard and tallow. Animal fats are used together with molasses to improve palatability and energy value of feeds (AFRIS, 2010). They are also used to control dustiness in feed. A lot of fat from cattle are used in cosmetics, especially in the manufacture of lipstick and eye make-up, soap, lubricants, hair sprays, conditioner, deodorant and creams (Gandhi, 2009). Tallow is also used in steel rolling industry to provide lubrication and also in some leather conditioners. The leather meals may also be hydrolyzed the same way as feathers (Gohl, 1981). Leather is composed primarily of collagen, a fibrous protein which has a poor amino acid profile. Leather scraps associated with the production of various leather products can be collected and hydrolyzed in a similar manner as poultry feathers and used as supplemental protein for livestock (AFRIS, 2010). Hydrolyzed leather meal has been shown to be an acceptable source of crude protein for ruminants at levels not exceeding 6% of the diet (Knowlton, Hoover, Sniffen, Thompson & Belyea, 1976). Gohl (1981) reported that hydrolyzed leather meal can be included in broiler and pig diets at levels of up to 8 and 13% respectively, with no adverse effect.

The digestibility of horns and hooves meal has also been shown to increase progressively with fineness of the ground materials (Gohl, 1981). Horn and hoof meal contain crude protein (69.5 to 88.6%), ash (5.6 to 15.8%) and ether extract (4.7 to 14.7%). The protein is mainly keratin and other proteins. Horns and hoof meals have been used at low levels in poultry diets with variable results and it seems to be unpalatable to most classes of livestock (Gohl, 1981; Babayemi *et al*., 2014). A high digestibility of about 80% for crude protein has been reported for horn and hoof meal prepared by steeping the hoofs and horn in 10% sodium carbonate for sixty hours at 20^{o}C, after which the material is boiled in water for one hour and dried at a high temperature until it turned golden yellow (AFRIS, 2010).

Gelatin is the product of connective tissues of beef animal. Other products that contain gelatin might include gum, fruit snacks like gummy bears, and marsh mallows and many medical products (Liu, 2009). In the past many beef by-products were favorite foods in Asia, but health concerns have led to increased focus on non–food uses such as pet foods and pharmaceuticals such as anti-rejection drugs used during organ transplant to help the body accept the new organ. Other medical uses such as insulin in diabetic patients and the sticky part of bandages are made from animal insulin and fatty acids respectively (Liu, 2009). In developed countries, animal by-products from the slaughter house may include meat trimmings, inedible parts, organs, fetuses and certain condemned carcasses but not including blood, hair, hooves, horns, manure and stomach content, and hide trimming (Miles & Jacob, 2009). Some of these however, form edible parts in many developing countries.

Olomu (1995) reported that meat meal is almost similar to meat and bone meal except that it guaranteed low phosphorus to show that little or no bone was added. Meat meals are widely used in feeds for poultry and pigs. They are usually too expensive to feed to ruminants, which in any case generally find meat products unpalatable. Because of the high price of meat meal, they are used to balance the amino acid composition of diets rather than as major source of protein (Gohl, 1981). Normally, less than 5% meat meal are used in growing and finishing diet for pigs and less than 10% in the diet for piglets and poultry. The product is also a good source of lysine but it is somewhat deficient in methionine, cystine and tryptophan (Olomu, 1995). The protein quality is lower than fish meal or soya bean meal for application in feeding swine or poultry when used to supplement crude protein in cereal based diets (AFRIS, 2010).

Blood meal is high in protein (about 80%) and energy, and can form an excellent source of lysine, if properly prepared. It is very rich in leucine but low in lsoleucine (Olomu, 1995). Blood meal is hydroscopic and need to be dried to less than 10 - 12% moisture and stored in a dry place. Combining blood meal with other supplemental protein sources was shown to improve performance in ducks (AFRIS, 2010). Blood meal is also used as fertilizer, but if over applied, it can burn plants with excessive ammonia. Liu (2009) reported that blood could be used to produce edible products for human beings. For example, in Europe, animal blood has long been used to make blood sausages, blood pudding, biscuit and bread. Blood plasma has an excellent foaming capacity and can be used to replace egg white in the baking industries. Haem derived from animal blood is a valuable source of organic iron. Blood is also used in food as an emulsifier, stabilizer, a clarifier and color additive.

In the laboratory, many blood products such as plasma, albumen, globulin and fibrinogen are used as nutrient for tissue culture media, as necessary ingredient in blood agar and as peptone for microbial growth. Blood also has industrial uses, as an adhesive in the manufacture of paper, plywood, fibre, plastic and glue. Blood is used as sprays in insecticides and fungicides and as a stabilizer in cosmetics, and as a foaming agent in fire extinguishers. Similarly, USDA (1993) reported the uses of cattle blood in the manufacture of shoe polish and in the sizing of leather as well as in the making of calico printers in fixing certain pigment colors in cloth. A blood substitute, called Hemopure has been developed by Biopure Corporation (Boston, MP) from an extract of cow's blood.

When ruminant animals are slaughtered, the contents of their rumen can become a valuable feed resource, which can be dried immediately in the sun and used to replace bran in poultry feed and can constitute up to 10% of the total ration (Williamson & Payne, 1990). It can also be ensiled, but it needs to be mixed with a readily fermentable source of carbohydrates in order to be ensiled properly. It can also be mixed with blood for use in poultry feeding. Rumen content can serve as a good source of water-soluble vitamins, crude protein and dietary energy for herbivores (AFRIS, 2010). Only the content of the first three (3) stomach are used for this purpose, while the content of the 4th stomach is a liquid and of low feeding value (Williamson & Payne, 1990; Mohammed, Igwebuike, & Kwari, 2005).

2.3 Cattle Production Characteristics in Nigeria

2.3.1 Cattle population and distribution in Nigeria

Cattle population in Nigeria has been estimated as 15.3 million (Umar, 2007; Umar *et al*., 2008; Tibi & Aphunu, 2010). There are many breeds of cattle indigenous to Nigeria. According to Pagot (1992) and Babayemi *et al*. (2014), the popular breeds of cattle in Nigeria include White Fulani, Red Bororo, Sokoto Gudali, Adamawa Gudali, Wadara, Azawak, Muturu, Keteku, Ndama and Kuri.

(i) White Fulani (Bunaji): White Fulani is the most numerous and widespread of all Nigerian cattle breeds (Blench, 1993; Meghen, MacHugh, Sauveroche, Kana, & Bradley, 1999). The Nigerian national livestock research survey (NNLRS) 1999 and Alphonsus, Akpa, Barje, Finangwai and Adamu (2012) estimated that white Fulani represent 37% of the national herd. They are found from Lagos to Sokoto, Katsina and Kano States and spread across the Nigerian Middle Belt. The only areas from which they are significantly absent are Borno, where Rahaji and Wadara predominate, and in the south-east, where there are no resident zebu. The movement of cattle into the derived savannah and to the edge of the humid zone has largely been of Bunaji and pastoralists generally agree that they are superior to all other breeds of zebu in resisting diseases with the ability to thrive under a variety of conditions (Blench, 1993; Meghen *et al.*, 1999). The main limiting factors of this tropical breed of cattle include late sexual maturity, long interval between calving and short lactation length.

The white Fulani cattle are however, important for their genetic predisposition of hardiness, heat tolerance and adaptation to local conditions (Alphonsus *et al*., 2012). It has white coat color and it is fairly large, height about 130 cm, bull weighs about 500 kg and cows 325 kg. The hump is large and well developed, navel flab is small, horns are of medium length up curving, and lyre shaped. The white Fulani is a triple-purpose animal, with milk production of 2,300 kg per lactation. It may be fattened for beef, kept for milk production, or used as draught animal, especially the bull. Crosses of White Fulani and Holstein recorded increased milk production at NAPRI-Shika, Zaria (Alphonsus *et al*., 2012). Age at first calving was 42 - 45 months but in Fulani herds it can be as high as 5 years. They provide much of the beef consumed throughout Nigeria (Payne & Wilson, 1999; Alphonsus *et al*., 2012).

(ii) Red Bororo (Rahaji): The Red Bororo is the third most numerous breed of cattle in Nigeria, representing 22% of the national herd. The Rahaji is adapted to arid and semi-arid regions and are rarely found further south than Kaduna in the wet season, except for the isolated population on the Mambila Plateau in the northeast (Blench, 1993; Meghen *et al.*, 1999). The Rahaji is one of the largest zebu breeds and is distinguished by its deep burgundy-colored coat, pendulous ears and long, thick horns (Katie & Alistair, 1986; Williamson & Payne, 1990). Fulani pastoralists consider the Rahaji an extremely prestigious breed and many herds of 'white' cattle include a few Rahaji for crossbreeding. Nonetheless, it tolerates neither humidity-related diseases nor poor nutrition (Blench, 1993). Strikingly, a Fulani clan, the Rahaji, named for the breed they traditionally herded, has been obliged to exchange their stock for Bunaji as they have moved south into the Middle Belt because of high mortality among the 'red' animals (Meghen *et al.*, 1999).

(iii) Sokoto Gudali: The Nigerian national livestock research survey (NNLRS) estimated that Gudali represents 32% of the national herd. There are two quite distinct types of Gudali in Nigeria: the Sokoto Gudali (Bokolooji) and the Adamawa Gudali. The Sokoto Gudali stereotypically occurs mainly in the northwest of Nigeria, but in reality, it is now distributed widely throughout the country (Katie & Alistair, 1986; Williamson & Payne, 1990; Payne & Wilson, 1999). The Sokoto Gudali is a uniform cream, light grey or dun, the dewlap and skin folds are highly developed and the horns almost absent. The hair is short and the skin is thick and pigmented. The ears are pendulous and are useful milkers. Their milk yield at national animal production research institute (NAPRI) Shika was higher than that of white Fulani (Payne & Wilson, 1999; Alphonsus *et al*., 2012). It has a calving interval of 360 - 450 days. The udders in the female are well developed with good teats hence they are regarded as indigenous dairy breed. At maturity, the female weighs an average of about 330 kg, while the male weighs about 450 kg. The female produces an average of 1,500 kg of milk per lactation (Payne & Wilson, 1999).

(iv) Adamawa Gudali: The Adamawa Gudali, as its name implies, is restricted to Adamawa (Blench, 1993; Meghen *et al.*, 1999). The NNLRS (1990) estimated that Adamawa Gudali represent 2% of the national herd. At least two local types were originally recognized in Nigeria: the Banyo, with Rahaji blood and rather large horns, often with a white face and red eye patches, and the Yola, which has an admixture of muturu (Gates, 1952). The muturu element has been progressively diluted since the 1950s and the Yola breed is no longer recognized as a distinct variety by local herders. The Adamawa Gudali resembles the Bunaji in conformation. It is medium to large sized, with medium-length horns and usually pied, or with a white, black, red or brown coat. It has thick, crescent-shaped horns, a pendulous hump, and a short head and muzzle (Katie & Alistair, 1986; Williamson & Payne, 1990), however the pendulous hump is the feature that most reliably distinguishes it from the Bunaji. Both Kanuri and Fulani pastoralists own Adamawa Gudali cattle. It is rare for them to have complete herds of Adamawa Gudali, and often they are mixed with Wadara, Bunaji or Rahaji. Many farmers regard Adamawa Gudali as the indigenous race of the region and they are common in villages, where they are favored for ploughing, but when they become too large to pull a plough effectively, they are further fattened in the compound and sent to market (Payne & Wilson, 1999; Babayemi *et al*., 2014).

(v) Wadara: Wadara cattle, another Nigerian breed, are medium-sized, lightly built cattle, and are usually dark red, black, pied or brown. They are short horned and have a small erect hump, representing some 6.6% of the national herd. Wadara cattle are the ‘indigenous’ cattle of Borno and are referred to by the Koyam and related pastoralists as ‘our’ cattle. They are frequently called ‘Shuwa’ in the literature, after the Shuwa Arabs who also herd them. A related breed with a white coat, the Ambala, is often traded into Nigeria from Chad (Blench, 1993; Meghen *et al.*, 1999).

(vi) Azawak: The Azawak is another breed found in Nigeria and is said to be native to the Azawak valley northeast of Nigeria and is distributed along its northwestern border. It is lightly built with medium-length horns. Although Azawak in Niger republic is commonly described as red, the Azawak that enter Nigeria are usually a light fawn color, though they can also be white, brown, pied and black. The NNLRS (1990) estimated that they represent just 0.7% of the national herd. A small population of Azawak cattle exists in Nigeria throughout the year, but the majority is seasonally transhumant. Azawak are generally only found on the border north and west of Sokoto but there are also some in the northwest of Borgu and dotted along the frontier from Sokoto to Katsina (Blench, 1993; Meghen *et al.*, 1999).

(vii) Muturu: The West African dwarf shorthorn or muturu is small bodied, and blocky in conformation with short, fine-boned limbs. It has a compact body, no hump, a straight back, and a broad head. The face is slightly dished, and the horns are very short. In south-central Nigeria, the muturu is generally black, or black and white. The muturu on the Jos Plateau itself are usually black and white but are distinctly larger than the lowland animals. There are more variations in the northern populations; where brown, red or tawny animals are recorded. Within Nigeria, muturu cattle have a very disjointed distribution suggesting the gradual retreat of a once more widespread population (Payne & Wilson, 1999; Blench *et al*., 1998a).

Blench *et al.* (1998a) have reviewed the history, distribution, management and productivity of muturu. Inadequate maps of their distribution have seriously marred numerical estimates of the numbers of muturu. Muturu are widely dispersed and often stall-fed, and so are less visible than zebu. As a result, published population figures are little more than informed guesses. Moreover, since northern muturu are barely known and their trypanotolerance is unmeasured, they have usually been excluded from estimates of ‘trypanotolerant’ cattle. ILCA’s (1979) estimate of 120,000 muturu should be contrasted with that of Ngere (1983) who gave a figure of 60,000 or 0.7% of the national herd. Akinwumi and Ikpi (1985) surveying five states in the south, reported 85,000. The NNLRS (1990), the first survey to consider all the population islands, gave an estimate of some 115,000 for 1990 (RIM, 1992).

There are isolated populations of muturu along the Republic of Cameroon frontier up as far as southeastern Borno, adjoining the Michika-Mubi area of Adamawa. Small clusters exist in the Atlantika mountains, southeast of Yola and near Cham, east of Bauchi. Muturu are still relatively common in southeast of the Jos Plateau in the dry savannah (Blench, 1993; Meghen *et al.*, 1999). There is another nucleus of muturu north of Tegina in the northwest, with diverse coat-colors suggesting a link with the northeastern populations. Muturu were probably once kept throughout the whole of southern Nigeria and their disappearance from many areas is relatively recent. West of the river Niger, muturu were once widespread but are now uncommon. Both Keteku and Zebu have replaced them, or communities have ceased keeping them. At present, the major concentrations of muturu are in the southeast, in the Cross River area and among the Tiv people in and around Makurdi. Muturu are kept throughout the Igbo areas but in very low densities (Blench, 1993; Meghen *et al.*, 1999).

(viii) Keteku: The distribution and productivity of Keteku cattle have been studied in more detail by Blench, De Jode, Gherzi, & and Domenico (1998b). The definition of Keteku has become more problematic in recent years with an increasing proportion of zebu blood in 'Keteku' herds. As Fulani pastoral herds push even further south and increasingly inhabit regions previously restricted to trypanotolerant stock, more zebu stock are bought in for village herds. For example, the 'Biu', a zebu x savannah muturu cross found near Biu in southern Borno and described in the literature (Gates, 1952), has effectively become submerged in the local zebu gene pool. Thus, application of the name Keteku to an individual animal may reflect as much the owner's cultural background as its actual genetic composition. The population size given by ILCA (1979) was 180,000 Keteku in Nigeria. Keteku are significantly less common than previously thought and their distribution quite different. It is unlikely that there are as many as 100,000 of all types.

The Borgu Keteku also known as Kataku, Ketari, Borgu, Borgawa and Kaiama, is a trypanotolerant, stabilized muturu x zebu cross (Gates, 1952). It combines muturu and Bunaji features with white, grey and black types predominating, and more occasionally red and brown. The horns are long compared with a muturu, but the hump smaller, and the legs shorter than a Bunaji. In Nigeria, keteku herds are restricted to a narrow band along the Benin Republic border in the region usually known as 'Borgu'. Further east, keteku are occasionally kept adjacent to villages in northern Yoruba land. West African dwarf shorthorn was once common through this region and the keteku fills the same niche (Blench, 1993; Meghen *et al.*, 1999). Farmers who value their combination of size and trypanotolerance sometimes buy Keteku as investment stock in the Ondo area. Keteku were formerly distributed from breeding farms as part of livestock extension programmes and the Government Livestock Centre in Ado-Ekiti keeps a stock of keteku (Blench, 1993; Meghen *et al.*, 1999).

In contrast to other West African countries, there has been very little 'new' crossing of zebu and muturu in southern Nigeria. In some ways, it is surprising that the crossbreeding of zebu and muturu did not take place all along the line where the two types came into contact. Further east, among the Igbo, farmers tend to assume that the two breeds are incompatible; and that attempts at crossbreeding would conflict with religious strictures. The continuing genetic separation on the Jos Plateau probably reflects ethnic competition between the livestock farmers than animal production considerations (Blench, 1993; Meghen *et al.*, 1999).

(ix) N'dama: N'dama cattle are native to Senegambia and adjacent parts in the west of West Africa (Starkey, 1984; Blench *et al*., 1998b; Babayemi *et al*., 2014). They were first brought into Nigeria from Guinea in 1939 on an experimental basis, because they were trypanotolerant and yet were larger than muturu (Starkey, 1984; Blench *et al*., 1998b). The N'dama has a medium-sized compact body with lyre-shaped black-tipped horns and no hump. There is a small dewlap in the male, but a fairly large head. Although those imported into Nigeria are generally light brown, there are black and pied animals in Guinea. N'dama cattle have been sold to farmers and pastoralists with a view to improving the resistance of local herds to trypanosomiasis. In most cases, herders cross them with zebu and there are now few pure N'dama outside institutions, although some were recorded in northern Yoruba land (Blench, 1993; Meghen *et al.*, 1999).

(x) Kuri: The kuri is a large-bodied humpless longhorn whose exact historical origin is unknown (Blench, 1993; Meghen *et al.*, 1999; Babayemi *et al*., 2014). The kuri has distinctive, inflated, spongy horns unknown in any other breed and with a mean height of 1.5 m, and weight up to 550 kg. It is one of the largest breeds of African cattle. Kuri are noted for their extremely variable colors and their ability to thrive in semi aquatic conditions. The nucleus of the kuri cattle population is within the region of the former Lake Chad, and along its eastern shores. In Nigeria, kuri are found not only on the Lake but on its shores and along the Yobe valley, as far west as Gashagar. There is also a restricted export of kuri as traction animals to the region north-east of Kano. The breeds along the Komadugu Yobe are crossed with zebu and are generally referred to as Jetkoram in the literature (Blench, 1993; Meghen *et al.*, 1999).

2.3.2 Cattle herd size and productivity in Nigeria

(a) Herd size: Optimum herd size for an area and for a population can only be estimated after many variables have been considered (Akpa *et al*., 2012). A theoretical concept of optimum herd size takes account of the prevailing environmental condition, biological capacity (performance) of the species, herd management practice, and resource use and distribution (Iro, 2009). For the pastoral Fulani of northern Nigeria, none of these factors are static; therefore, optimum herd size is dynamic, varying by a wide margin, depending on the circumstance of the individual pastoralist.

Cunnings (1966) earlier found 100 - 150 as optimum Fulani cattle herd size, while Iro (1994) reported Fulani cattle herd size to be 80 - 100. In a related study Adisa and Badmos (2009) reported an average cattle herd size of 41, while majority of herdsmen (46.4%) herded 41 - 60 cattle. A recent survey of pastoralist households by Akpa *et al*. (2012) in Zaria and environs revealed that the pastoralist herd size ranged from 16 to 69 cattle per herd. Also Okoli *et al*. (2012) reported that majority of Fulani pastoralist (63.60%) maintained herd size of 41 to 70 heads in the humid rain forest of Imo State, Nigeria. Nigeria with a population of over 170 million people requires several heads of cattle to satisfy its demand for cattle and cattle products. With more than 80% of the cattle population in the hands of traditional pastoralists, the supply cannot match the demand. In an effort to bridge the gap, cattle importation is practiced. The imported figures as at January 1996 were 5,142 heads per annum.

The pastoralist's operational sizes were examined in a study conducted by Usman and Nasiru (2005) to determine the composition of the herds in terms of steers, lactating cows, non-lactating cows and the calves. The pastoralists were grouped into three categories namely small scale pastoralists (SSP), medium scale pastoralists (MSP) and large scale pastoralists (LSP). According to the study, the average herd size of the small scale pastoralists (SSP) was about 17 cattle, while that of MSP and LSP were 32 and 73 cattle respectively. Also, the composition of their herd indicated that LSP had more lactating and Non-lactating cows as well as calves than the other groups of pastoralists, while the MSP excelled in the average number of steer in the herd (Mbap, 1996). An examination of stock composition in Zaria showed a gender imbalance, with a preponderance of the female stock than the males. On the average, the female species constituted 60 to 75% in each herd. The advantages of keeping more females in the herd are obvious. A simulation of herd dynamics proved that the rate of growth of the herd peaks when female calves dominate the kraal (Iro, 2009). The young animals contributed about 50% of the herd size, with more females (35%) than males (15%). The proportion of breeding cows in the herd was 49.1%, while the proportion of the breeding bulls was 6%. The profitability of any cattle enterprise is highly determined by the number of breeding cows and young females in the herd (Whitley, 2008). This explains why the large proportion of the Fulani herd is composed of breeding cows and young females.

The males which were reasonably much in number at younger age but became fewer as they reached breeding age suggested that bulls in the herd were sold out when they reached breeding age as a source of income to the family and only few were retained in the herd as breeding bulls. It is usually not economical to keep many bulls in the herd since one mature bull can service at least 20 cows in natural mating (Neumann, 1990). From these results, the number of cows and young animals in the herd were almost equal (0.98). The proportion of breeding bulls to young animals was small (0.14), which also gave an approximately equal proportion of breeding bulls to cows (0.15). The ratio of young males to females was 0.42, indicating a higher number of young females than young males (Iro, 2009).

(b) Reproduction performance: Reproduction is the most important factor in determining profitability in a cow/calf enterprise. To maintain a calving interval of 365 days, a cow must re-breed in 80 to 85 days after calving. Poor reproductive performance is directly linked to the percentage of body fat in cows. Researchers have determined that a certain amount of body fat is required for the reproductive system to function, since inadequate nutrition is most often the cause of poor reproductive performance. Developing a nutrition program is easier and more cost effective when all cows on the farm can be managed in a similar manner. This is especially true when all cows on a farm are managed in a single herd, which is often the case with small production units (Babayemi *et al*., 2014).

Calving year around will make it very difficult to maintain adequate body condition on all cows at the critical times. Poor body condition is associated with reduced income per cow, increased post-partum interval, weak calves at birth, low quality and quantity of colostrum, reduced milk production, increased dystocia, and lower weaning weights. Increasing post-partum interval will result in a younger, smaller calf at weaning the next year and will result in lower incomes if sold at weaning. Weak calves at birth may not get adequate colostrum and are more susceptible to disease, reduced weaning weights, reduced feedlot performance and less desirable carcass traits. Research clearly shows that cows in moderate body condition will have a shorter interval from calving to first estrus than cows in thin condition (Babayemi *et al*., 2014).

According to Okoli *et al*. (2012), 90.90% of pastoralists in the humid rainforest of Nigeria allowed 6 – 10 calving per cow within its reproductive life, while a limited 9.10% may allow up to 11 – 15 calving per cow. This implies that most of the female animals culled for sale are very old animals, which is in agreement with the report of abattoir studies by Okoli, Ebere, Emenalom, Uchegbu and Esonu (2001). Cattle production and breeding efficiency on grazing rangelands of northern Nigeria is however low, especially during the dry season (Mapiye, Chimonyo & Dzama, 2009). For example, age at first calving and calving interval for cows exceed two years (Nqeno, Chimonyo, Mapiye & Marufu, 2009), steers reach slaughter weight between 24 and 30 months of age (du Plessis & Hoffman, 2004) and off-take rates vary between 2 and 10% per annum (Mapiye *et al*., 2009). According to Akpa *et al*. (2012), the average age at first calving of the breeding cows was 4.75 years. This agreed with data earlier obtained from Bunaji herds in Jos plateau (Synge, 1980), but higher than the 37 month reported in Government

Farm at National Veterinary Research Institute, Vom (Ologun, 1980). This variation is mainly attributed to low feed quantity and quality on communal grazing lands, particularly during the dry season (Angassa & Oba, 2007; Nqeno *et al*., 2009). Under such conditions, provision of feed supplements could be recommended to improve cattle production. Before any nutritional improvements are recommended, it is however, important to identify the types of nutrients limiting cattle production in a given zone (Ndlovu, Chimonyo & Muchenje, 2009a).

Akpa *et al*. (2012) also reported that bulls in the pastoral cattle herds usually reached considerable average age of 4.05 years before breeding. This could be probably due to poor nutrition and other environmental stressors. Blezinger (2008) reported that nutrition and feed intake of young bulls affect the age at which they reach puberty. However, Neumann (1990) suggested that bull calf of about 15 months of age should not be allowed to run with the cows, where control breeding is being practiced. Standard technical coefficients have been used to compare between what is obtainable in the research institution like National Animal Production Research Institute, Zaria or National Veterinary Research Institute, Vom and that prevailing under the traditional system in Nigeria (Mbap, 1996). The information collected were on calving rate, calving cycle, age at first calving, length of lactation, productive life and milk to butter ratio. These were found to be 3 – 4 years, 13 months (Pregnancy 9 months with 3 months resting period), 38 months, 280 – 300 days, about 10 years of age (ie. 5 – 6 lactation plus 4 years before lactation) and lastly the milk to butter ratio of 1 litre to 100 gms. In comparison with the above, the calving cycle in Nigeria ranges from 29 to about 43 months. The age at first calving ranges between 30 to 42 months, while the productive life ranges between 9 and 14 years (Mbap, 1996).

(c) Productivity: Protein, energy and minerals are the most critical nutrients affecting milk and beef production in the semi-arid areas (Devendra & Sevilla, 2002). Some reports have suggested that energy and minerals are not limiting nutrients to grazing cattle, but attributed losses in cattle productivity to deficiencies in protein (Tainton, 1999; Chimonyo *et al*., 2000). Poppi and McLennan (1995) and Devendra and Sevilla (2002), however, reported that during the early to mid-wet season, rangelands are not adequate sources of energy and minerals. This results in low cattle growth rates during this period and stands as a major constraint to increasing body weight gains (Shabi *et al*., 1998; DelCurto, Hess, Huston, & Olson, 2000) and consequently affecting beef production in the semi-arid areas. Generally, rangeland energy and mineral supplies in the late wet and dry seasons are arguably deemed to be sufficient to meet production requirements of cattle on pastoral system in the semi-arid areas (Poppi & McLennan, 1995; Chimonyo, Kusina, Hamudikuwanda, & Nyoni, 2000). Thus, cattle production efficiency on communal rangelands in the semi-arid areas is often determined by nutrient availability, which in turn, is mainly influenced by temperature and seasonal distribution of rainfall (Angassa & Oba, 2007).

The traditional cattle sector in Nigeria is generally characterized by low productivity occasioned by seasonality of quantitative and qualitative feed shortage, which is perhaps the major constraint to improved production and productivity of smallholder enterprises (Olaloku & Debre, 1992; Barje, Adebayo, & Lamidi, 2011). However, by extensive spatial grazing, the pastoralists optimize spatial resource use, allow the soil to rejuvenate, and prevent permanent land damage. The impact of seasonal variation in feed resources on the condition and performance of cattle grazing the guinea savannah zone of Nigeria has not been fully established. Such information is critical in developing appropriate feeding and disease prevention strategies. For example, the abrupt diet change that cattle experience from one season to another leaves them prone to digestive upset (Barje *et al*., 2011). Although the switch from a forage diet to a finishing diet high in grain gives beef its desired marble characteristic, it also upsets the animals' digestive system, which can impact their growth. Similarly, marked seasonal quantity and quality of feed resources supplied affect their performance and carcass quality (Barje *et al*., 2011).

2.4 Marketing of Cattle in Nigeria

The fact that cattle is mostly produced in guinea savanna zones of northern Nigeria and mostly consumed in the south (NLDP, 1992; Adamu, Filani & Mamman, 2005; Okoli & Kalla, 2008) has led to a situation in which there are multiplicity of intermediaries and stakeholders in the marketing chain (Babayemi *et al*., 2014). The challenge posed by this has been increased transaction costs and thus, upward trending final retail price of cattle and its products. The effect of the activities of these intermediaries and stakeholders is capable of making cattle and its products inaccessible to the poor who feed mostly on diets deficient in animal proteins. There is every reason to worry about this situation in Nigeria because the level of animal protein consumption is rated below the recommended levels (Mafimisebi, 2011). More worrisome is the fact that the country is in a critical and deteriorating national meat supply position in which beef alone accounts for about 70% of total national meat supply (Omoruyi, Orhue, Akerobo, & Aghimien, 2000; Umar, 2005; Tibi & Aphunu, 2010). The domestic production and cattle imports are together, not enough to meet about 60% of the actual demand (NLDP, 1992).

Marketing encompasses all business activities associated with the transfer of a product from the producers to the consumers (Kohls & Uhls, 2002; Girei, Dire & Bello, 2013). In the case of cattle, it is concerned with the movement of cattle from the pastoralists in the production locations in northern Nigeria to the final consumers who are resident in southern Nigeria (Omoruyi *et al*., 2000). The cattle marketing process makes possible the delivery of cattle to the buyers in the form, place and time needed (Girei *et al*., 2013). This process of bringing the cattle from where they are surpluses (production/origin areas) to where there are shortages (consumption/sink markets), a process known as arbitraging, needs to be fully understood to enhance the efficient working of cattle markets, which is vitally important in achieving sustainable and profitable agricultural commercialization in the livestock sub-sector in Nigeria (Mafimisebi, 2012). Marketing is an economic activity which stimulates further production and if efficiently done, both the producer and consumer get satisfied in the sense that the former gets a sufficiently remunerative price for the product to continue to produce, while the latter gets it at an affordable price that stimulates continued consumption (Umar, 2005).

Cattle and beef trade provides the largest market in Nigeria with millions of Nigerians making their livelihood from various beef-related enterprises (Umar *et al.*, 2008). Consequently, the outcome of enhanced production and marketing of cattle and its products carry the potentials to better the income and nutritional status of households and positively impinge their living standard. Efficient marketing plays an important role in the attempt to achieve wider accessibility and affordability of any product to consumers (Mafimisebi, 2011). This is obvious from the long established truth that production and marketing constitute a variety. Thus, lack of development in one will necessarily obstruct development in the other (Seperich, Woolverton, & Beirlein, 2002)

From time immemorial, the traditional system of cattle production of which the Fulani are the key actors, remains and will, for a long time to come, be the main source of cattle (Tukur & Maigandi, 1999). The main purpose of any rational producer is to make profit but the production goal of the Fulani goes beyond economic purposes. To them, rearing cattle is an integral part of their lives and culture. Nevertheless, profit constitutes a common yardstick against which the performance of any business enterprise is measured and it is an important factor in stimulating commercialization of any venture (Umar, 2005). Thus, the level of profit generated depends, to a greater extent, on how efficiently the market for a commodity works (Mafimisebi, 2012). The performance of a market is influenced by the structural characteristics of the market and the competitive behavior of actors in the marketing chain. Understanding how these factors work independently and together can provide a basis for identifying opportunities to be exploited and constraints that need to be removed for enhancement of commercialization. Gaining insights into how the cattle market works in Nigeria will therefore involve in-depth assessment of marketing efficiency in terms of the benefits derived by value chain participants and consumers (Babayemi *et al*., 2014).

According to the National Livestock Project Division (NLPD, 1992), the supply of cattle and its products has witnessed a decline, while the demand has been increasing with the result being a shortfall in the supply. The high cost of marketing cattle is often the commonly cited culprit for this situation. Owing to the considerable spatial separation of production area from consumption area and other ancillary factors, there is high handling cost, especially in relation to cattle transportation (Filani, 2006). Transportation of cattle from the north to the south in Nigeria presents a daunting problem because it is both a costly and risky business. Cattle are kept standing and in some cases, lying on top of each other in the vehicles throughout the long journey of 2 - 3 days. Most rural roads are seasonal and un-operational during the rainy season, while some interstate roads are also in bad shape. Therefore, trucks and vehicles are prone to accidents, while cattle and freight insurance is still unpopular among the generally semi-literate cattle rearers, middlemen and transporters. The possibility also exists of transporters and traders being robbed en transit (Filani, 2006).

Production without access to market has also been identified as a problem for many livestock producers in Nigeria (Mubi *et al*., 2012). Delgado, Rosegrant, Steinfeld, Ehui and Courbois (1999) however stated that livestock revolution can be expected to allow the rural poor in developing countries to contribute to the growing market, yet pastoral populations in Northern Nigeria lack reliable marketing outlets that could provide the full benefits of indigenous cattle resources, to be captured by both pastoralists and pastoral production system (Filani, 2006).

Marketing of cattle in Nigeria is an economic activity common to all the Northern pastoral regions and there are days designated for cattle marketing (Mubi *et al*., 2012). Many people who participate in the marketing activities depend on it as their sources of income, and to satisfy the economic needs and wants of the practitioners (Agboola, 1979). From this point of view, cattle marketing can be said to be the performance of all business activities which directs the smooth flow of cattle to consumers from sellers in order to accomplish the producer's objective (Mubi *et al*., 2012; Girei *et al*., 2013). This has played a vital role in Nigeria in terms of economic, social and cultural contributions to the people involved in rearing and marketing of cattle as well as all tiers of Government (Mafimisebi *et al*., 2013).

Marketing of cattle in Northern Nigeria is a function of so many factors among which are, transportation, pricing and financing, risk bearing and keeping of cattle for future marketing. Sixty percent of the marketable cattle crossing National boarders are destined to Nigeria (Von Kaufmann, 1986; Girei *et al*., 2013). More than half of the cattle traded are from neighboring Chad, Central Africa, Niger and Cameroon (Mubi *et al*., 2012). Large numbers of cattle, sheep and goats are imported as well as various milk products to a value of about two hundred and fifty million dollars in 2003 (FAO, 2006). As a result of this, there is need to tackle the problem of increase in demand for cattle products which will led to increase in productivity and subsequently efficiency in marketing of cattle in Nigeria just like other parts of the world (Mafimisebi *et al*., 2013).

The traders involved in selling and shipment of cattle are mostly men of varying ages. Mubi *et al*. (2012) reported that 100% of cattle marketers in Adamawa were men because of the marketing tasks involved coupled with the fact that the Northern Muslims that formed the largest population of the marketers do not allow their wives to go out for such business as also reported by Auwal (2005). Mafimisebi *et al*. (2013) reported similarly that 87% of cattle marketers were men in south western Nigeria. Mubi *et al*. (2012)

observed that the marketers were in different age groups such as 30, 31 – 40 and 41 years and above as reported by Mafimisebi *et al*. (2013) in south western Nigeria. This implies that both the young and the aged can successfully make marketing a business to live on, but the younger ones are more active than the aged and invariably more into the business (FAO, 1990). Mubi *et al*. (2012) reported that, 66% of cattle marketers were married which supports a similar result obtained by Kohls and Uhls (1985). This implies that marketing of cattle is a profitable venture that sustains individuals and families. They also reported that minority of the marketers can read and write indicating that they have attended secondary, tertiary or Qur'anic and primary education which was in contrast with Wakili (1996) who recorded least number of respondents with Quranic education and more attendance of post primary. Their analysis indicates that most of the marketers lack formal education which resulted in lack of proper keeping of records and poor communication during marketing among others. This could affect efficient marketing activities since Schultz (1995), reported that education enhances a person's ability to deal with economic disequilibria.

Mubi *et al*. (2012) reported that majority of the cattle marketers have cattle marketing experience ranging from 1 – 40 experience. The retailer agents form 43%, while the commission agents and wholesaler form 21 and 36% respectively. Ajiya (1998) revealed that insufficient capital by other commissioned agents is as a result of not being in the business for a long time, therefore they are not well established. Mubi *et al*. (2012) reported factors considered in attracting higher prices to include size and conformation of the animal, sex, color and health of the animal. The sources of capital to start the business of cattle marketing is another important issue to be considered. This is because; the source and capital base of the business determines the state of the business. Mubi *et al*. (2012) reported that 40% of the marketers obtained their capital from relatives and friends, 28% from banks, 27% from fellow traders, while 5% of the capital came from other sources.

2.5 Characteristics of Cattle Nutrition

2.5.1 Pasture land characteristics

Nigeria has a land area of 92.4 million hectares of which about 44% are under permanent pastures that supports its domestic ruminants of over 101 million (FMAWR, 2008; Shiawoya & Tsado, 2011). It is estimated that only about 3% of this number of animals are reared on improved pastures; the remaining 97% are raised on low nutrient native pastures and farmlands (Okorie & Sanda, 1992). According to Kallah (2004), grazing lands in Nigeria, including natural wetlands (*fadama),* grass and woodlands and forest reserves are estimated to cover about 32.42 million hectares, while cultivated croplands amount to about 39.41 million hectares. These lands provide substantial amount of forage and fodder as major sources of feed for the country's ruminant livestock, both domestic and wildlife.

In Nigeria, forage quality and availability vary greatly from season to season, which however, affects the output of the animals (Ogunbosoye & Babayemi, 2010). The nutritive value of pastures fall rapidly with maturity and during the dry season, the available feed is lignified. Likewise, protein, vitamins and mineral elements are limited in grassland pastures during the dry season (Bamikole *et al*., 2004). The nutritive value of any feedstuff is determined by its chemical composition and degradability and this is related to the forage and its environment. The rate of acceptability of forage is related to the readiness to which the forage is selected and consumed.

In spite of the infertile soils and hostile climatic environment, ruminant livestock survival in northern Nigeria has depended largely on the extensive native pastures, browses and farm crop residues found across and within the various agro-ecological zones. Nigeria's forage and fodder species vary widely and spread across the major agro-ecological zones of the country. Extensive areas of Nigeria's grazing lands are composed of indigenous forage species with their various botanical characteristics. Most of the species grown until recently are of the indigenous or local varieties that often have very low yields. Long periods of cropping, rough topography and frequent bush burning, among other factors, have given rise to mixed tree, shrub and grass vegetation in the savanna zones of the country. The grasses are composed of both annuals and perennials, and the trees show features characteristic of plants growing in low rainfall areas. Various nutrients and minerals, such as nitrogen, phosphorus and potassium, among others, have also been found to be a key limiting factors in the proper development of forage and fodder crops, and hence efficient utilization of these crops by our livestock (Babayemi *et al*., 2014).

2.5.2 Dry matter intake of pastoral cattle

Forage is the most economical ruminant feed during the grazing season (Virginie, André, & Didier, 2009; Kubkomawa *et al*., 2013). In pastoral systems there is forage diversity but the pasture is not established by man; they are natural (Rook *et al*., 2004). In such diverse landscapes, the ability to determine dry matter intake (DMI) and digestibility is a valuable area of study due to its impact on the nutritional status, productivity and health of animals as well as adding to the knowledge of cattle foraging behavior and impact of seasons on biodiversity and the dynamics of the plant community (Kelman, Bugalho, & Dove, 2003; Ali *et al*., 2004).

A considerable amount of research has been conducted in the temperate region using long chain saturated hydrocarbons (N-alkanes) as markers to estimate feed intake and digestibility (Dove & Mayes, 1991; Dove & Mayes, 2006). N-alkanes are saturated aliphatic hydrocarbons with length varying from 21 to 37 carbon atoms (Premaratne, Fontenot, & Shanklin, 2005). They are part of the cuticular wax of plant leaves and are usually part of the ether extract which are indigestible in nature. Grazing time alone cannot be used to determine DMI of grazing animals because intake rate also must be considered (Rutter, 2006).

Environment also plays an important role in resources utilization. On one hand, animals have a memory of food allowance, location and distribution. On the other hand, the rearing practices can explain the ability of cows to graze specific environment such as mountain slopes depending on the animal breeds (Meuret, Débit, Agreil, & Osty, 2006). Interaction between animals in the herd is sometimes cited to explain difference in animal grazing behavior. Sibbald, Shellard, and Smart (2000) reported that on homogeneous vegetation, total time spent grazing by Scottish blackface sheep is higher when space allowance is high (200 m^2 per head *vs* 50 m^2 per head) without impact on herbage intake or digestibility. They concluded that the relationship between time spent grazing and space allowance could be used to explain the extra activity required to maintain the group cohesion when space allowance increases.

Grazing ruminants prefer eating mixed feed resources such as grasses, legumes and browses (Rutter, 2006). In such diverse landscapes, the ability to characterize diet contents is a valuable area of study due to its impact on the nutritional status, productivity and health of animals as well as adding to the knowledge of ruminant foraging behavior, impact of seasons on biodiversity and the dynamics of the plant community (Kelman *et al*., 2003; Ali *et al*., 2004).

2.5.3 Nutrient requirements

Cattle are natural grazers and possess remarkable ability to digest plant carbohydrates that are generally indigestible to most other mammals (Church, 1977; Babayemi *et al*., 2014). It is natural then to assume that grazing is the best way to supply a nutrient-dense diet to growing cattle (NRC, 1984). Cattle require consistent source of protein, energy, minerals, vitamins and water to maintain productivity and health. The nutrient requirements of cattle can be broken down into maintenance, lactation, growth, and reproduction requirements (McBride, 1988). From these components, requirements for energy, protein, minerals, and vitamins are calculated. By understanding the different factors that affect requirements, producers can make adjustments to changes such as a month of cold weather, moving to a hilly pasture, or the last third of pregnancy (Byers, 1990).

The maintenance component includes all the nutrients required for the animal to breath, move, digest food, keep warm, repair tissues, and maintain body weight. Weight, age, breed, physiological status, activity and environmental conditions are the primary variables impacting maintenance requirements (McBride, 1988; Babayemi *et al*., 2014). Even though all nutrients are needed for maintenance, only energy requirements are divided into maintenance and non-maintenance portions. This is because energy is used more efficiently for maintenance than for other body processes such as growth (Byers, 1990).

Nutrient requirements for lactation are based on the amount of milk at peak lactation and the composition of the milk. Cows that produce more milk, and milk with more fat and protein will have higher nutrient requirements. Requirements for growth are determined by actual weight, average daily gain (growth rate), weight at maturity and composition of gain. Adjustments to requirements for reproduction are based on expected calf birth weight and stage of gestation. Usually, pregnancy does not significantly affect requirements until the last three months of pregnancy when the fetus is growing rapidly (McBride, 1988; Byers, 1990).

2.5.4 Energy requirements of cattle

Major determinants of animal's energy requirements are weight, body condition score, milk production, rate of growth, level of activity and impacts of climate (Byers, 1990; Babayemi *et al*., 2014). Fresh grass, with high quality grass-legume can meet energy requirement of growing or lactating cattle in the wet season. Energy supplementation on pasture helps in maintaining high grains and milk production. Dry cows can subsist on lower quality feed stuffs and maintain an acceptable body condition score in order to be successfully bred and delivered of a healthy calf. Energy supplements such as grains can result in better protein digestion and therefore higher milk production and greater weight gains. Forages have the ability to supply all the energy needed to maintain highly-productive cattle through out the growing season, but only managed intensively. Legume-grass pasture will easily have protein content greater than 18% during the vegetative stage. As plants mature, the nutrient values lowers.

Working with indigenous, cross bred and exotic cattle using an all-roughage ration of Giant star grass, Ikhatua and Olubajo (1979a) obtained digestible energy (DE) and metabolizable energy (ME) requirements for maintenance of 255.28; 194.18 and 208.58 Kcal DE/day/wt and 130.37; 125.10 and126.69 Kcal ME/day/wt for White Fulani (Bunaji). German Brown N' Dama and German Brown steer respectively. These values are about 78% of the ARC (1965) recommendation for steers of similar live weight. By supplementing the all-roughage rations with protein supplements Ikhatua and Olubajo (1981) observed a reduction in both the digestible and metabolizable energy requirement of the three breeds of cattle under investigation; the DE and ME required values for maintenance being 211.76; 148.61 and 161.77 Kcal and DE/day/wt and 118.71; 120.68 and 84.63 Kcal.ME/day/wt for the Bunaji, crossbreed and German Brown respectively.

2.5.5 Protein requirements of cattle

Protein is one of the main building blocks of the body. It is usually measured as percentage of Crude Protein (CP). It is a major component of muscles, the nervous system and connective tissue. Protein is composed of chains of amino acids. Adequate dietary protein is essential for maintenance, growth, lactation and reproduction. Protein is composed of several fractions which vary in their solubility in the rumen. Microbes in the rumen digest rumen soluble protein, rumen insoluble protein passes intact through the rumen to the lower digestive tract. A portion of this bypass (or escape) protein is digested in the small intestine (NRC, 1984; McBride, 1988; Byers, 1990; Babayemi *et al*., 2014). Cows generally require crude protein in the range of 7 - 14% of daily dry matter intake. Requirement is less for dry cows, while pregnant and lactating cows especially dairy cattle require more. Growing cattle e.g. replacement heifers and steers require from 10.5 - 14% of their dry matter intake to be protein.

Ikhatua and Olubajo (1979b) obtained estimates of 0.63, 0.94 and 1.25 g/day/wt and 0.89, 1.26 and 3.27 g/day/wt digestible crude protein (DCP) requirements for maintenance of Bunaji (WF); German Brown X, N' Dama and German Brown respectively. The DCP requirements for live weight gain were 0.032 (Bunaji), 0.019g (GB x N' Dama) and 0.023 (GB) g/day/wt respectively. All the digestible crude protein estimates from this work agreed with the generally accepted standards for digestible nitrogen of other African breeds of cattle given diets adequate in energy. Results this study (Ikhatua & Olubajo, 1979b) also indicated low nitrogen requirements for tropical breeds of cattle as well as exotic breeds managed under tropical conditions. The observations of Elliot and Topps (1964) that maintenance requirements of DCP for cattle can be reduced by supplementing low quality roughages with concentrate is a practice normally undertaken during the long dry season. Consequently Ikhatua and Olubajo (1979c) found that DCP requirements decreased with supplementation in all the three breeds. The nitrogen balance approach gave values of 1.06, 0.38 and 0.81 (0.75±0.20) g/day/wt, while values of 1.08, 0.51 and 1.20 (0.92±0.21) g/day/wt were given by the factorial approach.

2.5.6 Mineral requirements of cattle

All cattle require mineral elements for cellular respiration, nervous system development, protein synthesis, metabolism and reproduction purposes. Feed resources that contain minerals include; range or pasture plants, harvested forages, concentrates and mineral supplements (McDowell & Arthington, 2005; Babayemi *et al*., 2014). Forage intake by pastoral grazing cattle depends on the level of mineral consumption. Khan *et al*. (2005) reported that the levels of minerals in plants is a function of interaction between several factors which include soil type, plant species, stage of maturity, dry matter yield, grazing management and climate. Content of minerals in indigenous forages that grow naturally in Nigeria has been established (Njidda, 2011; Njidda & Olatunji, 2012). The minerals that often seemed deficient in beef cattle diets are sodium (as salt), calcium, phosphorus, magnesium, zinc, copper, selenium and sulfur (Njidda, 2011; Njidda & Olatunji, 2012; Babayemi *et al*., 2014). Attempts have been made to correct natural soil deficiencies for trace minerals by soil fertilization practices. Thus, it is implied that a beef producer needs to know the mineral and trace mineral content of the feedstuffs used in cattle rations. A general approach to prevent deficiencies is to feed a commercial salt mineral mix developed for the geographic location of the herd.

(a). The salt (NaCl) requirement for cattle is quite low (0.2% of the dry matter); however, there appears to be a satiety factor involved, since almost all animals appear to seek out salt if it is not readily available. Range cattle may consume 2 – 2.5 lb (1 kg) salt/head/day when forage is succulent but about half that amount when forage is mature and drier. Signs of a salt deficiency are rather nonspecific and include reduced feed intake, growth, and milk production (Njidda, 2011; Njidda & Olatunji, 2012; Babayemi *et al*., 2014). Salt should always be mixed with mineral, because salt drives intake. Cattle have almost zero nutritional wisdom, they do not seek out feedstuffs or minerals when they are deficient, with the exception being sodium, so adding mineral to the salt generally improves intake among cattle with free-choice access to the mineral mix.

(b). Calcium is the most abundant mineral element in the body with about 98% functioning as a structural component of bones and teeth. The remaining 2% is distributed in extracellular fluids and soft tissues and is involved in such vital functions as blood clotting, membrane permeability, muscle contraction, transmission of nerve impulses, cardiac regulation, secretion of certain hormones, and activation and stabilization of certain enzymes (Onyeonagu, Obute, & Eze, 2013). Most roughage is relatively good source of calcium. Cereal hays and silages and such crop residues are relatively low in calcium. Although leguminous roughages are excellent sources of calcium, even non legume roughages may supply adequate calcium for maintenance of cattle (Onyeonagu *et al*., 2013). Because lactating beef cows do not produce nearly the amount of milk that dairy cattle do, their calcium requirement is much less. The total ration should provide calcium: phosphorus ratio of 1.2 to 2:1, with cows at minimum of 1.2:1 and feedlot steers at minimum of 2:1. Ca requirement of growing cattle is 1.2 - 4.4 g/ head /day and lactating dairy cows, 1.6 - 4.2 g/head/day (ARC 1980).

(c). Phosphorus has been described as the most prevalent mineral deficiency for grazing cattle worldwide (Onyeonagu *et al*., 2013). Approximately 80% of phosphorus in the body is found in the bones and teeth, with the remainder distributed among the soft tissues. Phosphorus may be deficient in some beef cattle rations, because roughages often are low in phosphorus. Furthermore, as forage plants mature, their phosphorus content decline, making mature and weathered forages a poor source. Most natural protein supplements are fairly good sources of phosphorus. Because adequate phosphorus is critical for optimal performance of beef cattle, including growth, reproduction and lactation, a phosphorus supplementation program is recommended using either a free-choice mineral mixture or direct supplementation in the diet (Underwood, 1981).

In a phosphorus deficiency, reduced growth and efficiency of feed conversion, decreased appetite, impaired reproduction, reduced milk production, and weak, fragile bones can be expected. Good sources of supplemental phosphorus include steamed bone meal, mono- and dicalcium phosphate, defluorinated rock phosphate, and phosphoric acid. Corn co-products like corn gluten and distillers grains with soluble are also high in phosphorus.

Because most grains are relatively good sources of phosphorus, feedlot cattle rarely suffer a phosphorus deficiency, although phytic acid chelation of phosphorus in grains may render up to one-half of it unavailable, especially for monogastric animals such as swine and poultry(Babayemi *et al*., 2014)..

(d). Magnesium maintains electrical potentials across nerve endings. In a deficiency, the lack of control of muscles is obvious. A magnesium deficiency in calves results in excitability, anorexia, hyperemia, convulsions, frothing at the mouth, and salivation, but such a condition is uncommon. Magnesium requirement for cattle is 2 g kg^{-1} DM in the diet (ARC 1980; NRC 1996; Babayemi *et al*., 2014).

(e). Potassium is the major cation in intracellular fluid and is important in acid-base balance. It is involved in regulation of osmotic pressure, water balance, muscle contractions, nerve impulse transmission and several enzymatic reactions (Onyeonagu *et al*., 2013). Potassium deficiencies normally are not anticipated in cattle diets because most forages are good sources, containing 1 – 4% (Onyeonagu *et al*., 2013; Babayemi *et al*., 2014). A potassium deficiency might be anticipated when diets extremely high in grain are fed (eg, in finishing cattle), because grains may contain <0.5% potassium. A marginal to deficient level of potassium in growing and finishing cattle results in decreased feed intake and rate of gain. Body stores of potassium are small, and a deficiency may develop rapidly. It is good practice to supplement rations for growing and finishing cattle such that they will contain >0.6% potassium on a dry-matter basis (Onyeonagu *et al*., 2013). Potassium (K) of 8 g/kg is recommended for grazing cattle (Underwood, 1981).

(f). Copper and cobalt deficiencies are likely more widespread than previously thought. Cobalt functions as a component of vitamin B_{12}. Cattle do not depend on dietary vitamin B_{12}, because ruminal microorganisms can synthesize it from dietary cobalt (Underwood, 1981). In cattle therefore, a cobalt deficiency is a relative vitamin B_{12} deficiency, and such cattle show weight loss, poor immune function, unthriftiness, fatty degeneration of the liver, and pale skin and mucosa. Copper functions as an essential component of many enzyme systems, including those that involve the production of blood components. Recommended levels of cobalt and copper should be provided in the diet, either by supplementation of the total mixed ration or as part of the free-choice mineral mix or supplemental mix (McDowell, 1992).

(g). Iodine is an integral part of thyroxin and as such, is largely responsible for control of many metabolic functions. However, some soils do not have sufficient iodine to meet most livestock needs. Iodine requirements in cattle can be met adequately by feeding stabilized iodized salt (Njidda, 2011; Njidda & Olatunji, 2012).

(h). Selenium is part of the enzyme glutathione peroxidase, which catalyzes the reduction of hydrogen peroxide and lipid hydroperoxides, thus preventing oxidative damage to the body tissues (Njidda, 2011). White muscle disease in calves, characterized by degeneration and necrosis of skeletal and heart muscles, is the result of a selenium deficiency. Other signs of a selenium deficiency include unthriftiness, weight loss, reduced immune response, and decreased reproductive performance. Selenium can be included in mineral mixes at a level up to 120 ppm so that cattle intake is 3 mg/head/day (Njidda & Olatunji, 2012).

2.5.7 Vitamin requirements of cattle

Vitamins are important for formation of catalysts and enzymes that support growth and body maintenance in animals. Although cattle probably have metabolic requirement for all the known vitamins, dietary sources of vitamins C and K and the B- complex are not necessary in all but the very young. Vitamin K and the B vitamins are synthesized in sufficient amounts by the ruminal microflora and vitamin C is synthesized in the tissues of all cattle. However, if rumen function is impaired, as by starvation, nutrient deficiencies, or excessive levels of antimicrobials, synthesis of these vitamins may be impaired (McDowell, 1992).

According to NRC (2001) Vitamin A can be synthesized from β-carotene contained in feedstuffs such as green forages and yellow corn. Vitamin A supplementation should be included in the mineral mix at about 1,200 to 1,700 IU's (International units) per pound of dry matter of feed intake per day. However, this ability varies among breeds; Holstein cattle perhaps are the most efficient converters of carotenes, whereas some of the beef breeds are much less efficient. Therefore, providing supplemental vitamin A to cattle should be considered. Vitamin A is one of the few vitamins that cattle store in the livers. Cattle on a diet deficient in vitamin A may not begin to show signs for several weeks. Newborn calves, which have small stores of vitamin A, depend on colostrum and milk to meet their needs. If the dam is fed a ration low in carotene or vitamin A during gestation, severe deficiency signs may become apparent in the young suckling calf within 2 – 4 wk of birth, while the dam may appear healthy.

It is a good practice to provide 2 – 5 lb (1–2 kg) of early-cut, good-quality legume or grass hay in the daily ration of stocker cattle and pregnant cows to prevent vitamin A deficiency. Most commercial protein and mineral supplements are fortified with dry, stabilized vitamin A. The daily requirements for beef cattle appear to be about 5 mg of carotene or 2,000 IU of vitamin A/100 lb (45 kg) body wt; lactating cows may require twice this amount to maintain high vitamin levels in the milk.

Vitamin A deficiency under feedlot conditions can cause considerable loss to cattle feeders, especially if high-concentrate and corn silage rations low in carotene have been fed. Destruction of carotene during hay storage or in the GI tract, or the failure of beef cattle to convert carotene to vitamin A efficiently, may increase the need for supplemental vitamin A. Growing and finishing steers and heifers fed low-carotene diets for several months require 2,200 IU of vitamin A/kg of air-dry ration. Commercial vitamin A supplements are not expensive and should be used when such rations are fed and any danger of a deficiency exists. An alternative way to supply supplemental vitamin A is by IM injection: studies show that an extremely high dose (6 million U) would be needed to supply adequate vitamin A. As with all vitamins and minerals, a steady supply in the diet is the ideal method for supplementation.

Vitamin D deficiency is comparatively rare in pastoral cattle, because they are usually outside in direct sunlight or fed sun-cured roughage. The ultraviolet rays of sunlight convert provitamin D found in the skin of animals (7-dehydrocholesterol) or in harvested plants (ergosterol) to active vitamin D. Direct exposure to sunlight, consumption of sun-cured feed, or supplementary vitamin D (300 IU/45 kg body wt) prevent a deficiency. Green forage, high quality hay and cereal grains are typically high in Vitamin E.

2.5.8 Water requirements of cattle

Water is a fundamental constituent of all living cells. Its presence in adequate amount in the body tissues is an essential pre-requisite for the normal maintenance of life. It is intimately connected with the transformation of nutrients and excretory matter from the digestive system, the cells of the different body tissues and the excretory organ. Cattle require 3 - 30 gallons of water per day, at the rate of one gallon of water per 45 kg body weight during wet season and two gallons of water per 45 kg body weight during hot weather. Factors that affect water intake include, age, physiological status, temperature, body size, sources of feeds, roughages, concentrates and succulence. To show its significance, French (1956) reported that starving animals may lose nearly all their glycogen and fatty resources, half of their body protein and about 40% of their body weight and still remain, alive while the loss of only 10% of body water causes serious disorders and further losses may quickly lead to death.

In the semi-arid/arid regions of the Sudano-sahelian ecological zone, drought alternate with seasonal and often short rainy seasons. During the dry season, feed and water can be so scarce that animals do not have enough to eat and drink. This plight of livestock owners/herdsmen drives the transhumant migratory movements to areas with pasture and water.

The effect of this seasonal feed and water shortages on the survival and performance of animals drew research attention to investigate the influence of restricted water on feed intake, nutrient utilization and nitrogen metabolism of young growing zebu cattle and the West African dwarf goats of the Southern humid rain forest zone. The results of Ikhatua, Olubajo, and Adeleye (1985) indicated that feed intake and water consumption were negatively correlated, indicating that as the amount of water intake was reduced, the mean voluntary feed intake (VFI) increased and water to feed ratio increased. It was also observed that apparent digestibility of all the nutrients improved with reduction in the amount of water consumed and consequently resulted in better animal performance in live weight gain. Water reduction did not affect N-metabolism of the bulls.

From these results, it was deduced that the survivability of these breeds of cattle under water stress and low quality forages available during the prolonged dry season is probably attributed to increased N-recycling as well as a reduction in N-loss during the period. These findings also affirmed that increased recycling of urea into the saliva in the presence of enough energy derived from the feed intake by the animals might have assisted higher rumen function. Working with bucks of the West African dwarf breed fed maize Stover. Ikhatua, Dede, and Otote (1992) observed similar findings as reported with the growing bulls.

2.6 Cattle feed resources in Nigeria

Feeds are substances voluntarily taken in by animals to provide nutrients such as energy, protein, mineral and vitamin metabolized in the body, and produce tissue fluid by products such as meat and milk. Most feeds are natural substances which most commonly are organic matter with little composition of inorganic mater. Feeds could be from grasses, legumes, leaves of tress or plants in the form of browse (Yahya, Takahash, Matsuoka, Kibon, & Dibal, 2000).

In Northern part of Nigeria, ruminants suffer greatly due to the fact that the nutrient available in the grass during the dry season do not meet their maintenance level, which therefore make most animals depend on other sources or non-conventional supplementary diets (Devendra, 1989; Njidda, 2010). During the dry periods in guinea savannah zones of Nigeria, diets for ruminant animals, especially forages, crop residues or by products are limited by shortages in amount and quality (Shelton, 2004; Babayemi, Demeyer, & Fievez, 2004a) and result in difficulties in livestock production in the zone (Odenyo, Osuji, Karanfil, & Adinew, 1997).

2.6.1: Forage grasses

Nigerian grasses grow on uncultivated land on which animals have access for grazing. They are found along roadsides and fallow lands in the coastal forest zones of Nigeria. Most of the natural grassland/rangeland assumes more important proportions in the open derived savannah zones of the country. Most farmers rely on natural grassland for their grazing animals. Carrying capacity of the natural grassland is very low compared to that of planted fertilized pastures. Productivity of natural grassland is affected by factors such as soil fertility, the amount of browse species available, density of canopy and management practices such as rotational grazing, stocking rate, fertilizer application, burning and the length of the resting period (Ademosun, 1974; Babayemi *et al*., 2014).

According to Aregheore (2001), in the Sahel savannah zone where the rainy season is short and lasts between three and four months of the year, the dominant grass species include *Aristida stipoides* and *Schoenefeldia gracilis.* The Sudan savannah zone which falls within the tsetse fly free zone belt of West Africa is excellent for rearing and breeding of cattle. The grasses in this zone are the quick growing annual species that reseed easily. The grass species found are *Cenchrus* spp., *Schoenefeldia gracilis*, *Eragrostis tremula*, *Aristida*and *Loudetia* species, *Pennisetum pedicillatum*, *Andropogon gayanus* and *Andropogon pseudapricus*. The Guinea savannah zone is characterized by grass species such as *Chloris spp., Hyparrhenia spp., Paspalum spp., Melinis spp., Hyparrhenia spp*., *Andropogon gayanus*, *Imperata cylindrica*, *Pennisetum pedicellatum*, *Digitaria* spp. and *Setaria sphacelata.* These tall grasses are replacement for the destroyed forest trees that are characteristic of the Guinea savannah proper, while the Southern Guinea savannah or the tree savannah zone that represents a transitional zone between forests and the savannah zones consist of the following grass species; *Pennisetum purpureum*, *Andropogon tectorum*, *Panicum maximum*.

The productivity, chemical composition and nutritive value of grasses and legumes found in Nigeria vary greatly according to species, the nature and fertility of the soil, water relations; seasons of the year, disease control and the stage of growth at which the grass species are cut or grazed. The effect of seasonality on ruminant livestock production is also very important. During the mid-wet season, forage biomass is higher in quality and quantity, with crude protein up to 9% in most of the native grasses. Natural grasses and legumes are rich and highly digestible at this period. As the dry season sets in the protein level drops and the roughage quantity increases. There is an increase in lignin content and voluntary intake decreases. This is a poor feed resource, resulting in weight loss and decreased fertility and milk yield for up to 4 – 5 months of the year. The severity and duration of low-quality feed is common to all parts of the country due to the rapid growth of pasture grass species. In the drier northern states of Nigeria where most of the ruminant livestock are concentrated, the prolonged dry season and high temperatures accompanied by rapid deterioration in quality (mostly proteins) of available pasture affects the productivity of animals (Aregheore, 2001).

The marked seasonal changes affect the quality and quantity of forage (Aregheore, 1996). Under favorable conditions dry matter yield in the northern savannahs can reach as much as 2 000 kg per hectare, enough to support one to two ruminant livestock units per hectare. However, after the rainy season the quantity of forage declines rapidly and the lack of woody vegetation means that little forage is available in the dry season. Given the short-term availability of high-quality pastures, movement of animals is eminently reasonable and ecologically sound during the dry season (Aregheore, 1995; Nuru, 1996; Aregheore, 2001).

The effect of seasonality on ruminant livestock production is also very important. In the mid wet season, forage biomass is higher in quality and quantity, with crude protein up to 9% in most of the native grasses. Natural grasses and legumes are rich and highly digestible at this period. As the dry season sets in, the protein level drops and the fibre increases. There is increase in lignin and voluntary intake decreases which makes it a poor feed, resulting in weight loss and decreased fertility and milk yield for 4 - 5 months of the year. The severity and duration of low-quality feed differs from the south to the north within the states. To worsen the ecology and its available food resources further, there is widespread annual burning of native grasslands, thereby drastically reducing the amount of forage on offer (Nuru, 1996).

Thus, a combination of the following factors - low-quality roughage and bush burning, which reduce the biomass available in quantity and quality have been observed to lead to weight losses ranging from 300 to 400 g per head per day for cattle (Zemmelink, 1974) and up to 15% of body weight in sheep (Otchere *et al.,* 1977). For example, the crude nitrogen content of *Cenchrus biflorus*, a characteristic Sahelian grass, can drop from 16% in growing plants during the rainy season to 4% in straw in November and only 2.6% in straw in April (Boudet, 1975). For cattle a nitrogen content of at least 5% is required to prevent weight loss. Without supplemental feed, cattle under these conditions will clearly tend to lose weight and may not survive if they must be driven long distances to market.

During the period of rapid growth the nutrient content of natural grasses on average is about 25% dry matter; 10% crude protein; 6% ash and a fibre content of 35% crude fibre or 43% acid detergent fibre (ADF). As the dry season advances and conditions become severe, their nutritional quality declines to the extent that crude protein could fall to as low as 2%. Ash values also decline to about 3 – 4% because of translocation to the root system, while fibre content increases in response to the process of lignification, and sometimes the crude fibre could be as high as 50 or 60% ADF (Smith, 1992).

2.6.2 Forage legumes

Legumes are not generally common in natural grasslands therefore the contribution of fixed nitrogen is usually low. The legumes which include *Stylosanthes guianensis*, *Centrosema pubescens*, *Pueraria phaseoloides*, *Calopogonium mucunoides*, *Desmodium* spp. and *Atylosia scarabaeoides* are found in the savannahs of the north. There are also a number of tree legumes and multipurpose trees such as *Leucaena leucocephala*, *Spondias mombin*, *Gliricidia sepium*, *Erythrina* spp. that provide foliage for livestock at all seasons of the year (Aregheore, 1995; Aregheore & Yahaya, 2001; Babayemi *et al*., 2014).

Browse in the form of trees and shrubs form integral part of ruminant production since feeding browse has become an essential practice, especially in the dry season when herbaceous forages are scarce and low in nutritive value (Aregheore, 2001). Large numbers of browse legumes and multipurpose trees have been tried experimentally and subsequently introduced to ruminant farmers (Mecha & Adegbola, 1980). Browse legumes are shrubs and trees that are of considerable nutritional importance as livestock feed during the dry season of the year (Babayemi *et al*., 2014). Most nomads and smallholders know them and therefore use them for their livestock (Aregheore, 1996;

Onwuka, Taiwo, & Adu, 1992; Carew, Mosi, Mba, & Egbunike, 1980). The fruits of some form an important feed resource during the dry season.

Many browses contain high levels of essential elements such as calcium, sodium and sulphur as well as critical micronutrients such as iron and zinc which have been shown to be deficient or borderline for productive purposes in many grass species (Olubajo, 1974). In long-term studies that were designed to evaluate the effects of browse supplementation on the productivity of sheep (Reynolds & Adediran, 1987) and goats (Reynolds, 1989), pregnant ewes and does maintained on a basal diet of *Panicum maximum* were supplemented with graded levels of a 1:1 (w/w) mixture of *Gliricidia sepium* and *Leucaena leucocephala* over two reproductive cycles. Supplementation with browse increased growth rate to weaning of both kids and lambs by 45%. Direct supplementation to kids and lambs doubled growth rate from birth to six months in both species. Also browse supplementation increased overall daily dry matter intake by the dams during the final two months of pregnancy and four months of lactation (Smith, 1992).

Examples of browse legumes found in north and south of Nigeria are *Leucaena leucocephala*, *Gliricidia sepium*, *Acacia* spp. (*A. albida*, *A. nilotica*), *Albizia*, *Ficus elasticoides*, *Mangifera indica*, *Musa* sp., *Spondias mombin*, *Cajanus cajan*, *Tamarindus indica,* and *Parkia clappertonian,* to mention but a few (Babayemi *et al*., 2014). Leucaena is widely accepted as the best browse legume and has naturalized in some parts of Nigeria.

Leucaena and *Gliricidia* foliage yields are higher in the wet season (Aregheore, 1995; Balogun & Otchere, 1995). Their leaves provide protein-rich supplements to traditional village diets to increase small ruminant productivity (Jabbar, Reynolds, Larbi, & Smith, 1977). Dry matter digestibility (DMD) of *Gliricidia* as a sole feed was found to be 54 – 57%, while the addition of cassava tubers (Ademosun *et al.*, 1985a) or cassava peel (Ifut, 1987) raised DMD to 70 - 74%. In a *Panicum maximum* plus *Gliricidia* diet, DMD fell as the proportion of *Panicum* in the diet increased (Ademosun, Bosman, & Roessen, 1985a; Ademosun, Jansen, & 1985b; Houtert & Ifut, 1987). A combination of *Panicum, Gliricidia* and cassava peel, DMD tended to increase as the level of consumption of cassava peel increased (Ifut, 1987). The presence of a fermentable energy source in the diet allows high nitrogen feed such as *Gliricidia* and *Leucaena* to be utilized more efficiently (ARC, 1980). Based on these experiences a small amount of sun-dried cassava peel (about 50 g/day) would be ideal as a supplement (Jabbar *et al*., 1997).

Bamikole, Ikhatua, Arigbede, Babayemi, and Etela (2003) evaluated the feeding value of *Ficus religiosa* with *Panicum maximum* fed to West African Dwarf goats at different ratios of 0:100; 25:75; 50:50; 75:25 (which were mixtures of forages) and 100:0 (solely *Ficus religiosa*) in a 105 day trial. Their results demonstrated that feed intake, weight gain, digestibility and N utilization can be enhanced by feeding *Ficus religiosa* in mixture with *Panicum maximum* and it can be used in diet mixtures up to 75% of DM fed. Yahaya *et al.* (2001) evaluated the nutritive value of three browse trees (*Ficus polita, F. sycomorus* and *Acacia sieberiana)* with sheep on dry matter and crude protein digestibility; and degradability of neutral detergent fibre and acid detergent fibre. Results of the investigation demonstrated that *Acacia sieberiana, F. polita* and *F. sycomorus* can sustain sheep on a maintenance diet and could also be used as a supplementary feed during the dry season.

2.6.3 Browses

Browse has been defined as leaves shoots and sprouts including tender twigs and stems of woody plants, which are cropped to a varying extent by domestic animals (Devendra & Burns, 1983). It could however, be extended to include the fruits, pods and seeds which provide valuable feed, especially, if the seed is deciduous. Therefore, in the tropics browse plants have been found to be of significant potential in terms of adoptability, productivity and acceptability for ruminants in order to balance the difficulties of feed shortages in the dry season (Hutagalung, 1981). In northern Nigeria, traditional herdsmen and other pastoral groups habitually cut down branches from various trees species such as *Acacia, Adamasonia, Balanite egyptica* and *Ficus spp,* making them available to livestock during the dry season when no other forage is available (Yahya *et al.,* 2000).

Browse plants, beside grasses, constitute one of the cheapest sources of feed for ruminants. The diversity and distribution of browse plants in Nigeria have received early attention in studies carried out in the north (Saleem, Oyatogun, & Chheca, 1979), southwest (Carew *et al*., 1980) and middle belt (Ibeawuchi, Ahamefule, & Oche, 2002) of Nigeria. Tree fodders are capable of maintaining higher protein and mineral contents during growth than grasses, which decline rapidly in quality with increase in maturity (Shelton, 2004). Tree fodders therefore form part of the complex interactions between plants, animals and crops (Aganga & Tshwenyane, 2003). They help to balance a plant-animal soil ecosystem from which there is a sustainable source of feeds (Devendra, 1994). The availability of a variety of these feeds and the selection process enable the herbivores, especially the goats, sheep and cattle to extend as well as meet their feed preferences and requirements.

Leguminous trees and shrubs often have thorns, fibrous foliage and growth habits which protect the crown of the tree from defoliation (Njidda, 2010). Many plants also produce chemicals which are not directly involved in the process of plant growth (secondary compound) but act as deterrents to insects and fungal attack. These compounds also affect animals and the nutritive value of the forages. Mycotoxins (fungal metabolites) produced by saprophytic and endophytic fungi are potential sources of toxins in forages (Norton, 1994). The utilization of browse is equally limited by the high lignin content and the presence of anti nutritional factors, which may be toxic to ruminants. However, the toxic compounds seem to become of significance nutritionally only when the plant constitutes a high proportion of the diet. Hence, the effects of high protein forage could override the effect of the toxic compounds when used as supplement in the diets.

The Crude protein (CP) content of *Ficus polita*, *Ficus thonningii* and *Leptadenia lancifolia* were reported to be high ranging from 13.85 to 16.65%, which is above the 7% CP requirement for ruminants needed to provide ammonia required by rumen microorganism to support optimum microbial activity (Njidda, 2010). The high CP content of many browse species is well documented and is one of the main distinctive characteristic of browse compared to most grasses. Norton (1998) reported a range of CP contents from 12 to 30% for tropical tree legumes, and Le Houerou (1980) found a mean of 12.5% in West African browse species with about 17% for the leguminous species. Generally, the CP content in browse has been shown to be above the minimum level required (7%) for microbial activities in the rumen (Norton, 1998). The species in the Leguminosae family have a higher protein content compared to other species, although species in the Capparidaceae family have on average 25% more protein than legumes (Le Houerou, 1980).

Le Houerou (1980) also noted that all browse species are able at all their physiological stages to meet the energy requirements of livestock at maintenance level and often well above, and thus West African browse are considered to be excellent fodder, with very few exceptions. The difference in CP content between species can be explained by inherent characteristics of each species related to the ability to extract and accumulate nutrients from soil and/or to fix atmospheric nitrogen, which is the case for legumes plants. The other factors causing variation in the chemical composition of browse forages include soil type (location), the plant part (leaf, stem and pod), age of leaf and season (Njidda, 2010). With regard to the location, some authors have reported that browse plants in the Sahelian zone are higher in N compared to plants in the humid zone (Rittner and Reed, 1992). Younger leaves are richer in N than mature leaves, which however contain more N than the later. The fruits are shown to have N content that range between young and old leaves, and vary little with stage of maturity (Breman & Kessler, 1995). With regard to the fibre content, Rittner and Reed (1992) reported similar mean for NDF and lignin contents across different ecological zones as follows, 40.1 and 11.7% in the Sahelian zone, 45.7 and 10.5% in the subhumid zone and 43.6 and 9.3% in the humid zone respectively. Fall (1993) found a range of 31 to 57% for NDF and 19 to 43% for ADF.

In a study conducted by Njidda (2010), NDF and ADF contents in *Ficus polita* and *Ziziphus abyssinica* were considered lower than the values reported by Bibi-Farouk, Osinowo, and Muhammad (2006) and Sena *et al.* (1998). These species also had high lignin content which is a component of the cell wall, and deposited as part of the cell wall-thickening process (Boudet, 1998). Lignin is in general higher in browse than in herbaceous plants. The content varies according to species, age and the plant parts. Positive correlations were reported between contents of lignin and soluble or insoluble proanthocyanidins (Rittner and Reed, 1992). Reed (1986) also found a negative correlation between the content of NDF and soluble phenolics, while the correlation with insoluble proanthocyanidins was positive. The browse forages had low to moderate content of fibre, which a positive attribute since the voluntary DM intake and digestibility are dependent on the cell wall constituents (fibre), especially the NDF and lignin (Bakshi & Wadhwa, 2004).

The total condensed tannins (TCT) as reported by Njidda (2010) in *Ficus polita* and *Ziziphus abyssinica* browses ranged from 0.15 to 0.39 mg/g DM. The level is lower than the range of 60 to 100 g Kg DM that is considered to depress feed intake and growth (Barry and Duncan, 1984). However, in ruminants, dietary condensed tannins of 2 to 3% have been shown to have beneficial effects because they reduce the protein degradation in the rumen by the formation of a protein-tannin complex (Barry, 1987). The phenolic content of the browse as reported by Njidda (2010) ranged from 0.24 to 0.65 mg/g DM. The values are lower compared to that reported by Osuga, Abdulrazak, Ichinohe, and Fujihara (2006). Phenolic compounds are the largest single group of saponin concentrations, and total phenolics in plants can reach up to 40% of the dry matter (Reed 1986; Tanner, Reed, & Owen, 1990). In grasses, the major phenolic is lignin that is bound to all plant cell walls, and is a significant limiting factor in their digestion in the rumen (Minson, 1990). Lignin is also a limiting factor in the digestion of legumes, but is bound largely to the vascular tissue (Wilson 1993), with often high concentrations of other free and bound phenolic compounds (phenolic acids, coumarins and flavonoids) in floral, leaf and seed tissues (McLeod, 1974). Oxalate content in the study conducted by Njidda (2010) was low. It has been reported that 20 g/kg oxalate can be lethal to chicken (Acamovic, Steward, & Pennycott, 2004).

Oxalate has been shown to deplete the calcium reserve, but these *Ficus polita* and *Ziziphus abyssinica* browse species were found to contain reasonable amount of calcium, magnesium and phosphorus (Le Houerou, 1980; Akinsoyinu & Onwuka, 1988). Calcium and carbon are also released from the hydrolysis of Ca oxalate some of which will be either absorbed or excreted by the ruminant animals. With Ca absorption rate of ruminants put at 31% (Randy, Heintz, Lynch, & Sniffen, 1984; Haenlein, 1987) and P at 4% absorption (Adeloye & Akinsoyinu, 1985) reasonable amount of the Ca and P intakes will be lost via faeces and urine to the soil. Such voided minerals/nutrients are thereby recycled for further use to support plants which are ploughed back into the soil, when so much N is returned to the soil. This reduces the use of inorganic N fertilizer and lends weight to the use of organic manure in farming. However, given the time to adapt, the microorganisms in the rumen can metabolize moderate amounts of oxalate.

The mean saponin value as reported by Njidda (2010) was 2.26% with a range of 2.02 to 2.55 mg/g DM. Feedstuffs containing saponin had been shown to reduce methane production (Teferedegne, 2000; Babayemi, Demeyer, & Fievez, 2004b). Cheeke (1971) reported that saponin have effect on erythrocyte heterolysis, reduction of blood and liver cholesterol, depression of growth rate, bloat (ruminant) inhibition of smooth muscle activity, enzyme inhibition and reduction in nutrient absorption. Saponins have been reported to alter cell wall permeability and therefore produce some toxic effect when ingested (Belmar, Nava-Montero, Sandoval- Castro, & Menab, 1999). The anti nutritional effects of saponins have been mainly studied using alfalfa saponins. Sharma and Chandra (1969) observed that 4 - 7 weeks of *ad libitum* feeding of *albizia* gave rise to toxic manifestation in sheep. Symptoms included listlessness, anorexia, weight loss and gastro-enteritis. The toxicity of saponins can be reduced by repeatedly soaking the feed in water, though the level recorded in the study carried out by Njidda (2010) may not pose any problem to the animals.

The phytin levels reported by Njidda (2010) ranged from 2.22 to 5.81 mg/g DM, which is lower than the 13.80 to 25.20 mg/g DM reported by Okoli, Anunobi, Obua, and Enemuo (2003) for the southeastern browses in Nigeria. These levels are unlikely to have any adverse effects on ruminants. The HCN contents of the browse species examined by Njidda (2010) were equally low and ranged from 0.05 to 0.08 mg/g DM. The lethal dose of HCN for cattle and sheep is 2.0 to 4.0 mg per kg body weight. The lethal dose for cyanogens would be 10 to 20 times greater because the HCN comprised 5 to 10% of their molecular weight (Conn, 1979). However, the quantity of HCN produced by most tropical browses is too low to pose major animal health problems (Kumar and D'Mello, 1998; Kumar, 2003). Generally, only plants that produce more than 20 mg HCN/100g fresh weight are considered deleterious (Everist, 1981). The value for fluoroacetate as reported by Njidda (2010) ranged from 0.0010 to 0.0014mg/g DM. The value was negligible to pose any problem to animals although if the compound is in large amounts it is known to inhibit the Krebs cycle by formation of fluoroacetate (Everist, 1974) and is used as a poison for rats and rabbits (Norton, 1994a).

Available information on browse plants diversity in Nigeria is not exhaustive (Mecha and Adegbola, 1985) and mostly unpublished (Okigbo, 1980; Orok & Duguma, 1987; Okafor & Fernandez, 1987). The report of Okoli *et al*. (2003) in southeast region contradicts the reports of Wahua and Oji (1987), Reynolds and Atta-Krah (1987) and Okafor and Fernandez (1987) who respectively identified 35, 30 and 27 browse plants for the entire southeast region. The report of Okoli *et al.* (2003) indicated that there were much more browse resources in the region than the few highlighted by the studies. Through the help of animal keepers in a farmer-researcher combined survey, these investigators uncovered well over 160 plants consumed by ruminants within the southeastern ecological niche. Some of these plants however, were not common to all the sites studied. Information on the distribution and diversity of browse plants in Nigeria is also lacking (Ahamefule, Obua, Ibeawuchi, & Udosen, 2006). A detailed study of the browse plants found within 36 states Nigeria is essential to generate baseline data and to determine the potential browse resource within the major ecological frontiers of the states. The potential yield of browse would provide useful tool for the determination of stocking rate and indeed the carrying capacity of a range or land under grazing. Deforestation, urbanization and bush burning are some of the major factors responsible for dwindling proceeds of browse feed resource for ruminant livestock, especially in northern Nigeria. Conservatory methods however, would ensure that locally adapted and well established species do not become extinct.

In Nigeria, pasture development has not been developed except on Government and University, experimental, teaching and demonstration farms. Consequently ruminant livestock depend on natural grasslands that are nutritionally poor. The introduction of pasture crops into Nigeria started in the 1950s (Onifade & Agishi, 1988) and over the years pasture agronomists and ruminant livestock nutritionists have investigated pasture plants that could stand the variations of agro-ecological zones (De Leeuw & Brinckman, 1974; Olubajo, 1974; Ademosun, 1974). Scientists in Nigeria have identified suitable pasture plants to meet the variations of the agro-ecological zones, therefore, different grasses and legumes are found in the different agro-ecological zones (Olubajo, 1974; Agishi, 1979; 1983 ; Onifade & Agishi, 1988).

It will however, require social and cultural changes amongst the nomadic and livestock owners to adopt the technologies that have been developed and to treat livestock ventures as commercial enterprises, and not just a way of life. As part of the new technology in animal husbandry, improved pastures produce more dry matter of high nutritive value and lead to greater animal productivity than do native pastures (Nuru, 1996).

2.6.4 Forage preference of cattle

Short-term preference studies were carried out by Amole *et al*. (2013) using growing Muturu calves based on diets of local grass forages found in South-Western Nigeria. Two grass species such as guinea grass (*Panicum maximum*) and elephant grass (*Pennisetum purpureum*) at four and eight weeks of re-growth were harvested when needed either for pelleting or for fresh green chop. The diets were served to animals individually and later in group. Feed preference was assessed from the total intake and the chemical composition of each diet was also assessed. The CP content of the grasses ranged from 105 to 133 g/kg DM with pelleted *Panicum* at 8 weeks old having the highest CP. Pelleted grasses of 4 week old had the lowest NDF in the trial. Green chopped *P. maximum* of 4 weeks old was most preferred by the calves. Age at harvest influenced preference as forages harvested at 4 weeks old had higher intake. Forage preference considered in terms of intake rate indicated that growing calves preferred fresh *P. maximum* of 4 week old to the other samples used in their study. Group feeding also influenced forage preference.

Also, Ajayi *et al.* (2008) reported that if grass of any age is effectively managed, it can strategically be exploited to ameliorate forage scarcity during the off season. An example of these is processing it into pelleted forms, hay and silage which can be stored for feeding during the dry season. Therefore, since ruminants according to Babayemi and Bamikole (2006) are the best assessors of the nutritive value of any feed, as they always consume more of the forages that are high in protein than the high lignin containing grasses, a knowledge of the selectivity of the available forage will go a long way in increasing production and also the establishment of pasture and its conservation through various means such as silage, hay and pellet production to meet the nutritive needs of animals in periods when there is low availability of forage. The researchers concluded that in order to optimize DM intake by animals, farmers should consider the type of grasses and their age at harvest particularly for cattle. Pelleting improves acceptability of forages when rejected by animals in fresh forage form due to advanced age. Forage acceptability by animals on pasture or under zero grazing conditions is also a function of forage, inherent chemical traits, forage morphology. Therefore, effort should be made to encourage farmers to establish and maintain locally available forages that are also adapted to social and environmental conditions of respective areas.

2.6.5 Pasture improvement

Although about 32.42 million hectares of grazing lands and 39.41 million hectares of crop lands in Nigeria provide substantial amount of feed for the country's livestock, extensive areas of the grazing lands are composed of indigenous species, which are of low yield, quality and seasonal in growth (Magbagbeola, Adetoso, & Owolabi, 2010; Shiawoya & Tsado, 2011). With the increasing livestock population in the last few years, there is need to increase the quantity and quality of the forages available in the country. Over the years therefore, many improved varieties of forages have been introduced by research institutes, Federal and State Governments with the aim of improving the natural pastures and providing more nutritious feed to the national herds (Ajileye, 1993). There is however, the need to develop or adopt strategies that will assist these introduced forage species to cope with and even overcome most of the factors that militate against high productivity. Such technologies should take into consideration the peculiarities of various agro-ecological zones in which these forage and fodder crops grow, in order to obtain useful results for dissemination to livestock producers (Shiawoya & Tsado, 2011).

As part of the new technology in animal husbandry, improved pastures produce more dry matter of high nutritive value and lead to greater animal productivity than do native pastures. Some forage species of promise that have been investigated in the derived savannah zone are *Andropogon gayanus* and *Panicum maximum*. Both proved very productive and palatable (Ademosum, 1976) and can stand close grazing provided they are well established before being grazed. At moderate stages of growth, *Pennisetum purpureum* is readily grazed and liked by animals. It is also good forage for silage making when harvested at a height of 2 m and mixed with maize cut at milk stage. The tall grasses have high yield in terms of dry matter but at maturity they become coarse, fibrous and rough and the feed value reduces substantially. *Cynodon nlemfuensis,* a spreading perennial has been used as an improved grass in the derived savannah zone. It can stand close grazing and trampling and forms excellent association with *Centrosema pubescens*. In association with *Panicum maximum* it tends to suppress its profuse tillering characteristics, but it provides an excellent soil cover around bunches of *Panicum maximum*. Besides the above some other cultivated forage species in the savannah zones are Rhodes grass, Digitaria, and Signal grass.

The use of highly productive good quality pasture grasses and legumes resulted in increased productivity in grazing animals in trials in Nigeria (de Leeuw & Agishi 1978). Research data on both indigenous and exotic forage species in the savannah zones have been reported (Agishi, 1983; Onifade & Agishi, 1988; Shehu & Akinola, 1995). Shehu and Akinola, (1995) evaluated the growth of two grasses such as buffel grass (*Cenchrus ciliaris*) and green panic (*Panicum maximum*) and two tropical legumes such as Caribbean stylo (*Stylosanthes hamata*) and Townsville stylo (*S. humilis*) in pure stands and grass legume mixture. Caribbean stylo-green panic swards gave the highest dry matter yields of 3.83 tonnes/ha and 4.97 tonnes/ha in the first and second years. Caribbean stylo-buffel grass mixtures produced the largest yields of 2.38 and 3.94 tonnes/ha for each year of the study. Also crude protein concentration varied from 18.22 to 5.94% in the legumes and 7.43 – 2.37% in the grasses. On the basis of crude protein they recommended 95 days after sowing and 90 days of re-growth for conducting hay harvest and livestock grazing on all swards.

The use of pasture legumes is advocated to reduce feed deficiencies and the low quality of available feed during the dry season period. The use of high yielding legumes as a sole crop or in mixture with grasses is one way of achieving year-round quality forage. Centro (*Centrosema pubescens*) in this regard has emerged as one of the best legumes for the derived savannah and forest zones following initial screening at Ibadan (in western Nigeria) and Shika (in northern Nigeria) (Omokaye, 2001). Thus, due to *C. pubescens* quality it was recommended for sown pastures as well as range improvement and/or rehabilitation (Agishi, 1983).

Omokaye (2001) also examined the effect of sowing date, phosphorus level and stage of maturity on herbage quantity/quality and chemical composition of *C. pubescens* in the year of establishment and reported that forage yields at the initial harvest, yields of regrowth and total yields decreased as planting date was delayed but increased with phosphorus application. Delay of the initial harvest to 14 weeks post planting dramatically increased forage yield while still providing a high quality product. The materials harvested from all treatments, at the initial harvest were high in quality. The N and Ca concentration in centro, even in the unfertilized material were above the critical levels of 1.8% N and 3.5% Ca suggested by Minson, Tobbs, Egarty, and Layne (1976) for young beef cattle. Also the P concentrations were above the critical level of 0.12% suggested by Little (1980).

2.6.6 Fodder banking for cattle production

The fodder banking involves the fencing, planting, concentrating, storing and reserving of forage legumes in hays and silos to which concentrates, mineral and vitamin premixes are added (Mohammed-Saleem, 1986). Fodder banks convert plants such as *Stylosanthes guianensis*, *Centrosema pubescens* and *Desmodium spp* into supplementary or fall back forage kept in small to large plots for dry season use by aging, ailing, nursing, and lactating animals (Tarawali & Pamo, 1992).

The Fodder bank concept started in Nigeria in the late 1970's through the activities of the ILRI Sub-humid Programme, Kaduna and involved establishment and management of concentrated units of forage legumes by pastoralists near their homestead (Saleem & Suleiman, 1986). The legumes are fed to "selected" animals as dry season supplementary feed, with 4-ha fodder banks having a potential dry matter yield of 4 to 5 t/ha which would adequately meet the supplementary needs of eight lactating cows during the dry season (Saleem, Mohammed - Suleiman, & Otsyina, 1986; Saleem & Suleiman, 1986; Otsyina, von Kaufmann, Mohammed-Saleem, & Habibu, 1987).

According to Haydock and Shaw (1975), the factors involved in fodder bank production in the sub-humid zone of Nigeria include land, labor, capital, soil, climate, seed, fire and ants. Understanding how these factors operate under the varying conditions of different parts of the sub-humid zone helps to identify the problems and prospects of fodder bank development. For example, the availability of land for fodder banks depends on where a pastoralist chooses to settle since the most common choice is in the vicinity of crop farmers. Fallow land is specifically more attractive because it has less tree and shrub cover and requires less clearing, but there may be difficulties in obtaining it because of rising demand for cropland. Crop farming communities will therefore play significant roles in providing land for fodder banks to those pastoralists settled in their neighborhood and must eventually benefit from fodder banks or else the intervention will have limited applicability.

Pastoralists settled on grazing reserves or in less heavily populated areas may have easier access to land, but the generally poorer soil and higher ligneous cover of these sites may require a different approach to fodder bank establishment and management. Pastoralists' decisions on how much labor and capital to allocate to fodder banks will determine the area of land that can be used, the method of land preparation and other inputs affecting the productivity and continued existence of the banks.

2.6.7 Crop residues and by - products used in cattle production

Poor nutrients supply in required quantity and quality is the major set back to livestock productivity in Nigeria. The precarious condition gets worse during the long dry periods when animals are unable to meet their protein and energy needs from available low-quality herbage with consequent marked seasonality in weight loss and productivity (Ademosun, 1994). The utilization of the cheapest and most available feedstuff is a major challenge facing livestock farmers in Nigeria amidst feed crisis (Bogoro, 1997). These cheap feed resources include crop residues, agro-industrial by products, animal processing wastes, brewery waste and by-products, farm animal wastes (poultry litters and animal faeces), and other forms of fibre, protein and energy by-products suitable for ruminant feeding as well as browse plants (Adegbola, 1985; Alhassan, Ehoche, & Adu, 1987).

Crop residues are post-harvest roughage materials or plant materials left after the removal of the primary food from the crop plant. Though sometimes referred to as “farm waste”, they are distinct from agro-industrial by-products which are products arising from factory or household processing of the harvested crop (Alhassan, 1985). Almost all crops cultivated for human consumption contain residual materials which can be consumed and converted to valuable products by livestock. Estimates in Africa alone show that more than 340 million tones of fibrous crop residues are produced annually (Kossila, 1984; Umunna & Iji, 1993). Adegbola (1982) estimated that 45 million hectares of savannah land is available for livestock grazing and also over 111.5 million tones of crop residues are produced in Nigeria each year.

Crop residues comprise a vast array of plant materials that vary in their origin as well as their physical and chemical nature. A variety of crop residues are available in Nigeria, some abundant and more useful, others available only in small quantities and therefore of secondary importance. About 22 species of plants are cultivated for human consumption. In Nigeria, 24.6 million tonnes of millet, 17.2 million tonnes of guinea corn, 2.5 million tonnes of maize, 0.2 million tonnes of rice, 1.3 million tonnes of groundnut and 3.7 million tonnes of cowpea residues have been estimated in the major production areas of Sokoto, Kano, Bauchi, Adamawa, Kaduna, Benue, Borno and Anambra States of Nigeria (Alhassan, 1985). It has been observed that most of the crop residues are abundant during the months of September to November (early dry season), while they are mostly needed and utilized between March and July (during the late dry and early rainy seasons) when the available pasture is low in quantity and quality. Some crop residues are used as mulch, bedding, fuel, building materials or source of organic fertilizer. These abundant crop residues can supply enough roughage for the ruminant population in the country if properly harnessed, processed and preserved (Alhassan, 1985).

Crop residues are characterized by high content of fibre usually above 40%, low content of nitrogen (0.3 -1.0%) and low content of essential minerals such as Sodium (Na), phosphorous (P) and calcium (Ca) (Adegbola, 1998). Cell wall estimated by neutral detergent fibre (NDF) accounts for at least 72% of the dry matter and represents a large source of potential energy for ruminants (Umunna & Iji, 1993). The ability of rumen microorganisms to digest cell polysaccharides, consisting mainly of cellulose and hemicellulose is limited by lignin. Since fibre is often used as a negative index of nutritive value in predicting the total digestible nutrient (TDN) and net energy, the available energy from crop residues is likely to be low in relation to crop residue yield (Van Soest, 1988). The consequences for ruminant animals are low feed intake (about 1.2 kg DM/100kg live weight) and low performance (Adegbola, 1998). Therefore, crop residues, being fibrous in nature require that their quality be upgraded for effective utilization by livestock (Fadel Elseed, 2005).

The nutritive value of crop residues varies according to species, varieties, environmental conditions, stage of maturity and methods of harvest, storage and feeding among others factors. In general, crop residues are characterized by low levels of one or more key nutrients which limit their utilization by livestock. Cereal stovers and straws which form the bulk of crop residues are inherently low in crude protein (< 60 g per kg DM), readily fermentable, metabolizable energy (< 7.5 MJ/kg DM) (Sundstol and Owen, 1984), essential minerals and contain high levels of structural carbohydrate or fibre (Alhassan, Shoche, Adu, & Obilana, 1983; Sundstol & Owen, 1984). As a result, the DM intakes (DMI) are too low (about 10 – 15 g DM/kg live weight/day) to permit adequate nutrient intake for maintenance and production. Consequently, when stovers and straws are fed to ruminants, their intake and digestibility are low, resulting in low level of performance.

Generally, when crop residues are fed to ruminants their intake is low and their utilization is limited by the slow rate of, and total degradability and the rate at which particles breakdown to a critical size small enough to leave the rumen. However, leguminous crop residues are usually better and may be used to complement forages if they are available in adequate quantities. Crop residues from legumes are usually sold to livestock farmers thereby providing added income for crop farmers. There appears to be no toxic substances in straws and stover, except when they are mouldy. However, phenolics and other aromatic compounds may reduce digestibility in some sorghum and millet varieties (Reed, Capper, & Neate, 1988).

Most of these crop residues are utilized by ruminant animals, and can be enriched by different processes some of which can be carried out by small (rural) farmers themselves. Processing of feed involves the use of any treatment which alters the composition of that feed by physical, chemical or biological action (El-Shobkshy, James, Marai, Owen, & Philips, 1989; Taiwo, Adebowale, Greenhalgh, & Akinsoyinu, 1992). Variations in chemical composition and nutrient content of crop residues may be due to: the type of crop, proportion of morphological parts of plant harvested, extent of weathering prior to utilization, chemical characteristics of the soil upon which the crop was cultivated, and level of feeding and fertilization. However, alterations in composition do not simply mean improving the nutritional value of the feed but, also include a large range of other improvements such as lengthening the storage life of the feed, detoxification, change in particle size, improving palatability, isolation of specific parts of the feed and reduction in effluent production. The main treatment methods for improving the voluntary intake characteristics and nutritive value of crop residues and by-products are physical, chemical and biological (El-Shobkshy *et al.*, 1989). Other methods of improving crop residues and by-products include residue management, breeding and selection, and supplementation.

Physical treatment of crop residues could be achieved by means of milling, grinding and chopping, steaming and ionization. The treatment is generally aimed at reducing the particle size of the material (Lufadeju, 1988). These are the commonest methods adopted which are aimed at increasing the surface area available to enzymatic digestion of cellulose by rumen microorganisms and to increase the animals voluntary intake. Reduction in particle size increases ease of handling, facilitates better storage, reduces wastage, reduces selective eating by animals and improves feed intake and digestion as relatively larger surface area becomes available for microbial activities.

Several chemicals have been used to upgrade crop residues and agro industrial by-products. The choice of a particular chemical depends on its effectiveness in improving digestibility and intake, cost of treatment, availability and freedom from chemical residues that could be toxic to animals directly or animals and man through faeces and urine polluting soils and water courses. In addition, the chemical should be non-hazardous to handle by man and non-corrosive to machinery. Chemical treatment through the use of alkali such as sodium hydroxide (NaOH), potassium hydroxide (KOH), calcium hydroxide (Ca(HO)2) has been shown to improve digestibility of poor roughage considerably (Klopfenstein, 1978). This alkali acts as delignifying agents by breaking the bond between lignin and hemicelluloses or cellulose. NaOH (caustic soda) has so far been considered the most effective alkali for treating crop residues. Caustic soda has also been shown to have limited acceptability in a growing economy like Nigeria. This is due to its high cost and corrosive nature.

Calcium hydroxide though less expensive and safer to handle with no problem of calcium residue is however weaker than NaOH and needs a long time to react on the crop residue depending on the ambient temperature (El-Shobkshy *et al.*, 1989). Furthermore, poor solubility of calcium hydroxide represents a considerable disadvantage to its use and renders it less effective. Potassium hydroxide, like NaOH is expensive in the pure form. It is also effective in upgrading crop residues and by-products. Wood ash which is a crude form of KOH has been used in treating crop residues by soaking in solution containing 50 g ash/kg residues. Sulphuric acids have been tested for their suitability to upgrade roughages, hydrochloric acid and chlorine (Arndt, Richardson, Albino, & Sherrod, 1980), nitric acid (Arndt *et al.*, 1980) and formic, orthophosphoric acid or propionic acids. The high cost, unavailability and the danger associated with the corrosive nature of acids place them beyond the reach of the average farmer.

When protein supplements are scarce and expensive, the use of ammonia either in anhydrous or aqueous form becomes advantageous. Treatment of roughages by ammonia has been carried out in most developing countries. It supplies nitrogen to and, delignifies the treated material. The response to ammonia has been found to be highly dependent on temperature, straw variety and moisture content. The straw is usually treated in either polythene covered sack or tunnel using aqueous ammonia or an oven using anhydrous ammonia. However, ammonia treatment of crop residue has been reported (Lufadeju, 1988) not practicable in Nigeria and other developing countries with low technological base because of the unavailability of the forms (anhydrous and aqueous) of ammonia, and even if they are available, the high cost of transportation of gaseous ammonia in special gas cylinders, and the highly technical personnel required to handle this potentially hazardous material do not make them economically feasible.

A safer alternative to ammonia has been urea, which is available in most areas as fertilizer and precursor of ammonia. The use of urea as a precursor of ammonia has been recommended for developing countries for its simplicity and safety in application, availability in local markets at cheap prices and preservative properties (El-Shobkshy *et al.*, 1989). The idea of using urea or poultry litter originated from alkali treatment aimed at breaking the lignin bonds in crop residues like straw, thus releasing the energy contained in them for use by the animal to which these are fed. But, Ngele (2008) reported an increase in CP from 4.4% in untreated rice straw to 12.4% in 4% urea treated rice straw.

Biological treatment of crop residues is based on the use of certain microorganisms that are very efficient in lignin metabolism but with low degradation rates of cellulose and hemicelluloses. Biological treatment is potentially safer and cheaper than chemical and physical treatment, but the presence of unwanted microorganisms may be a disadvantage (El-Shosbkshy *et al*., 1989). Treatment of sorghum stover with *Trichoderma harzanium* enhanced the crude protein of the substrate, while the crude fibre content was reduced. Biological treatment of crop residues need controlled conditions which are difficult to achieve at smallholder farming level (El-Shosbkshy *et al*., 1989).

2.6.8 Crop residues and by - products management and utilization

Crop residues when allowed to stay for long in the field after harvest, tend to decline in their nutritive value. Alhassan, Kallah, and Bello (1987) reported that good crop residue management could be enhanced by packing the residue not later than 28 days after grain harvest. Rainfall tends to leach out the cell contents which lead to a reduction in digestibility of the residue. Also, moldiness of the crop residues due to high humidity can decrease animal acceptability as well as decrease fermentable carbohydrate. It is therefore important to harvest or graze crop residues on time and handle the harvested materials well to avoid negative effects on the nutritive value of the residues.

Supplementation of low quality roughage is done by feeding limiting nutrients in the form of concentrates (energy and protein), minerals, non-protein nitrogenous (NPN) substances (Urea, biuret, poultry litter) or green forages. Supplementation has generally aimed at one or combination of two distinct objectives: Feeding for a positive associative effect; small quantities of supplements are used to enhance intake and digestibility (Hannah, Geohran, Vanzant, & Harmon, 1991). Supplementation for positive associative effects is usually done when straw is not treated (Leng, Preston, Sansoucy, & kunji, 1991).

Substitutional supplementation aims at reaching a desired level of supplementation, often by substituting a part of the basal feed in the ration. Alhassan *et al.* (1987) reported a higher dry matter intake (DMI) when graded levels of cotton seed cake (CSC) were given as supplement fed to sheep and goats. They further reported that CSC supplementation in excess of 60 to 90 g/day in sheep depressed straw intake whereas in goats it was 50 to 75

g. However, an improvement in nitrogen retention was observed in both ruminant species given these levels of CSC.

In a more recent report by Ngele (2008), significant increase in daily total feed intake (DTFI) and daily weight gain (DWG) was observed in rams fed urea-treated or untreated rice straw with various supplements. Mixed supplements (protein + energy) gave better results than single supplements (protein or energy). Alhassan *et al.* (1987) observed that intake of sorghum stover by sheep was improved by urea-ammoniation, but not significant. Increasing the level of supplementation with CSC improved stover intake by sheep fed the unammoniated stover, but resulted in decreased intake of ammoniated stover by sheep.

Live weight gains were also improved by ammoniation and supplementation. The interaction between urea-ammoniation of stover and CSC supplementation resulted in better live weight gains in sheep. However, ammoniation and supplementation did not affect DM, NDF and ADF digestibilities, but resulted in increase in cellulose and hemicellulose digestion. Ammoniation and supplementation resulted in higher N-balance in the sheep and increases in rumen ammomia concentration, but increasing level of supplementation did not apparently affect rumen ammonia concentrations. It was concluded from these results that ammoniation of sorghum stover (SS) and CSC supplementation improved the nutritional quality of SS fed to sheep.

The effect of supplementation on intake and digestibility was more marked at lower levels of supplementation than at the higher levels. At higher levels of supplementation, ammoniation had no advantage probably because the ruminal ammonia concentration required for maximum microbial biomass production has been met by the degradation of the supplement. It may be that at this high level of ammonia concentration energy will be a limiting factor. It was also concluded that supplementation with CSC at 1% of the sheep body weight with ammoniated but not with ammoniated SS, will maintain sheep live weight. Higher levels with either straw can result in marginal gains, while lower levels will lead to live weight losses.

Adegbola (2002) reported that addition of urea to rice straw increased the CP to 13.67%. Also, a significant increase in total dry matter intake (DMI) was observed. The intake of rice straw was significantly reduced by groundnut hay and CSC supplementation, indicating that a substitution effect has taken place at the levels of supplementation. Both CP intake and digestible CP intake were increased by addition of supplements. Supplementation of rice straw did not affect digestibility of dry matter (DM), organic matter (OM), cellulose and hemicellulose. The pH increased significantly after feeding and was higher for high fibre diets.

2.7 Cattle Performance Evaluation

2.7.1 Body weight

Growth is measured as an increase in body weight and it includes not only cell multiplication (hyperplasia) but also cell enlargement (hypertrophy) and incorporation of specific components from the environment for example, deposition (Flier & Maratos-Flier, 2000). Growth is commonly monitored by using body weights because it is easier and quicker to perform, does not require much expertise and it is not tedious to perform. Body weights are thus commonly used for monitoring nutritional status and growth of animals (Chimonyo *et al*., 2000). However, the body weight of an animal *per se* does not reflect its nutritional status (Oulun, 2005). Animals with large frames may have higher body weights with low level of body reserves than small framed ones with abundant reserves. Changes in body weight, therefore, become more informative than body weights *per se*.

Large variations in body weight may occur as a result of changes in gut fill and bladder fill, pregnancy and parturition or may be a reflection of tissue hydration rather than significant alterations in body protein or fat content (NRC, 1996). To minimize the effect of frame size of the animal, body weight measurements should be collected regularly, often on a monthly basis. The influence of gut fill on body weight measurements can be reduced by weighing the animals at a consistent time of day. This requirement is difficult to meet, since animals are usually presented to the handling facilities at different times. Calibration of weighing scales may also present some difficulty which may lead to errors in measurements.

2.7.2 Body condition scores

Body condition scoring describes the systematic process of assessing the degree of fatness of an animal (Gatenby, 2002; Todd, 2008; Addass, 2011). The score reflects the plane of nutrition on which an animal has been exposed over a reasonable length of time (Stuth, Dyke, Jama, & Corbett, 1998). The loin, ribs, tail head, brisket, flank, vulva and/or rectum and udder are the important parts of the body used in determining the score. Physiologically, the proportion of protein and water of the animal's bodyweight decrease as it gains body condition (NRC, 1996).

Several authors have documented association between body condition scoring and fertility (Buckley, O'Sullivan, Mee, Evans, & Dillon, 2003) and health (Roche & Berry, 2006). The 6 -point scale other wise known as the Scotish or British system of scoring is however, quite popularly used by dairy producers. The 9 - point scale known as the American scoring system is recommended for tropical cattle, such as *Bos indicus* (Nicholson & Butterworth, 1986). Body condition scoring is easy to apply and has been extensively used as a management tool largely in the dairy and beef sectors. It is however least reliable for calves and weaners, as they tend not to have heavy fat deposits.

Despite the reported repeatability estimates in experienced assessors, the general subjective nature of body condition scoring makes it difficult for inexperienced herd managers to correctly score the animals (Ferguson, Galligan, & Thompson, 1994). Unlike body weight measurements, the automation of body condition scoring have to date been unsuccessful (Berry, O'Brien, O'Callaghan, O'Sullivan, & Meaney, 2006). There is a general consensus that the genes that influence body condition scores and body weights are either closely linked or could have pleiotropic effects on each other. Berry *et al*. (2006) observed a low correlation coefficient between body weight and condition scores. An objective indicator of nutritional status, which could be reliably and routinely used to aid management of cattle in rural areas, is to determine levels of nutritionally related blood metabolites (Oulun, 2005; Agenas, Heath, Nixon, Wilkinson, & Phillips, 2006).

Earlier workers such as Lawman, Scott, and Somerville (1976) and Pullan (1978) reported 6 point scale, with point 0 being animals that are severely emaciated and at the point of death, while point 1 has the animals that are emaciated and physically weak with all ribs and bone structure easily visible. Cattle in this score are extremely rare and are usually inflicted with a disease and/or parasitism (Gatenby, 2002; Todd, 2008; Addass, 2011). In score 2, the cows appear emaciated, similar to BCS 1, but not weakened. Muscle tissues seem severely depleted through the hindquarters and shoulders. Score 3 has animals that appear moderate to thin. The last two ribs could be seen and little evidence of fats is present in the briskets, over the ribs, or around the tail heads. The spine processes are smooth and not individually identifiable. Score 4 has animals appearing in very good flesh. The briskets are full, the tail heads show pockets of fats and the backs appear square due to fats. The ribs are very smooth and soft to handling due to fats cover. Score 5, cows are obese. Their necks are thick and short and their backs appear very square due to excessive fats. The briskets are distended and they have heavy fats pockets around the tail heads.

Body condition score (BCS) of beef cows at the time of calving has the greatest impact on subsequent rebreeding performance (Ndlovu *et al*., 2007). On the average, cows that calve in a BCS 3 or 4 have difficulty exhibiting their first heat by 80 days after calving. Whereas cows that calve in BCS 5 or 6 tend to exhibit heat by 55 days after calving and therefore, have a better opportunity to maintain a 365 day calving interval (Ndlovu *et al*., 2007). Although cows that calve in a BCS of 7 have a short postpartum interval, it is not economical to feed cows to a condition score of 7.

Thin cows at calving (BCS 4 or thinner) produce less colostrum, give birth to less vigorous calves that are slower to stand and these calves have lower immunoglobulin levels, thus impairing their ability to overcome early calf-hood disease challenges. This illustrates the importance of targeting mature cows to calve in a BCS of at least 5. Because 1st-calf-heifers have only reached about 85% of their mature weight after calving and require additional nutrients to support growth, they need to be fed so they are a BCS of 6 at calving.

Body condition scoring could be done using only visual indicators or a combination of visual and palpation of key bone structures for fat cover (Ndlovu *et al*., 2007). Palpation could be done during routine processing of cows through a chute. The key areas for evaluation are the backbone, ribs, hips, pin bones, tail head and brisket. Palpating cows for fatness along the backbone, ribs and tail head will help refine that skill of visual assessment of body condition. This is because using eyes to judge body condition can be difficult with cattle, like Highland or Galloway cattle, with the thick hair that hide a lot of what you can feel by touch. Other factors in addition to hair coat that can affect visual body condition scores are age of cow, rumen fill, and stage of pregnancy. Body condition scores should be recorded so that links to productivity and herd management can be examined. Several years of such information could reveal, for example, needed management changes. However, the greatest single factor influencing rebreeding performance of beef cows is body condition at calving, especially for spring-calving females. If producers wait until calving to manage body condition of their cows, they will find it very difficult and expensive to increase the body condition of a lactating cow.

Although evaluation of body condition could be looked at as an ongoing process, there are several key times when body condition scoring should be considered. These periods include late dry season in systems where females are managed almost entirely on vegetative or dormant grazed forage. For example, if cows are thin, early weaning should be considered. Non-lactating cows may pick-up condition by grazing forage alone or by feeding a small amount of supplement along with the grazed forage. Again, if young cows are thin and grass in the pasture is decreasing in nutrient quality there is need to strategically wean calves. Particular attention should be paid to young cows weaning their first calves, as they are most likely to be thin at this time. There may be need to consider early weaning of calves and giving cows access to higher quality forage.

For years, progressive cattle producers have recognized the important relationship between the physical appearance of their animals and reproductive performance outcomes. Body condition scores also allow producers to group cattle according to their nutritional requirements, thereby improving the efficiency of nutrition programs. Furthermore, body condition scores standardize the description of body condition in beef cows which greatly enhances communication among cattle producers, university educators, veterinarians and industry advisors. Body condition scoring of cows allows for analysis of present management practices and application of research results and recommendations for individual cattle herds (Akpa *et al*., 2012).

Fertility is the ability of male and female animals to produce viable germ cells, mate, conceive and deliver normal living young. The lifetime productivity of a cow is influenced by age at puberty, age at first calving, calving interval and number of services per conception and calving to conception interval (Mukasa-Mugerwa, Tegegne, & Ketema, 1992; Malau-Aduli, Abubakar, & Dim, 1993). Reproductive ability is the primary source of all benefits derived from livestock, but earlier selective breeding has focused on increased animal production traits (Oni, Buvanendaran, & Dim, 1988; Shehu, Olurunju, & Oni, 2005). The reproductive performances of a herd have been shown to be one of the most important starting points in any animal improvement package (Mukasa-Mugerwa *et al.,* 1992). This implies that whatever the goal of the production system is, reproductive traits appear to be economically important in cattle improvement programmes.

2.8 Cattle Physiological Parameters

2.8.1 Body temperature of cattle

Body temperature is defined as the degree of heat of a living body (Jeffrey and Michael, 2010). An animal's temperature is actually the result of the balance between heat produced by basal metabolism and muscular activity of the body, and the heat lost from the body (Hahn, Eigenberg, Neinaber, & Littledike, 1990; Jeffrey & Michael, 2010). Approximately 85% of heat loss is through the skin, while the remainder is lost through the lungs, digestive and urinary secretions (Babayemi *et al*., 2014). The actual regulation of body temperature is accomplished mainly through thermoregulatory centers located in the brain. An animal's abnormal temperature may play a part in the veterinarian's ultimate diagnosis of a disease, and the visual symptoms of abnormal temperature are often the first noticeable clue the owner may detect (Shelton 2000; Daramola & Adeloye 2009). When an animal's temperature is above normal limit, it is considered to have a fever; while if it is below normal, it is called hypothermia (Nienaber, McDonald, Hahn, & Chen, 1990; Oladimeji, Osinowo, Alawa, & Hambolu, 1996; Ayo, Oladele, Fayomi, Jumbo, & Hambolu, 1998).

Domestic animals do not have constant normal temperatures since considerable variations in the temperature of normal animals are observed under different conditions. In general, animal temperatures will vary, depending on physical activity, stage of pregnancy, the time of day and environmental surroundings (Prendiville, Lowe, Earley, Spahr, & Kettlewell, 2002). When the body temperature increases by at least 1°F over the normal upper limit, the animal is considered to have a fever. In most fevers, the temperature usually rises rapidly, reaches a peak and then falls to a lower level. Generally, the height of the temperature indicates the height of the fever. Usually, the temperature never exceeds 39.0^0C in horses or 39.1^0C in cows even in severe infectious diseases (Babayemi *et al*., 2014). However, in all animals suffering from heat stroke, the temperature may exceed 39.7^0C.

Although the measurement of temperature is one of the most characteristic and reliable methods to judge the degree of fever, it does not always have a direct relationship in animals, especially in cattle. One must also consider other symptoms such as chill, uneven distribution of the external temperature, pulse and respiration rates, appetite, digestion, morbidity, etc. Subnormal temperature (hypothermia) may or may not indicate disease. It occurs in a variety of ailments, such as chemical poisoning, indigestion, and calving paralysis. Subnormal temperatures are much less frequent than fever temperatures (Babayemi *et al*., 2014). Body temperature when properly used can be a good indicator of illness. A greater incidence of calf illness can be identified using body temperatures rather than visual observation alone (Shelton 2000; Daramola & Adeloye 2009). One common rule of thumb in beef cattle operations is to designate cattle with rectal temperatures of 39.9^0C or greater as sick.

Body temperature rises in cattle infected with a disease-causing organism as the immune system begins to fight the infection. Some untreated cattle overcome infection and recover, while others suffer elevated body temperatures and show other signs of illness. In cattle that begin to succumb to disease, clinical signs worsen and body temperature eventually falls well below normal, creating a dangerous health situation. Early detection of elevated body temperatures and rapid recognition of clinical signs of illness are important for effective treatment of sick cattle (Babayemi *et al*., 2014).

To use body temperature properly as a measure of illness, it is necessary to know what is "normal." Unfortunately, normal temperatures for cattle rise during the day. Cattle producers must consider this when deciding when to use body temperature as an indicator for culling sick cattle (Nienaber *et al.*, 1990). Cattle do not maintain body temperature in a tight range as humans do. Unlike humans, cattle expel body heat primarily through respiration rather than sweating. In fact, body temperature in cattle follows a daily pattern where there is a period of increasing heat load and rising body temperature followed by a period of heat dissipation and falling body temperature. Cattle body temperature rises during the day rather than the animals spending energy to get rid of the heat. Minimum body temperature usually occurs early in the morning and then increases steadily during the day (Hahn *et al*., 1990). The heat load built up during the day is dissipated at night such that body temperature falls gradually during the night, reaching a daily low early in the morning. It also occurs in controlled environments with a standard temperature, so factors other than the outside temperature have a significant influence on cattle body temperature. Feeding, activity level, solar radiation and humidity also influence cattle body temperatures. Acute elevations in body temperature occur directly after feeding or exercise. Fevers are identified more accurately when body temperatures are at their daily lows (Gaughan, Mader, Holt, Josey, & Rowan, 1999).

For proper identification of sick cattle, make sure that body temperatures are not taken too late in the day when false positives for illness might occur. While working cattle in the late evening may seem like a good idea, cattle generally need several hours past sundown to dissipate heat and cool down from an extremely hot day. It is critical to take temperatures before mid-morning (Paula-Lopes *et al*., 2003). Producers measuring cattle temperature in the afternoon, even on a cold day, and letting cattle stand around for three or four hours before processing may identify cattle for treatment that are actually healthy (Nienaber *et al.*, 1990; Paula-Lopes *et al*., 2003). There is the need to minimize exercise and stress just before measuring temperatures. Cattle should never stand for more than 20 minutes in alleyways or chute of handling facilities before temperatures are taken. Once in the chute, measure body temperatures immediately. It may be necessary to divide cattle into small groups that could be worked in a reasonable amount of time instead of trying to work the entire group at once.

Temperature is valuable for monitoring animals, core body temperatures are inherently difficult to obtain and rectal temperature only approximates core body temperature. Because restraining animals to manually collect rectal temperatures may cause stress that alters those temperatures, a reliable method with no human intervention is likely to provide a more accurate measure (Daramola & Adeloye, 2009).

Attempts to measure body temperature of cattle have been made at various anatomical locations including rectum, ear (tympanic), vagina, reticulum-rumen, and udder (milk) (Olson *et al.*, 1991). Rumen temperatures have been demonstrated to be effective measures of core body temperature. The Bella Health System (BHS, Bella Health Systems, Greeley, CO), formerly marketed a Cattle Temperature Monitoring System (CTMS, MaGiiX Inc., Post Falls, ID), which utilizes RF identification (RFID) technology within a rumen bolus, a panel reader placed at a parlor entrance or exit and a software package to collect, analyze and view data.

In many parts of the world, body temperature is measured with a clinical mercury, digital or infraray thermometers. The procedure for taking an animal's temperature using Mercury thermometer is:

(a) Shake the mercury column into the bulb end of the thermometer

(b) Moisten or lubricate the tube and

(c) Insert the bulb end through the anus into the rectum. Insert the full length of the tube into the rectum and leave the thermometer in the rectum for about 3 minutes (Shelton

2000). Recently digital and infraray thermometers are used to measure rectal temperature of cattle with ease (Gaughan *et al*., 1999).

2.8.2 Respiratory rate of cattle

Respiration is the act of breathing, or more specifically, the acts of taking in oxygen, using it in the body tissues and giving off carbon dioxide (Gaughan, Holt, Hahn, Mader, & Eigenberg, 2000; Babayemi *et al*., 2014). Respiration consists of inspiration, or the expansion of the chest or thorax and expiration, or the expulsion of air from the lungs. The respiratory system is frequently subjected to primary and secondary disease, so stock owners must consider the area affected when an animal is not normal. Many diseases that affect all classes of farm animals eventually spread and settle in areas of the respiratory system. In examining respiration in an animal, check movement and sound at the nostrils and in the chest area (Babayemi *et al*., 2014). Give attention to the following factors: Rate (number of inspirations per minute), Depth (the intensity or indication of straining) and character (normal breathing involves an observable expansion and relaxation of the ribs (costa) and abdominal wall.

Any interference in breathing that may show more or less effort in either of these areas affects the character of the breathing (Gaughan *et al*., 2000). Rhythm (change in duration of inspiration and expiration), Sound (normal breathing is noiseless except when the animal is exercising or at work). Snuffling, sneezing, wheezing, rattling, or groaning may indicate something abnormal, dyspnea (labored or difficult breathing). Variations in rate of respiration can be caused by many factors including body size, age, exercise, excitement, environmental temperature, atmospheric conditions, pregnancy, and fullness of the digestive tract. If variations in respiration rates are encountered and environmental conditions are suspected as being a possible cause, it is a good idea to check the rate of two or three other animals for comparative purposes (Gaughan *et al*., 2000).

In observing the respiratory system of an animal, begin at the nostrils and work rearward. Note anything abnormal in respiration, breath, nasal discharge, nasal cavities, sub-maxillary lymph nodes, cough, larynx and trachea, surface of thorax (chest), and auscultation of thorax (sounds in chest) (Babayemi *et al*., 2014). Although the average stock owner is neither trained nor equipped to examine all these areas, he can make some intelligent observations concerning many of them. Respiration rates (RR) are taken by manual observation (using a stopwatch, counting uninterrupted flank movements, and by using a stethoscope (Gaughan *et al.*, 2000).

2.8.3 Pulse rate of cattle

The pulse may be defined as "the rhythmic, periodic thrust felt over an artery in time with the heartbeat." The important factors to note in taking the pulse are frequency, rhythm and quality (Hopster & Blokhuis, 1994; Babayemi *et al*., 2014). Frequency is determined by counting the number of heartbeats occurring in one minute by using a stethoscope. Rhythm typifies a normal pulse seen in a series of rhythmic beats that follow each other at regular intervals. Quality is best described as the tension on the arterial wall; it is an indication of the volume of blood flow (Ameen, Joshua, Adedeji, Ojedapo, & Amao, 2010). Pulse rates could be palpated in superficial arteries when they are in soft tissue and can be pressed against a hard or bony structure. To determine the rate accurately, count the pulse for one full minute. Judge the rhythm and quality by alternating pressure on the artery for another full minute (Hopster & Blokhuis, 1994).

The pulse in cattle and horses could be felt in approximately the same location: where the external maxillary artery crosses the lower edge of the mandible, just in front of the masseter muscle. In horses, pulse might also be taken on the inside of the forearm (radial bone) where the radial artery travels down the bone. In sheep and goats, the saphenous artery, which runs down the inside of the hind leg, is the most accessible location (Hopster & Blokhuis, 1994). In swine, the pulse cannot be felt at all. With this animal, the heart itself must be palpated directly. The normal pulse frequency varies in different species and individual animals. Age, size, sex, breed, atmospheric conditions, time of day, exercise, eating, and excitement are all factors that influence variations in the pulse rate as described by Hutchinson, Brown, and Allen (1976) and John *et al*. (2013). Heart rates are measured by feeling the pulse, listening to heart tones, electrocardiogram (ECG), Polar Sport Tester (PST) and telemeter methods (Ameen *et al*., 2010).

The heart frequency, which tells how animals feel, could also be analyzed by using an implanted transmitter and the animal's heart rate and temperature can be recorded by using a special receiver (Hopster & Blokhuis, 1994). The heart rate could be affected also by the measuring equipment and by the manner of measuring (Hopster & Blokhuis, 1994).

2.9 Cattle Hematological Parameters

Hematology is the study of numbers and morphology of cellular elements of blood such as the red cells (erythrocytes), white cells (leucocytes) and the platelets (thrombocytes). Hematological studies are of ecological and physiological interest in helping to understand the relationship of blood characteristics to the environment (Ovuru & Ekweozor, 2004) and so could be useful in the selection of animals that are genetically resistant to certain diseases and environmental conditions (Mmereole, 2008; Isaac, Abah, Akpan, & Ekaette, 2013). The blood examination gives the opportunity to investigate the presence of several metabolites and other constituents in the body of animals and it plays a vital role in determining the physiological, nutrition and pathological status of an organism (Aderemi, 2004; Doyle, 2006). According to Olafedehan *et al.* (2010) blood examination for their constituents can provide important information for the diagnosis and prognosis of diseases in animals. Blood constituents change in relation to the physiological conditions of health (Togun *et al.*, 2007). These changes are of value in assessing response of animals to various physiological situations (Khan & Zafar, 2005).

According to Afolabi, Akinsoyinu, Olajide, and Akinleye (2010), changes in hematological parameters are often used to determine various status of the body and to determine stresses due to environmental, nutritional and/or pathological factors.

Hematological investigation has gained a global popularity as a prime diagnostic and management tool in veterinary practice. It ascertains the physiological, nutritional and pathological status of an animal and helps distinguish the normal state from the state of stress, which can be nutritional, physical or environmental (Aderemi, 2004). The value of hematological parameters in the evaluation of the physical and health status of animals and birds (Zvorc, Mrljak, Susic, & Gotal, 2006), the diagnosis, prognosis, treatment and prophylaxis of many livestock diseases (Klinkon & Zadnik, 1999) has been well stressed.

The hematology of indigenous cattle and other livestock species have been well investigated (Oladele, Ogundipe, Ayo, & Esievo, 2001a; b). Similarly, the hematology of some of these species has been investigated in important livestock diseases such as trypanosomosis (Bawa *et al.*, 2005). Investigation has also been made into the hematology of exotic cattle and their crosses with Zebu under the tropical conditions (Saror & Coles, 1975).

2.9.1 Blood collection, management and analysis

In many studies, blood is usually obtained from various veins of animals such as jugular, saphenous, tail, wing, abdominal and pineal into sample bottles. Two methods are applicable in determining the concentration of cells in suspension: total and differential cell counts. The total measures the total number of all types of cells in a unit volume of fluid, while the differential measures the number of given type of cell either as a proportion of the whole cell population or as an absolute number per unit volume (Coles, 1974). Blood samples that are either used for laboratory analysis or blood transfusion are usually anti-coagulated. Recommended anticoagulants are ethylene-diamine-tetra-acetate (EDTA), oxalate and heparin (Coles, 1980).

EDTA has the advantage of preserving cells as well as their stainability and morphological characteristics, but care must be taken not to exceed the recommended level as excess of it adversely affect the determination of Packed cell volume (PCV). Packed cell volume decreases when EDTA is present in excess, because of cell shrinkage (Penny, Carlisle, Davidson, & Gray, 1970; *Coles*, 1980). For reliable hematological data, blood sample should be stored at refrigeration temperature (4^0C) for short time. In over stored blood, there is the tendency for red blood cells (RBC) to swell and haemolyse, while the white blood cells (WBC) undergo alteration in morphology and lyses (Schalm, Jain, & Carol, 1975).

Storage of blood with EDTA in a refrigerator at (4^0C) for 24 hours produced little effect on the PCV of bovine blood (Fisher, 1962). The tendency of RBC to swell slowly after 24 hours of storage and by six days of storage leading to about 7 - 10% increase in PCV also increases the tendency of haemolysis (Penny *et al.*, 1970). Complete haemolysis will start to occur in a sample on days 28 and 17 in all samples on days 41 and 24 in blood with EDTA and oxalate anticoagulants respectively (Igbokwe & Sanu, 1992). Swelling of the RBC depends on the cell membrane permeability and elasticity and the failure of bovine RBC to swell may probably be due to its peculiar cell membrane properties.

Red blood cell (RBC) and white blood cell (WBC) counts could be determined using a haemocytometer. The PCV could be estimated by the microhaematocrit method and the hemoglobin (Hb) concentration by the cyanmethaemoglobin method. The mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) are calculated from the Hb, PCV and RBC values (Jain, 1986). In more recent studies, red blood cell counts, total white blood cell counts, hemoglobin, packed cell volume, MCV, MCH and MCHC are determined by an automated hematological analyzer (Coulter SPKS, PCL holding company, Germany)

(Matwichuk, Taylor, Shmon, Kass & Shelton, 1999; Aengwanich, Daungduen, Pamok, & Suppaso, 2007; Farooq, Ijaz, Ahmad, Rehman, & Zaneb, 2012).

Blood smear is used with Wright-Giemsa in differential WBC count (Matwichuk *et al*., 1999; Aengwanich *et al*., 2007). Blood samples are also analyzed for Hb, total erythrocyte count (TEC), PCV, total leukocyte count (TLC) and differential leukocyte count (DLC) using an automated hematology analyzer (Sysmex K21, Kobe, Japan) which is off-hand calibrated with human and bovine blood using multiple samples.

2.9.2 Red blood cells (RBC)

Red blood cells (erythrocytes) serve as a carrier of hemoglobin. This hemoglobin reacts with oxygen carried in the blood to form oxyhaemoglobin during respiration (Johnston & Morris, 1996; Chineke, Ologun, & Ikeobi, 2006). According to Isaac *et al.* (2013) since red blood cell is involved in the transport of oxygen and carbon dioxide in the body a reduced red blood cell count implies a reduction in the level of oxygen that would be carried to the tissues as well as the level of carbon dioxide returned to the lungs (Ugwuene, 2011).

The quality and amount of red blood cells in the animal's body depend on the nutrient availability, state of health, physiological status of such animal (Soetan, Akinrinde, & Ajibade, 2013). Animals in sound health that are provided with good feeding, environmental conditions and other management welfare would always have a good amount of RBC (Isaac *et al,* 2013). Isaac *et al.* (2013) also reported that cattle of good hematological composition are likely to exhibit better performance and productivity. Studies conducted by Olayemi, Nwandu, and Aiyedun (2007) reported the red blood cells of Sokoto Gudali and White Fulani cattle to be 9.63 and 8.63 × 10^6mm^3 respectively, while Aiello and Mays (1998) reported 5 to 10× 10^6mm^3 to be within the normal values.

2.9.3 Packed cell volume (PCV)

Packed Cell Volume which is also known as haematocrit (Ht) or erythrocyte volume fraction (EVF) is the percentage (%) of red blood cells in blood (Purves, Sadava, Orians, & Heller, 2003). According to Isaac *et al.* (2013) PCV is could be used to understand the transport of oxygen and absorbed nutrients in the blood. Increased PCV shows a better transportation and thus results in an increased primary and secondary polycythemia (Ndlovu *et al*., 2007). Furthermore, Chineke *et al.* (2006) posited that high PCV reading indicated either an increase in number of Red Blood Cells (RBCs) or reduction in circulating plasma volume. It is the most accurate means of determining red blood cell volume and can be used to deduce total blood volume and hemoglobin levels.

According to Coles (1974) since PCV is the proportion of blood volume occupied by cells, blood cell counts have major clinical, diagnostic, nutritional and environmental significance; indicating loss, destruction or under production of cells (e.g. in leucopenia or anemia), as unusual demand for cells as in leukocytosis or neoplastic proliferation as in leucosis. Farooq *et al*. (2012) reported mean PCV value of Cholistani breeding bulls in Pakistan to be 37.18%, while Jain (1998) reported PCV range of 24 - 46% for cattle. Their results were in line with the work of Aengwanich, Chantiratikul, and Pamok (2009), who reported a mean PCV of 36.50% for crossbred male beef cattle in Thailand showing positive relationship with management and environmental conditions.

2.9.4 Hemoglobin concentration

Hemoglobin is the iron-containing oxygen-transport metalloprotein in the red blood cells. Decrease of hemoglobin, with or without an absolute decrease of red blood cells, leads to symptoms of anemia. Anemia has many different causes, although iron deficiency is the most common cause. As absence of iron decreases heme synthesis, hypochromic red blood cells (lacking the red hemoglobin pigment) and microcytic red blood cells (smaller than normal) (Kneipp *et al*., 2006). Hemoglobin has the physiological function of transporting oxygen to tissues of the animal for oxidation of ingested food so as to release energy for the other body functions as well as transport of carbon dioxide out of the body of animals (Ugwuene, 2011; Omiyale, Yisa, & Ali-Dunkrah, 2012; Soetan *et al.,* 2013; Isaac *et al.,* 2013).

According to Peters *et al*. (2011), previous reports stated that PCV, hemoglobin and mean corpuscular hemoglobin are major indices for evaluating circulatory erythrocytes, and are significant in the diagnosis of anemia and also serve as useful indices of the bone marrow capacity to produce red blood cells as in mammals (Awodi, Ayo, Atodo, & Dzende, 2005; Chineke *et al.,* 2006). Mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration indicate blood level conditions. A low level is an indication of anemia (Aster, 2004). Olayemi *et al*. (2007) reported the Hg of Sokoto Gudali and White Fulani cattle to be 11.18 and 9.31, MCV of 38.20 and 43.58, MCH of 12.36 and 11.66, MCHC of 32.42 and 26.28 respectively. In similar studies, RAR (2009) reported normal Hg reference values of cattle to be 8 to 15g/dl, MCV (40 to 60 fl), MCH (11 to 17pg) and MCHC (30 to 36 g/dl), while Aiello and Mays (1998) reported Hg (10 to 15), MCV (39 to 55), MCH (13 to 17) and MCHC of 30 to 36 which are directly propositional to feeding, health care delivery and environmental management.

2.9.5 White blood cells (WBC)

The other major type of blood cells are the white blood cells (WBC), which are also referred to as leukocytes (Iwuji & Herbert, 2012; Isaac *et al.,* 2013). For every leukocyte present in a sample there will normally be 600 to 700 RBC. The major functions of the white blood cells are to fight infections, defend the body by phagocytocis against invasion by foreign organisms and to produce or at least transport and distribute antibodies in immune response. Thus, animals with low white blood cells are exposed to high risk of disease infection, while those with high counts are capable of generating antibodies in the process of phagocytocis and have high degree of resistance to diseases

(Soetan *et al*., 2013) and enhance adaptability to local environmental and disease prevalent conditions (Kabir, Akpa, Nwagu, Adeyinka, & Bello, 2011; Okunlola, Olorunisomo, Aderinola, Agboola, & Omole, 2012). RAR (2009) reported normal WBC value of 4 to 12 × 10^3 as function of good and proper management practices.

2.9.6 Blood metabolites

To develop organized markets for promoting indigenous cattle products, there is need to develop parameters that objectively assess nutritional and health status of the animals, while they are still growing. For example, there is need to determine desirable breeds that maintain the least blood cholesterol levels (Ndlovu *et al*., 2007). Breed differences and genetic variation within breeds in rate and efficiency of growth, disease resistance and tolerance, and meat quality can be assayed using blood metabolites so as to establish genetically superior animals adapted to harsh environmental conditions. Although body weight measurement and body condition scoring are easier to perform and are cheaper to determine, they have limitations that could be complemented by the use of blood metabolites and hematology.

Metabolite profiling provides useful information such as the occurrence of negative energy balance, under nutrition and the presence of disease. These profiles need to be established in animals destined for sale or export, as they also determine the quality of the meat produced. Similarly, frequent monitoring of blood parameters, for example once in every season, assists in diagnosing metabolic problems and determining animals that are metabolically superior on veldt or to identify animals that require supplementary feeding (Otto, Baggasse, Bogin, Harun, & Vilela, 2000).

In practice, metabolite herd testing has a number of constraints that need to be overcome. The major challenges include highly skilled labor required for blood sampling, availability of sampling ingredients, expertise in processing and storing blood and, perhaps, the most important, the high cost of analyzing the samples. There is, for example, need to use friendly and appropriate techniques for restraining and bleeding that minimize stress. Appropriate infrastructure, such as strong cattle handling facilities is also needed. Many pastoral communities lack such facilities. Communities and the farmers, thus, need to be educated on the need for determination and application of blood parameters as a tool to aid beef cattle management. This should destroy the generally held myth that animals are only handled when they are clinically sick or when they ready for slaughter. Such costs of analyzing for blood samples are however, in most cases, beyond the reach of many farmers, especially the resource-limited farmers in rural areas.

Again, blood metabolite concentrations represent an integrated index of the adequacy of nutrient supply in relation to nutrient utilization of cattle (Chester-Jones, Fontenot, & Veit, 1990). They give an immediate indication of an animal's nutritional status at any point in time (Pambu-Gollah, Cronje, & Casey, 2000). In the dairy industry, the use of metabolic profiles for assessing the nutritional and health status of cows is widespread (Doornenbal, Tong, & Murray, 1988; Grunwaldt *et al*., 2005).

(a) Blood glucose: Blood glucose, hydroxyl butyrate and non-esterified fatty acids are the most common metabolites used to assess the energy status of cattle (Ndlovu *et al*., 2007). Blood glucose has a moderate diagnostic value in the assessment of nutritional status of cattle as it varies moderately in blood. Insufficient nutrient intake can reduce circulatory glucose and cholesterol levels. In conditions of under nutrition, the blood levels of propionate and other precursors derived from the diet decreases, thus, causing a reduction in the rate of glucose synthesis (Reynolds, Aikman, Lupoli, Humphries, & Beever, 2003).

Glucose levels in calves were lower than those of mature animals (Doornenbal *et al*., 1988). In growing animals, glucose requirement is determined by growth rate, which is set by metabolizable energy intake (Reynolds *et al*., 2003), whereas in mature animals only maintenance energy is required. The physiological status of an animal also affects the glucose concentration (Otto *et al*., 2000). Glucose concentrations were higher in non-pregnant and non-lactating cows as compared to lactating cows due to the high energy demand in lactating cows for milk production. Previous studies have shown that the percentage of total glucose supply oxidized is reduced in lactating compared to dry cows and tissue utilization of glucose decreases while there is an increase in use of lipid for energy (Reynolds *et al*., 2003).

Grunwaldt *et al*. (2005) reported an effect of season on glucose levels shown by a significant increase in blood glucose levels in autumn (February) as compared to summer (May). Glucose levels decrease with an increase in body temperature and respiration rate of animals normally experienced in hot summer season. Feed quality also affects blood glucose levels. For example, Chimonyo *et al*. (2000) observed a significant reduction of the levels of plasma glucose in winter in cows.

(b) Blood protein: At present there is no single metabolite that could be measured, which directly reflects protein status. As a result, a combination of parameters needs to be utilized, including blood urea nitrogen (BUN), creatinine, and total protein, albumin, and creatinine levels. Albumin and total protein have low variability in blood. As a result they both have a high diagnostic value in the assessment of nutritional status as compared to creatinine which has low diagnostic value due to its high variability in blood. Serum albumin is a very sensitive and early nutritional indicator of protein status (Agenas *et al*., 2006) because its turnover is only 16 days. Deficiency of protein impairs both humoral and cell mediated immunity, thus predisposing an animal to diseases (Titgemeyer & Loest, 2001).

Total protein levels are lower in young animals and higher in mature animals, whilst albumin levels are lower at birth and then increases (Doornenbal *et al*., 1988; Otto *et al*., 2000). Total protein and albumin reflect availability of protein and their concentration decline in the face of protein deficiency. Total protein levels were low in non-pregnant non-lactating cows (Otto *et al*., 2000).

(c) Blood lipids: Lipids are of importance in the assessment of nutritional status of cattle and include non-esterified fatty acids, cholesterol, hydroxyl butyrate and lipoproteins. There is low variability in the blood levels of non-esterified fatty acids as compared to cholesterol which has moderate variability. Non-esterified fatty acids therefore have a high diagnostic value in the assessment of nutritional status as compared to cholesterol. The reason for moderate variability of cholesterol is probably attributed to its metabolic variation with the blood glucose levels. Effect of season on cholesterol levels is also not clear. Elevated levels of cholesterol, triglycerides and phospholipids are indicative of copper deficiency. The essential nature of copper is due to its cofactor role at the active site of a number of enzymes (Engle & Spears, 2000).

Non-esterified fatty acids (NEFA) are released into the circulation as a direct result of lipid catabolism. Their concentrations are commonly used in assessing energy status of dairy cows. Mayes (2000), Adewuyi, Gruys, and van Eerdenburg (2005) and Chimonyo *et al*. (2000) observed elevated NEFA levels in undernourished cows that were used for draught power. High NEFA values result in either elevated ketones or fat production by the liver (Oikawa & Katoh, 2002). Associated with fat in the very low density lipoproteins (VLDL) structure is a substantial amount of cholesterol. As a result, it has been suggested that NEFA to cholesterol ratio is more appropriate in assessing the energy status of animals.

Serum NEFA concentrations are more sensitive to changes in energy balance than body condition scoring in transition cow situations. Hydroxybutyrate (BHB) and NEFA elevated concentrations indicate short-term negative energy balance and adipose tissue catabolism (Reist *et al*., 2002; Agenas *et al*., 2006). At present, measurement of beta-hydroxybutyrate concentration is most commonly used. However, beta-hydroxybutyrate concentrations may not be sensitive enough and can come from dietary sources (Agenas *et al*., 2006).

(d) Urea nitrogen: No marked age differences have been detected in albumin levels (Otto *et al*., 2000). Dietary protein nutrition or utilization and the associated effects on ovarian or uterine physiology have been monitored with urea nitrogen in plasma. Concentrations above 19 mg/dl have been associated with altered uterine pH and reduced fertility in dairy cows (Butler *et al*., 1998). Monitoring of blood urea levels could be used for measuring protein status in cattle from different feeding regimes and seasons (Hammond, 2006). Values for urea within the optimum range (<3.6 mmol/l) in cattle indicate that the effective rumen degradable protein (ERDP) is adequate. High blood urea levels could indicate a high protein intake or the excessive mobilization of muscle (Chimonyo, Hamudikuwana, Kusina, & Ncube, 2002). In ruminants a decrease in the blood urea concentration is related to low dietary intake of protein due to the recycling of urea from blood back to the rumen when dietary protein intake is low (Oulun, 2005). Grunwaldt *et al*. 2005 observed similar levels of urea nitrogen in summer and in autumn.

The most common application of the use of blood urea nitrogen is as a retrospective diagnostic tool to analyze biological responses to protein or energy supplementation, change in pasture or forage on offer, or change in pasture management (Hammond, 2006). Serum urea concentration may also increase despite low-protein feeding if energy intake is restricted, which is thought to reflect increased breakdown of endogenous proteins for energy production, a decrease in renal re-absorption of urea and/or hemo-concentration (Oulun, 2005). High dietary protein (nitrogen) intake resulting in blood urea nitrogen of greater than 19 to 20 mg/dl has been associated with an altered uterine environment and decreased fertility (reduced conception rate, decreased pregnancy rate) in lactating dairy cows and heifers (Elrod & Butler, 1993; Butler *et al*., 1998).

(e) Creatinine: Creatinine, a by-product of the breakdown of creatinine and phosphor creatinine in muscle, is most commonly used as an indirect indicator of renal function and its impact on blood urea nitrogen. Serum creatinine concentrations vary due to an animal's diet, breed, muscle mass and sex (Otto *et al*., 2000; Miller, LeRoy, Tarpley, Bain, & Latimer, 2004; Hammond, 2006). Grunwaldt *et al*. (2005) also showed lower creatinine levels during the summer than in autumn. Reduced concentrations of creatinine indicate prolonged active tissue protein catabolism (Agenas *et al*., 2006). An increasing muscle mass from animal walking long distances in search of pasture can increase serum creatinine levels (Otto *et al*., 2000).

2.10 Serum biochemical constituents

Determination of biochemical constituents of serum can provide valuable information in respect to nutrition, sex, age and physiological and health status of the animal (Osman & Al-Busadah, 2003). It is a well known fact that variations exist in biochemical constituents with regards to sampling procedure, analytical technique, physical factors, environmental conditions and variation in species and breeds (Beaunoyer, 1992). The knowledge about normal values of biochemical variables in blood serum and other physiological variables of cattle is important for assessment of damage of organs and tissues in different diseases and for assessment of developmental stages as well as welfare of the animal (Otto *et al*., 2000).

2.10.1 Serum enzymes

Information from the literature has revealed considerable differences in the activity of enzymes. There are also considerable differences between reference values of enzyme activity claimed by different authors. Enzymes are very sensitive indicators of cell damage; their activities are changed by tiny alternations so that enzyme activity could differ between single animals resulting in different results between studies. Reasons for these differences are partly differences between breeds and breeding conditions where the results were obtained. Analytical procedures and temperatures at which the activity of enzymes was measured also influence results. In majority of literature the mentioned analytical procedures are deficiently described, so it is very difficult to compare the data, because it is not clear at which temperature the activity of enzyme was measured (Otto *et al*., 2000).

(a) The enzyme Aspartate Aminotransferase (AST): AST is present in different tissues of animals and is a sensitive indicator of soft tissue damage (Otto *et al*., 2000). In heart and skeleton musculature as in liver, there is high activity of AST. The AST is present in cytoplasm and in mitochondria so its activity is increased chiefly by cell necrosis in smaller amount also by damage of the cell membrane (Kraft & Dürr, 1999). Measuring of AST activity in combination with creatinine kinase (CK) is used for diagnostics of muscle damage (Kaneko, 1997). There is also high activity of AST in the liver, therefore, in the case of liver damage, AST activity in the serum increases.

Liver enzymes have low diagnostic value for nutritional status due to their high blood variability. Red blood cells contain AST which can leak into plasma before there is any visual evidence of haemolysis (Abutarbush & Radostits, 2003). Many conditions that produce a significant rise in creatinine kinase (CK) activity will also produce elevated to high levels of AST (Abutarbush & Radostits, 2003). Vitamin E and selenium deficiency in the diet causes nutritional muscular dystrophy and diagnosis is usually based on elevated levels of the muscle enzymes, CK and AST (Abutarbush & Radostits, 2003). Vitamins C, E and selenium are important in the protection of cellular membranes from free radicals that cause peroxidation of the membrane lipids (Abutarbush & Radostits, 2003; Karakilc, Hayat, Aydilek, Zerin, & Cay, 2005).

In healthy cows, the serum enzyme activity is low or absent. Neither seasonal nor physiological variations have been reported on AST (Yokus & Cakir, 2006). In contrast, there are higher AST levels during the rainy season than in the dry season (Ndlovu *et al*., 2007). More significantly, Grunwaldt *et al*. (2005) observed breed differences in ALT levels, where the Criollo Argentino had almost twice the amount of ALT as compared to that of Aberdeen Angus cows.

In calves, after first colostrum intake the AST activity in serum increased from 23 U/L before intake, to 38 U/L at the age of 3 hours. This is most likely due to absorption from colostrum or because of activation of enzymes in calf intestine because of colostrum intake (Kurz & Willet, 1991). However, Hammon and Blum (1998) established that in calves that received only milk replacer instead of colostrum, activity of AST increased on the second day after birth so they are of the opinion that other factors may be influencing the increased activity of some enzymes. Specifically, the activity of AST decreased after the first week, and from 42nd to 84th day of life it increased slowly (Egli & Blum, 1998). Mohri, Sharifi, and Eidi (2007) also observed increase of AST activity from the 14th to the 84th day of age.

(b) Alkaline Phosphatase (ALP): For a long time the enzyme Alkaline Phosphatase (ALP) has been used in diagnostics as indicator of liver damage. The ALP is important also in diseases of skeleton and is usually found in the intestine, liver, kidney and bones. In serum of young fast growing animals isoenzyme from bones predominates, while in older animals that grow slower, the activity of ALP is reduced (Kaneko, 1997). Serum activity of ALP is thus higher in young animals than in adult ones and it decreases with age. After first colostrum intake serum activity of ALP increased from 235 U/L before intake to 364 U/L at the age of 3 hours, most likely due to absorption from colostrum and activation of enzymes in the calf's intestine resulting from colostrum intake (Kurz & Willet, 1991). The activity of ALP was highest in calves after birth, then decreased and remained stable to the age of 60 days, after which it decreased slightly more (Knowles *et al*., 2000). In calves to the age of 6 months the activity of ALP can reach 1800 U/L, while in young cattle to the age of 3 years it has been shown to decrease to 500 U/L (Kraft & Dürr, 1999).

In adult animals activity of ALP can increase with increased activity of osteoblasts. Activity of ALP is also increased during acute and chronic liver diseases (especially cholestatic hepatopathias) and in diseases of bones (rachitis, periostitis).

(c) Alanine aminotransferase (ALT): ALT activity in cattle is not specific for the liver, in order to have a diagnostic significance (Kramer & Hoffman, 1997). Serum ALT has been reported (Otto *et al.*, 2000; El – Sherif & Assad, 2001) to be affected by physiological status of cattle. ALT activity in the blood plasma is also influenced by age and muscle activity (Weigert *et al.*, 1980). The serum ALT creates the structural components of the body of the fetus in pregnant animals, hence is important for pregnancy. According to Milinkovic-Tur, Peric, Stojevic, Idelar-Tuk, and Pirsljin (2005), the activities of ALT in the blood is associated with implantation, embryo survival, growth, uterine carbohydrate metabolism, amino acid metabolism and glycogen deposition. Adedibu, Opoola, and Jinadu (2013) reported serum ALT of lactating and non lactating cows to be 28.70 and 28.40IU/L in Zaria, Kaduna state, respectively.

(d). Creatinine kinase (CK): The highest activity of creatinine kinase (CK) is in the skeleton and heart musculature. Measuring of the activity of CK in serum is first of all used for diagnostics of skeletal musculature damage. The activity of CK could be increased also after effort, long-lasting lying of the animal or convulsions. Miopathias as a consequence of vitamin E and Selenium deficiency which usually appear in veal animals (calves, lambs), sometimes also in adult animals, have been found to cause increased activity of CK (Smith, Fry, Allen, & Costa, 1994).

The activity of CK in calves is high after birth but later it decreases rapidly and stabilized by the age of 60 days, but may be increase slightly by 80 day of age (Knowles *et al.*, 2000). The mean activity of CK in calves of Simmental breed was 11.2 ± 2 μkat/L (671.8

± 119.9 U/L) at birth then it decreased to at age of 7 days and remained at that level upto the age of 42 days, and thereafter increased upto the 84th day to read 21.3 ± 10.7 μkat/L (1277.7 ± 641.8 U/L) (Egli & Blum, 1998). Increased activity of CK after birth has been associated with parturition and adaptation to the stress of extra uterine life. The increasing of CK activity with age has also been attributed to the growth and gaining of muscle mass and partly to the increased activity of the calves. At this age they are in group pens where they have enough space for movement.

(e) Gamma – glutamyl Transpeptidase (GGT): The highest activity of gamma – glutamyl transpeptidase (GGT) is in bile ducts epithelium and in kidney. The enzyme is found in membrane structures of the cells. The increased serum activity of GGT is usually associated with cholestasis and bile ducts damage. Very high activity of GGT is also in colostrum of cattle, sheep and goats. Hammon and Blum (1998) measured colostrum GGT in cows and found mean activity to be 22.432 U/L. After colostrum intake, the enzyme is absorbed through intestinal wall; consequently the GGT activity is increased at this period and can be used for indirect estimation of colostrum supply (Bostedt, 1983). The GGT activity in newborn calves was 10-31 U/L, after colostrum intake it increased to 370-5000 U/L, then it slowly decreased to the age of 20 days when it stabilised (Braun *et al*., 1982). In calves that received only milk or milk replacer instead of colostrum, the GGT activity did not increase (Boediker, 1991). In the first week of life GGT activity was high later it decreased rapidly (Knowles *et al*., 2000; Egli & Blum, 1998).

The GGT activity below 100 U/L at the age of 2 days indicates insufficient colostrum supply or disturbed absorption (Klee, 1985). Tyler *et al*. (1999b) claimed that activity of GGT above 50 U/L in the calves serum indicate sufficient colostrum supply, while Perino, Sutherland, and Woollen (1993) stated that 200 U/L should be regarded as the boundary value.

(f) Lactate Dehydrogenase (LDH): Enzyme lactate dehydrogenase (LDH) catalyses reversible oxidation of pyruvate to lactate. The enzyme is present in numerous organs and tissues. The activity of LDH in calves increases slowly in the first 24 hours of life, from 421 U/L immediately after birth to 759 U/L at the age of 24 hours. This increase is more likely a physiological event than due to absorption from colostrum (Kurz & Willet, 1991). The LDH activity increased slowly to the age of 56 days and thereafter remained at the same level upto the age of 84 days (Egli & Blum, 1998). Egli and Blum (1998) reported much high LDH activity in calves, probably due to measuring procedure since the activity of LDH is measured by reaction of transformation pyruvate to lactate, which can expire in both directions.

2.10.2 Serum electrolytes

To promote normal tissue growth, homeostasis, enzyme function, cell regulation and immune function, it is imperative that minerals be maintained within normal concentrations in the body (Underwood & Suttle, 1999). Minerals play vital roles in forage digestion, reproductive performance and the development of bones, muscle and teeth. Sub-clinical trace mineral deficiencies occur more frequently than recognized by most livestock producers (Underwood & Suttle, 1999). Mahusoon, Perera, Perera, and Perera (2004) observed marked breed differences in mineral metabolism in goats. Mineral levels have been shown to vary with seasons (Yokus & Cakir, 2006), whereas Grunwaldt *et al*. (2005) showed no significant differences in autumn and summer for inorganic phosphate and calcium levels. Mineral absorption increases in the gastrointestinal tract, while mobilization is increased in the bones (Invartsen & Andersen, 2000).

Calcium, phosphorus and magnesium have high diagnostic value in determining the nutritional status of animals due to their low variability in blood. Calcium is the most abundant mineral in the body; approximately 98% functions as a structural component of bones and teeth (Ndlovu *et al*., 2007). The remaining 2% is distributed in extracellular fluids and soft tissues, and is involved in such vital functions as blood clotting, membrane permeability, muscle contraction, transmission of nerve impulses, cardiac regulation, secretion of certain hormones and activation and stabilization of certain enzymes, whereas phosphorus on the other hand is involved in every metabolic reaction and energy transfer within the body (Invartsen & Andersen, 2000). Phosphorus is required for normal milk production, growth and efficient use of feed and by the rumen microorganisms in the digestion of cellulose and synthesis of microbial protein (Ndlovu *et al*., 2007).

Physiological status affects calcium levels in cattle, where highest levels were obtained in non-pregnant and non-lactating dairy cows (Otto *et al*., 2000). Season was also reported to have no effect on inorganic phosphate and calcium levels (Yokus & Cakir, 2006). Magnesium is an essential cation involved in many enzymatic reactions as a cofactor to adenosine triphosphatases. It is critical in energy-requiring metabolic processes, in protein synthesis, membrane integrity, nervous tissue conduction, neuromuscular excitability, muscle contraction, hormone secretion and in intermediary metabolism (Laires, Monteiro, & Bitcho, 2004). Serum magnesium concentration is maintained within a narrow range by the small intestine and kidney, which both increase their fractional magnesium absorption under conditions of magnesium deprivation (Ghamdi *et al*., 1994). If magnesium depletion continues, the bone store helps to maintain serum magnesium concentration by exchanging part of its content with extra cellular fluid (Laires *et al*., 2004). In dairy cows, magnesium levels are dependent on both physiological and seasonal variations (Yokus & Cakir, 2006). Serum magnesium levels reflect current daily intake rather than reserves, thus cattle are affected by low magnesium dietary content (Whitaker, Goodger, Garcia, Perera, & Wittwer, 1999). Grass tetany occurs when the level of magnesium in blood falls below a critical threshold (below 1.2 mg per 100 ml) (Herdt, Rumbeiha, & Emmett, 2000).

2.11 Cattle Health Care Delivery

Animal health is the condition of animal that enables it to attain acceptable levels of production within the farming system in which it is maintained (Etuk, Okoli, & Udedibie, 2005). Good health in animals will increase production efficiency, protection against epidemic diseases, and improvement of human health by safeguarding humans against zoonotic diseases (Tyler, 1990; Lindberg, 1995). Effective health care delivery is a key factor influencing the productivity of the livestock sector (Umali, Feder, & de Haan, 1994).

2.11.1 Cattle modern veterinary practices

Provision of properly coordinated veterinary services has improved the productivity of livestock greatly in recent years. However, the smallholder farmers who still dominate production in West Africa (and most of the developing world) have not found it easy to adapt to the mode of operation of these services, mostly because of the cost implication and accessibility problems (McCorkle, 1995; Okoli *et al*., 2002). Thus, farmers and herders may only access veterinary services as a last option, especially when all others have failed. This was amply exemplified in Bolivia by van't Hooft (2003) when she described two basic livestock-keeping strategies: diversified livestock keeping and specialized keeping. In the former, health care is based on local practices and medicine embodied in the IK systems of the people, sometimes complemented with selected "modern practices" (Schilihorn van Veen, 1991).

It has been severally highlighted that in most West African countries, orthodox animal health care is plagued many problems, which include inadequate manpower and logistics, scarce and erratic supply of veterinary drugs and supplies, high cost of said drugs and services. poor infrastructure, and counterproductive government policies that do not complement the development of alternative and indigenous medicine (Adekunle, Oladele,

& Olukaiyeja, 2002; Hounzanghe-Adote, 2004; Hounzangbe-Adote, Moutairou, & Hoste, 2005). The relationship between these problems and the current dependence on orthodox veterinary medicine has resulted in a failure to solve the majority of animal health problems in the subcontinent. The IK of livestock owners, however, forms the foundation for and complements the success of all sustainable animal health care programs in developing countries. It is only recently that orthodox veterinarians and other scientists have begun to recognize the fact that livestock owners have holistic understanding and approach in dealing with diseases and other livestock production problems.

The demand for veterinary services by Fulani pastoralists has been determined in Sokoto and Zamfara States in north-western Nigeria (Ogungbile, 2000). The findings showed that herders' response to veterinary service cost was relatively inelastic, although the small-scale herders responded slightly more than the large-scale herders. The inelastic response to service cost is an indication of willingness by the herders to pay for veterinary services (Ogungbile, 2000).

A consequence of this has been that after an initial period of suspicion, pastoralists have generally adopted modern veterinary medicine with enthusiasm. The result has been a major socio-economic transformation that essentially sabotages the notion of a traditional pastoralist. Vaccinations and drugs allow pastoralists to increase the size of their herds and to expand into regions that were previously closed to them (Blench, 1994; Boutrais, 1995). Fixed veterinary services have reduced pastoralists' flexibility to move their herds, placing greater stress on areas near where services are provided (Bovin & Manger, 1990). Unprecedented pressure was placed on feed and water resources, and stock that would have died in previous conditions was kept alive, creating large herds of poorly fed animals that often harbored sub clinical pathogens.

A major problem has been that when internationally organized campaigns against epizootics have ended, the normal veterinary infrastructure has been unable to supply a service of similar quality, and pastoralists then become desperate for medicines. This usually stimulates the development of an extensive black market in drugs, many of which have expired and some of which are blatant fakes, with potentials of causing havoc in pastoral herds.

Nonetheless, over recent years there have been considerable improvements in the techniques of reaching remote pastoral communities with veterinary services. The most important of these is the training of "paravets" who can treat minor ailments, recognize epizootic conditions and major traumas and alert the veterinary authorities. Such programmes are in operation in Ethiopia, Kenya, Somalia, Uganda, Chad, the Central African Republic and Mali, where they are achieving varying degrees of success (Catley & Walker, 1997). In addition, in some countries, traders and private vets are making drugs available in remote areas and treating animals. This has the advantage of providing some service where the government may provide none, but the obvious drawback is that there is no control over the quality and dosage of drugs. Pastoralists are increasingly taking control of the medication of their herds and are thus forced to make choices based on a very concrete appreciation of the economics of using drugs versus the value of an individual animal.

However, the limited effectiveness of traditional veterinary systems still keeps down herd size and, thus, pressure on resources. Veterinary programmes are usually initiated without any consideration being taken of their consequences for overall animal production (Konczacki, 1978). The medical aspect simply takes precedence, as it does in human medicine, and programmes are often self-perpetuating. When the impact on environmental resources is considered, there is usually also the hope that pastoralists will voluntarily destock, since their animals now have higher survival rates. The introduction of modern veterinary medicine therefore demands a whole new management system, as the nature of a major threat - disease - is thereby radically changed (Bernus, 1983). Herd maximization is justified by the argument that, if there are more animals to begin with, the impact of shock events will not be so devastating. However, when resource availability becomes the single most important factor that limits herd size, this argument breaks down: the more the animals, the greater the shock.

2.11.2 Ethno-veterinary practices in cattle production

Ethno veterinary medicine (EVM) is a scientific term for traditional animal health care that encompasses the knowledge, skills, methods, practices, and beliefs about animal health care found among community members (McCorke, 1986). According to Misra and Kumar (2004), EVM is the community-based local or indigenous knowledge and methods of caring for, healing and managing livestock. This also includes social practices and the ways in which livestock are incorporated into farming systems. The EVM knowledge has been developed through trial and error and deliberate experimentation.

Global awareness of the potential contribution of indigenous knowledge (IK) to sustainable development and poverty alleviation was recently heightened. Information originating from developing countries suggested that IK is playing important roles in many sectors of agriculture such as intercropping techniques, animal production. pest control, crop diversity, animal health care, and seed varieties as well as other forms of natural resources management (Anon., 2002). Because of this increased awareness and flow of information, academics, policy makers, and development practitioners have shown increasing interest in IK. For example, with modern ethno-botanical research, studies of the diversity of ruminant browses in southeastern Nigeria (Okoli *et al*., 2002; Okoli *et al*., 2003) and elsewhere in the sub-region (Bognounou, 1993; Hounzangbe-Adote, 2004; Hounzanghe-Adote *et al*., 2005; Tamboura, 2006) have yielded information of scientific promise on plants of ethno-veterinary importance.

Walter and Dietrich (1992) and Ba (1994) reported that traditional medicine still plays an important role in the nomadic life. It has been practiced since time immemorial because it was the only medical system accessible to the majority of farmers living in remote areas. According to these authors, traditional healers and pastoralists know a lot about the transmission and spread of animal diseases. Therefore, disease prevention plays an important role; for instance, traditional tick control involves avoiding places with high infestation of ticks and feeding of certain plants that make ticks fall off an animal. Furthermore, before leaving the enclosure in the morning, women and children pick ticks from the animals and throw the ticks into a fire burning near the entrance to the enclosure. Shady trees are deliberately avoided in case of tick infestation, while tick eradication by burning the infested pasture is widely practiced (Ba, 1994; Bary, 1998).

A silent revolution that is bringing back the previously neglected ethno-veterinary medicine and knowledge of indigenous people in addressing hitherto intractable animal health problems especially localized ones. According to Provost (1974), disease control should be based on the geographical area since vegetation zone also influences the kind of disease prevalent in an area. Theere is a large overlap between standard and indigenous veterinary practices, with many local practices having close equivalents in allopathic veterinary medicine. They therefore recommended that in the field, especially in the tropics, standard veterinary medicine and traditional practices should be complementary.

Pharmaceutical drugs are often more effective and convenient to use than traditional remedies, but the latter have the advantages that they are locally available and usually cheaper. In remote and inaccessible locations of the tropics, ethno-veterinary interventions are often the first line of defense against potentially crippling health problems (Agaie, Onyeyili, Muhammad, & Osunkwo, 2004). Thus, as stated, a strategic marriage of the two on a case-by-case basis could be a potentially successful tool in improving livestock productivity in the tropics (Etuk *et al*., 2005).

Furthermore, ethno-veterinary medicine lends itself easily to local adaptation and application. However, while efficacy of some traditional medicines has been validated (Bayala, 2005; Tainboura *et al*., 2004; Tamboura, Bayala, Lompo, Guissou, & Sawadogo, 2005), standardization of extracts and dosage regimes needs to be done. Based on this, health management needs to take cognizance not only of the production system and objectives but also of the prevalent IK when prescribing strategies in each locality. This is in agreement with the work of van't Hooft (2002), who stated that measures taken to reduce the mortality rate in diversified livestock keeping should be based on the strategies, the practices, and the knowledge of rural families, and that such measures should combine traditional and modern veterinary medicine.

Ethno-veterinary medicine differs not only from region to region but also among and within communities (Tamboura, 2006). The work division and professional specialization drive this variation, which may make men know more about large animals, while women may be more familiar with small animals or with certain types of diseases, such as gynecological, mastitis, and neonatal care. Hunters may have a wealth of information on hunting with dogs. In some parts of southeastern Nigeria where small ruminants are usually under permanent confinement, information on the diversity and utilization of indigenous browses has been found to reside mostly with women and children, who are traditionally saddled with the responsibility of collecting browses for the animals (Okoli *et al*., 2003). In others, like Burkina Faso, Mali, and Niger, nomadic herders are more specialized in cattle diseases, while poultry and small ruminants are well treated by sedentary agro-pastoralists (Aké-Assi, 1992). Knowing about such differences can be crucial in the selection of respondents in research and partners for extension approaches, the design of training courses, and the selection of trainees for community-based animal health workers.

Stock raisers commonly know when their animals are sick. They can describe the disease, which season it commonly strikes, and what types of animals are affected. For example, West African stock raisers (Schilihorn van Veen, 1997) have long appreciated the association between amblyomma ticks and heart water with streptothricosis. They also know where to find the best pasture, how to avoid tsetse-infested areas, where to find salt licks, and so on, and they use tactical and seasonal movements as management tools (Tamboura *et al*., 1998a).

Practices are much more varied than just the use of herbal medicines. They also cover bone setting, vaccination against pox and other infectious diseases, branding, and integrated management practices. One of the most common non-herbal treatments is scarification and bloodletting to free the animal from spoiled blood and use of red-hot plates on the body of the animal to burn diseased spots. Indications of this type of therapy are lameness, the rheumatic complex, skin diseases, and infectious diseases of the digestive and respiratory tracts. There are obvious dangers to these practices, and some of them should be discouraged if there is no apparent empirical basis for their use.

Also, Rajan and Sethuraman (1997) reported that indigenous disease control measures are carried out through herd management, such as using herd dispersion to reduce the risk of infecting all animals belonging to one household, choosing an animal for breeding based on the health of the animal, and preventing contact between healthy and ill animals. Disease prevention can cause a herdsman and his herds to move, while pastoralists avoid regions where vector insects abound or cattle rearers use medication without proper care.

In Nigeria, the Fulani nomads have been known to possess a reservoir of IK that has helped them survive even under extremely unfriendly conditions. Leeflang (1993) reported that the Fulani’s response to FMD illustrates how IK sometimes outstrips contemporary western science. The Fulani sometimes move their cattle upwind of infected herds to prevent the disease from spreading, and sometimes they move them downwind to expose the animals to FMD, knowing that a mild case of the disease will not be fatal and will confer immunity. Western scientists learned that the FMD virus could be aerially transmitted over long distances only after recent outbreaks of the disease in Europe.

Leeflang (1993) also reiterated that Nigerian cattle owners also know that the fluid in the tongue blisters of animals infected with FMD is infectious to other animals. To control the spread of the disease, they collect this fluid, dip a tree thorn in it, and scratch the tongue epithelium of apparently healthy animals to vaccinate them. Vaccination against CBPP is a standard procedure for the Fulani. They slice lung tissue from a diseased animal and implant it under the skin on the foreheads of their cattle, sealing the incisions with mud. The Fulani recognize the role of insects in the spread of disease, that is, that trypanosomiasis is linked to tsetse fly bites, whereas ticks are known to transmit other blood diseases (Leeflang, 1993). Common preventive measures among the Fulani include applying effective homemade fly repellents, lighting smoke fires to drive off insects, and avoiding infested grazing areas and shade trees. To control ticks, they feed host animals salty plants so that ticks fall off, they pick off ticks and burn them and they burn off infested rangeland. They also practice annual migration, which was historically aimed at avoiding trypanosome infection. In the rainy season, cattle would be brought to the Fulani's ancestral homeland in the Sudan zone, where tsetse flies are found only among river vegetation. As the dry season advances, however, the grass in this zone quickly dries up and disappears and water supplies shrink or disappear as well. The Fulani would then move their cattle southward following disease-free tracks that had been scouted in advance by one of their members.

Ethno-veterinary research has focused on understanding both the general practice and screening of commonly used medicinal plants. Many indigenous plants have been found to possess medicinal properties. The ethno-veterinary characteristics and active principles of some of the plants from West Africa against common infections have been studied (Gefu, Abdu, & Alawa, 2000; Adewumi, 2004; Fajimi & Taiwo, 2005), while the majority have not received much scientific attention.

Specifically, in the last few decades, herbal remedies employed in animal production in Nigeria have attracted the attention of researchers. A review of the literature by Fajimi and Taiwo (2005) discussed the previous and current status of herbal remedies in animal parasitic diseases in Nigeria. Their study presented in quantifiable terms the degree of efficacy of whole or plant parts and their extracts in percentages of efficacy. Dosages and concentrations were reported in certain instances, especially in confirmatory research trials for which scientific validation is necessary, unlike in surveys in which dosages were not recorded but presented only as traditional practices among herdsmen. Similarly, comparative inferences were drawn between the efficacy of the tested herb arid its counterpart in modern medicine.

Adekunle *et al*. (2002) examined the use of indigenous control methods for pests and diseases of cattle among herdsmen in northern Nigeria and showed that the majority of herdsmen used indigenous methods to control pests and diseases in their herd; this included hygiene (93%), herbs (87%), herd sharing (22%), hush burning (48%), holy books (35%), incantations (28.6%), and local concoctions (35%). They found significant relationships between the use of IK and age,, marital status, and years of experience of the herdsmen.

Fieldwork at Tahara in northeastern Nigeria reported by Akingboye (1995) revealed that the majority of the Fulani herdsmen (Bororo) have knowledge of traditional plant preparations through which common herd diseases are cured. Seeds, roots, leaves, harks, tubers, and fruits are gathered for processing by grinding, boiling, or soaking in water and are used to tackle skin diseases, wounds, cold, and reduced appetite. The Fulani rely on the knowledge passed on by their forefathers to observe signs and symptoms of sickness in animals and to decide on the type of treatment. Commonly used species include baobab (*Adansonia digitata*) against diarrhea and skin disorders; ginger (*Zingiber officinale*) as a laxative, appetizer, and antibloat agent; garlic (*Alliurn sativum*) as an antidote; African locust beans (*Parkia filicoides*) for skin infections, wounds, and worms: tobacco (*Nicotiana tabacum*) against myiasis, hoof infections, and ectoparasites and neem (*Azadirachta indica*) as an insect repellent (Hounzangbe *et al*., 2002. Hounzangbe *et al*., 2004; Ibrahim, 1996). Neils *et al*. (2008) also reported 64.28% of Fulani cattle rearers in Adamawa state to treat their animals using ethno-veterinary medicine whilst 15.31% called for veterinary services (orthodox medicine) and 20.41% combine ethno-veterinary and orthodox medicine. The use of a single remedy or plant extract in treating more than one disease as well as combinations of various plant extracts for broad-spectrum therapy are common. For example, extracts of or ingredients from mahogany (*Khaya senegalensis*) are used to treat anthrax, diarrhea, dysentery, foot rot, helminth infections, and ringworm (Maas, 1991; Tamboura *et al*., 1998a; Fagnissè, 2006). Extracts from the mahogany tree are also used to improve appetite and fertility as well as to relieve animals in cases of gastric or emetic problems or poisoning and as a laxative (Alawa *et al*., 1996; Adewumi, 2004). The methods of processing vary from grinding or soaking in water to obtain solutions given by mouth to inclusion in feedstuff fed to the animal (Alawa, Lernu, Sackey, & Alawa, 1996; Jagun *et al*., 1998; Okoli, Okoli, & Ebere, 2002a).

The anti-inflammatory as well as the antipyretic activities of *Azadirachta indica*, (neem) have been evaluated and documented (Okpanyi & Ezeukwu, 1981). Neem is universally recognized as an effective insecticidal repellant (Birmah, 2000). The anti-inflammatory and analgesic properties of the methanolic extract of *Ramalina farinacea* at a dose of 1,600 mg/kg have been shown to suppress signs associated with inflammation and gave results comparable to those of indomethàcin (Udern, Esimone, Obinwa, & Akab, 2001).

Leaves of *Cassia occidentalis* are used as an anticonvulsant and as a purgative, *Adansonia digirala* (baobab) is used as an antidiarrhea in cattle, while *Erythrina senegalensis* has a potent diuretic property (Gefu *et al*., 2000). *Guiera senegalensis, Anogeissus leocarpus,* and *Sclerocarya birrea* have been found useful in overcoming dystocia in domestic animals (Hassan & Zalla, 2005). The root extract of *Nauclea latifolia* was observed by Madubuinyi (1995) to possess an antihepatotoxic effect and inhibited the multiplication of *Trypanosoma brucei*.

Similarly, Okoli *et al*. (2002a) surveyed the diversity of plants of ethno-veterinary importance in southeastern Nigeria. They found that indigenous farmers and healers utilized 24 plant species in the treatment of common livestock ailments, such as diarrhea, ecto - and endoparasitic infections, retained placenta, and dehydration, among others. Methods of preparation and administration were found to include direct feeding of the plant parts, drenching with aqueous decoction, or direct external application of plant juice on affected parts.

Adewumi (2004) reviewed the potential role of herbal plants in livestock production in Nigeria and highlighted the results of surveys carried out by different scientists in Nigeria that showed that herdsmen and indigenous livestock keepers were competent in the diagnosis of animal diseases and have various methods of preparation of medicinal plants for the treatment of their animals. These reports showed that herbs and plant extracts, seeds, leaves, and barks of certain trees, tubers, and roots were the most commonly used sources of drugs. The review, however, concluded that the toxicity of plants containing toxic components such as aristolochic acid and pyrrolizidine alkaloids should be made known to livestock keepers. Ethno-veterinary medical practice is also widespread among herdsmen and village livestock producers in northern Nigeria, which harbors most of the livestock in the country (Gefu *et al*., 2000). Modern veterinary inputs and services are usually not readily available to most of the villagers in the region. Therefore, they rely on local plants for livestock health management (Adewumi, 2004).

According to Alawa *et al*. (2002), herdsmen and livestock owners readily identify signs of disease. They also reported various traditional drugs and methods of treating some common animal health and production problems among Fulani herdsmen and village producers. They also noted the use of less-conventional treatments such as kerosene and spent engine oil. The authors concluded that considering the combination of ingredients used by the traditional animal health practitioners, it is likely that additive, synergistic, and nutritional effects might be involved in alleviating the problem of ill health in animals. The descriptive signs for a specific disease were common from one producer to another. The diseases and problems identified included ticks and flea infestations, swollen joints or feet, sprain, ringworm, retained placenta, respiratory diseases, poisoning, mineral deficiencies and low milk yield. Other diseases and problems included mastitis, kid navel disease or protection, infertility, helminthes infections, gastric or emetic problems, foot rot, diarrhea and dysentery, bloat, appetite promotion, anthrax, and acetonemia. According to Kaikabo, Mustapha, and Dagona (2004), the ancient Bade pastoralists of Nigeria possessed a sophisticated body of ethno-veterinary knowledge about animal diseases, treatments, and management practices that spanned from generation to generation to date. Ethno-veterinary practices were adopted by 85.7% of the pastoralists. The major reasons for their adoption were low cost, effectiveness, accessibility, and practicability.

CHAPTER THREE

MATERIALS AND METHODS

3.1 The Study Area

Adamawa State is located at the area where the River Benue enters Nigeria from Cameroon Republic and is one of the six states in the North-East geopolitical zone of Nigeria. It lies between latitudes 7^0 and 11^0 North of the Equator and between longitudes 11^0 and 14^0 East of the Greenwich Meridian (Mohammed, 1999). It shares an international boundary with the Republic of Cameroon to the East and interstate boundaries with Borno to the North, Gombe to the North-West and Taraba to the South-West (Adebayo, 1999; ASMLS, 2010a; ASMLS, 2010b), as shown in Figure I.

According to Adebayo and Tukur (1997), Adamawa state covers an area of land mass of about 38,741km². The state is divided into three Senatorial Zones (Northern, Central and Southern) which translated to agricultural zones as defined by INEC (1996), which are further divided into21 Local Government Areas (LGAs) for administrative convenience.

The State has a population of 2,102,053 persons (NPC, 1990). The main ethnic groups in the state are the Kilba, Higgi, Quadoquado, Lala, Yungur, Bwatiye, Chamba, Mbula, Margi, Ga'anda, Longuda, Kanakuru, Bille, Bura, Yandang, Fali, Gude, Verre, Fulani and Libo (Adebayo & Tukur, 1997; Adebayo, 1999). The dominant religions are Christianity and Islam, although some of its inhabitants still practice traditional African religions.

The major occupation of Adamawa people is farming. The soil type is ferruginous tropical soils of Nigeria based on genetic classification of soils by the Food and Agricultural Organization of the United Nations (FAO, 1996).

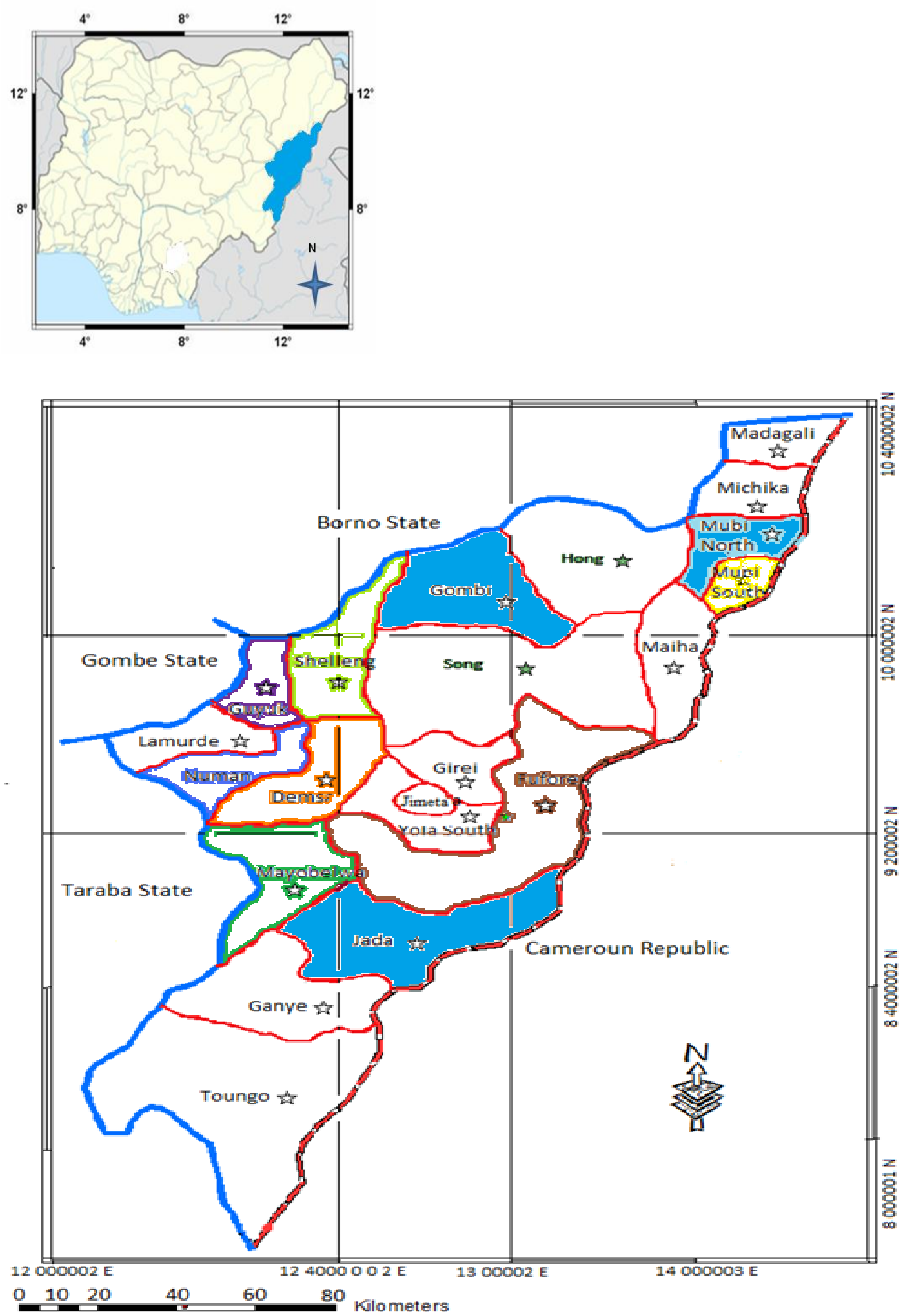

Figure I: Maps of Nigeria and Adamawa state, showing the study areas of Mubi North, Gombi and Jada Local Government Areas

The soils are a function of the underlying rock, the seasonality of rainfall and the nature of the wood-land vegetation of the zone. The soils are derived from the basement complex, granite and gnesis that form the ranges of mountains. The mineral resources found in the state include iron, lead, zinc and limestone (Adebayo & Tukur, 1997).

The common relief features in the state are the Rivers Benue, Gongola, Yadzaram and Kiri Dam, Adamawa and Mandara mountains and Koma hills. The state has minimum and maximum rainfall of 750 and 1050 mm per annum and an average minimum and maximum temperature of 15^0C and 32^0C, respectively. The relative humidity ranges between 20 and 30% with four distinct seasons that include early dry season (EDS, October – December); late dry season (LDS, January – March); early rainy season, (ERS, April – June) and late rainy season (LRS, July – September) according to Adebayo (1999). The vegetation type is best referred to as guinea savannah (Areola, 1983; Adebayo & Tukur, 1997). The vegetation is made up of mainly grasses, aquatic weeds along river valleys and dry land weeds inter-spaced by shrubs and woody plants. Plant heights ranges from few centimeters (Short grasses) to about one meter tall (tall grasses), which form the bulk of animal feeds.

Cash crops grown in the state include cotton and groundnuts, sugar cane, cowpea, benni seed, bambara groundnut, tiger nut, while food crops include maize, yam, cassava, sweet potatoes, guinea corn, millet and rice. The communities living on the banks of rivers engage in fishing, while the Fulani and other tribes who are not resident close to rivers are pastoralists who rear livestock such as cattle, sheep, goats, donkeys, few camels, horses and poultry for subsistence (Adebayo & Tukur, 1997; Adebayo, 1999).

3.2 Study Outline

The study was divided into two phases, study I involved detailed diagnostic study of pastoral cattle production in three Local Government Areas (LGAs) of the state to understand the current characteristics of pastoral cattle production including socio-cultural characteristics of producers; cattle morpho-physiological characteristics across four seasons and feed resources characteristics. Study II investigated semi-sedentary cattle production in the same LGAs to understand the cattle breeds morpho-physiological characteristics across for seasons and chemical compositions of feed stuffs utilized in maintaining the animals.

3.3: Study I Diagnostic Study of Pastoral Cattle Production in Three Local Government Areas of Adamawa State, Nigeria

3.3.1 Study sites

A two weeks preliminary survey of the study area was carried out to identify the study sites. The study sites (three LGAs) were purposively selected from each of the three senatorial zones representing agricultural zones in the state for the study. These represent the pastoral areas in the state with high numbers of cattle producers (Adebayo, 1999) and included Mubi North (Northern senatorial zone), Gombi (Central senatorial zone) and Jada (Southern senatorial zone) as shown in figure I.

Mubi North LGA is located at the northern part of old Sardauna Province, which now forms Adamawa North Senatorial district as defined by INEC (1996). The region lies between latitude 9^0 30´´ and 11^0 norths of the equator and longitude 13^0 and 13^0 45´´ East of Green witch Meridian. Mubi region is bordered in the North by Borno State, in the West by Hong and Song LGAs and in the South and East by the Republic of Cameroon. It has a land area of about 4,728.77 km² and human population of about 759,045 going by NPC, (1991) census projected figure (Adebayo & Tukur, 1991). It has an international cattle market linking neghbouring countries to southern Nigeria where cattle are consumed.

Gombi LGA is located in the Central Senatorial Districts and is strategically positioned North of the river Benue in Adamawa state. The region lies between latitude $10^0$09′ and $10^0$40' N and longitude $12^0$44′ and $13^0$23'E. It is bordered in the East by Hong LGA, West by Shelleng LGA, South by Song LGA and South-East by Biu LGA of Borno State. It has high number of cattle producers and a good cattle market every Friday (Adebayo & Tukur, 1991).

Jada LGA is located in the Southern Senatorial Districts of Adamawa State. It is located at an elevation of 360 meters above sea level and has population of 250,459 people. Its coordinates are 8°46' N and 12°9' E. It is bordered in the North-East by Yola South LGA, South- East by Ganye LGA, West by Mayo Belwa LGA and South by Zing LGA in Taraba state (Adebayo & Tukur, 1991).

3.3.2 Selection of study respondents and sampling design

During the two weeks preliminary survey, pastoralists at each study site were identified with the help of village heads and already identified respondents. The objective of the study was explained to them and their permission obtained to participate in the study. Actual participation in the study was base on willingness of a respondent to participate, and ownership of a minimum of 20 animals (15 females and 5 males) in the study area during the study period. Ten communities or pastoral camps were randomly selected at each of the study sites. Overall, 100 livestock farms were visited in each study location for interviews, direct observations and data collection. This was done across four seasons namely early rainy season (ERS), late rainy season (LRS), early dry season (EDS) and late dry season (LDS) from June 2013 to May 2014.

Actual data collection was carried out with the aid of short questionnaires, oral interviews and field observations. Well structured questionnaires were developed in English language and distributed to the respondents and where a farmer did not understand English, vernacular languages were used. The study was therefore a multi-stage sampling design.

3.3.3 Characterization of production components of pastoral cattle

(a) Cattle breeds: Four breeds of cattle identified in herds during the preliminary survey were used for the study. These included White Fulani (Bunaji), Red Bororo (Rahaji), Sokoto Gudali (Bokoloji) and Adamawa Gudali as shown in figure II. Ten males and ten females per breed making 80 animals in each study location were investigated across the four seasons. The ages of the animals used for the study ranged between 2 and 10 years old determined by farmers memory and farm records.

(b) Socio-cultural characteristics of livestock producers: Socio-cultural status of cattle producers such as sex, age, educational qualification, marital status, tribal and religious distribution and years of experience were determined by questionnaires, direct field observations and interviews on herd basis as shown in appendix I.

(c) Management characteristics: Cattle breeds were determined with the aid of farmers; observable peculiar breed distinguishing characteristics were documented. Herd size and purpose of production were determined by questionnaires and interviews of the cattle producers on herd basis.

(d) Reproduction practices: Breeding practices, mating methods, bull to cow ratio, age at first service, age at first calving and calving rate per cow before culling were also determined by questionnaires, direct field observation and interviews of the cattle producers on herd basis. Seasonal cattle reproductive variation and reproductive enhancement practice were equally determined.

(e) Feed resource characterization: Seasonal feed and water resource characterizations were carried out with the aid of questionnaires, direct field observation and interviewing of the cattle producers on herd basis. The identification of forages were done using botanical, English and Hausa names for ranking of aggregates and frequency of occurrences of plants in each study location.

Forage resources, legumes and browses common during wet period (May - September) were, also determined by questionnaires, interviews, kraal visits and direct field observations for at least two hours in the morning during grazing. Crop residues, by-products and browse resources available during dry period (October - April) were also determined by questionnaires, interview, kraal visits and direct field observation for at least two hours in the morning during grazing. Methods adopted for solving the problem of lean feed resources during critical periods of the year were also determined through informal discussions with the farmers.

(f) Ethno-veterinary healthcare: Information on veterinary, ethno-veterinary practices and plants used in ethno-veterinary healthcare were generated by questionnaires, interview, kraal visits and direct field observations. Parts of plants used and how they were prepared as well as diseases and parasitic conditions managed were also determined.

(g) Constraints to cattle production: Major constraints faced by cattle producers in the areas of natural resource availability, cattle disease management, government inputs and conflicts among others were also determined by questionnaires and interviews of the cattle producers on herd basis.

3.3.4 Morpho-physiological characterization of cattle

(a) Body condition scores (BCS): Body condition scores of 10 male and 10 female (20 animals) of each breed randomly selected in each study location were determined using visual indicators or a combination of visual and palpation of key bone structures for fat cover. The key areas that were evaluated were the backbone, ribs, loin area and tail head by the use of a scale 0 – 5 grades as described by Jefferies (1961), Lawman *et al*. (1976), Pullan (1978), Gatenby (2002), Todd (2008) and Addass (2011).

(b) Body temperature (T^o) : Rectal temperature of 10 male and 10 female (20 animals) of each breed were taken once in the morning (7 - 9 am) across four seasons using digital thermometer via the rectum as described by Piccione, Caola, and Refinetti (2007) and Burfeind, VonKeyserlingk, Weary, Veira, and Heuwieser (2010).

(c) Respiratory rate (beats/ minute): Respiratory rates were measured in 10 male and 10 female animals of each breed once in the morning (7 - 9 am) across four seasons by visually counting the number of flank or the chest area movement and sound of the nostrils per minute using stopwatch, or by auscultation using stethoscope (Mitlöhner *et al*., 2001; Eigen-berg, Brown-Brand, Nienaber, & Hahn, 2005) as shown in figure III.

(d) Pulse rate (beats/ minute): Pulse rates of 10 male and 10 female animals were determined once in the morning (7 - 9 am) across every season by feeling the pulse at the base of the tail or the external maxillary artery crossing the lower edge of the jaw as described by Hopster and Blokhuis (1994) and Marjan, Bogomir, and Ignac (2006) or by auscultation of heart beats using a stethoscope and stopwatch.

3.3.5 Hematological characterization of cattle

(a) Blood collection: The animals were restrained in the morning and from each 10 mls of blood were collected through jugular vein puncture using gauge 10 needles and 10 ml syringes. About 3 mls of the collected blood was discounted into ethylene-diamine-tetra-acetate (EDTA) treated bottle to prevent clotting, while the remaining 7 mls were discounted into plain Bijou bottles and allowed to clot at room temperature for 3 hours for serum formation. Blood samples were stored on ice pack and submitted to lab within 4 hours for analysis (Lawal *et al.*, 1998; Lamming & Darwash, 1999) as shown in figure IV.

(b) Hematological analysis: The Red Blood Cell (RBC), Packed Cell Volume (PCV), Hemoglobin (Hb) concentration, total White Blood Cell (WBC) counts, Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH) and Mean Corpuscular Hemoglobin Concentration (MCHC) were estimated by automated hematological analyzer (Coulter SPKS, PCL holding company, Germany) as described by Matwichuk *et al*. (1999) at the Clinical Pathology Laboratory of Federal Medical Center (FMC) Yola, Nigeria.

(c) Serum enzyme analyses: Clotted blood was subjected to centrifugation at 2500 rpm for 10 minutes to separate serum and the non-haemolyzed sera were stored at -20 °C until biochemical analysis. Enzyme - Link Immunosorbent Assay (ELISA) kits were used to determine serum enzymes such as aspartate aminotransferase (AST), alanine aminotransferase (ALT) and alkaline phosphatase (ALP) as described by Ali, Yousef, and Ali (2013) and Pandey, Jaiswal, Prakash Sah, Bastola and Dulal (2013) at the Clinical Pathology Laboratory of Ahmadu Bello University (ABU) Zaria, Nigeria.

3.3.6 Data analysis

Data generated from the survey were subjected to descriptive statistics such as frequency distribution and percentages, while data generated from the morpho-physiological study were subjected to analyses of variance (ANOVA) and significant means were separated using LSD procedure as contained in Statistix 9.1 package USA (2009). Furthermore, interaction between cattle breed and management system with the different study parameters (sex, season etc) on morpho-physiological parameters were determined using statistix 9.1 package (USA, 2009).

3.4 Study II Semi-sedentary Cattle Production Characteristics in Three Local Government Areas of Adamawa State, Nigeria

3.4.1 Study sites and experimental farms

The study was conducted in three semi-sedentary livestock farms purposively selected from each of the senatorial zones in the state as done in study I on the basis of willingness of the owners to participate in the study. At Mubi North LGA, the Federal Polytechnic Mubi, Livestock Farm was selected; at Gombi LGA, Ali Matakala Kwargashe Livestock Farm was used, while at Jada LGA, Alhaji Adamu Hamman Joda Livestock Farm was used.

(a) Federal Polytechnic Mubi, Livestock Farm: The Polytechnic was established in 1982 to serve the North-East geopolitical zone with middle class technical skilled man power. The livestock farm consists of five units, which include large ruminants (cattle), small ruminants (sheep and goats), piggery, rabbitary and poultry units. The common cattle breeds in the farm are White Fulani (Bunaji), Red Bororo (Rahaji), Sokoto Gudali (Bokoloji) and Adamawa Gudali reflecting the common breeds in the state. Cattle population ranged between 120 and 150 animals including service bulls, castrated bulls, bullocks, heifers, dry cows, nursing cows and pregnant cows. The small ruminants unit had over 100 animals. There were also piggery and rabbitary units with more than 50 animals in each. The farm also had a poultry unit that accommodated 2,000 to 4,000 birds of both layers and broilers. The cattle were sourced from Mubi International Livestock Market and were usually aggregated from other surrounding countries such as Cameroon, Chad, Senegal, Central Africa, Zambia and Burundi (Adebayo, 1999).

The livestock management in the farm involved taking out sheep, goats and cattle every morning and bringing them back in the evening by herdsmen to graze forages during the wet seasons and scavenge the crop residues and by-products during the dry seasons. Crop by-products were also gathered and preserved to supplement feeding during critical periods of the year. The animals drink water in the nearby Rivers Yadzaram and Vimtim but occasionally water was supplied to them using the polytechnic water tanker. Natural or pasture mating was the common breeding system in the farm. Make shift Kraals constructed with sticks and barbed wires were used to restrict cattle owned by individuals and members of staff, while permanent concrete kraal was used for cattle owned by the institution. The animals had access to veterinary services with limited use of ethno-veterinary medicine.

(b) Ali Matakala Kwargashe Livestock Farm: The farm is a non-institutional private farm established in 1994 and located in Lala District at the South-Western part of Gombi LGA. The common cattle breeds found in the farm were the Zebu including White Fulani (Bunaji), Red Bororo (Yakanaji), Sokoto Gudali (Bokoloji) and Adamawa Gudali. Cattle population ranged between 150 and 180 animals including service bulls, castrated bulls, bullocks, heifers, dry cows, nursing cows and pregnant cows. The farm also had more than 100 sheep and goats. The stocks were sourced from Fotta, Gombi, Song and Kwaya Kusar livestock markets in Adamawa and Borno states respectively.

The livestock management adopted by the farm was similar to that of the Federal Polytechnic, Mubi, where herdsmen were involved in taking animals out to grazing areas along riversides and bringing them back in the evenings. During the dry seasons, animals were moved to harvested crop fields within the vicinity of the livestock farm to scavenge the crop residues and by-products. Crop by-products also were gathered and presevered to supplement feeding during critical periods of the year. Some tree legumes and fodder herbs were specially allowed to grow in the farm and their leaves harvested for the animals feeding during critical periods of the year. Limited quantity of concentrates were also offered to the animals during the critical periods. The animals drink water in the nearby rivers and streams (Kwargashe and Nyora).

Natural or pasture mating was the common breeding system in the farm. Make shift Kraals constructed with sticks and barbed wires were used to restrict both cattle and sheep. The animals had limited access to veterinary services, while ethno-veterinary healthcare was commonly exploited.

(c) Alhaji Adamu Hamman Joda cattle farm: The livestock farm was established in 1999 for breeding, dairy and beef production. The farm consisted of two units, large ruminants (cattle) and small ruminants (sheep and goats). The common cattle breeds in the farm were again White Fulani (Bunaji), Red Bororo (Rahaji), Sokoto Gudali

(Bokoloji) and Adamawa Gudali. Cattle population ranged between 200 and 300 animals including service bulls, castrated bulls, bullocks, heifers, dry cows, nursing cows and pregnant cows. The small ruminants unit had more than 150 animals. The stocks were sourced from Numan, Ngrore, Jada, Ganye, Mayo Belwa and Zing livestock markets in Adamawa and Taraba States.

The management system practiced includes moving the animals to graze on pastures demarcated with barbed wires fences to prevent other stray livestock from trespassing. During wet seasons, abundant forages were presevered in form of hay and silage which were used with crop residues and by-products as an intervention feed resources during lean feed periods in the dry seasons. The animals drank from streams in the farm and occasionally, water was supplied to them from the farm bore hole. Natural or pasture mating was the common breeding system in the farm. Permanent concrete kraals were used and the animals had access to veterinary services, with occasionally augmentation with ethno-veterinary medicines.

3.4.2 Selection of study animals

The four cattle breeds identified in farms during the preliminary survey were used for the study. These included White Fulani (Bunaji), Red Bororo (Rahaji), Sokoto Gudali (Bokoloji) and Adamawa Gudali. Ten males and ten females per breed making 80 animals at each study farm were investigated across the four seasons (June 2013 to May 2014).

3.4.3 Morpho-physiological characterization of Cattle

Morpho-physiological parameters such as body condition scores (BCS), rectal temperature (RT^o), respiratory rate (RR) and pulse rate (PR) were determined according to the methods previously described in study I.

3.4.4 Hematological characterization of cattle

The blood samples were collected and analyses were also carried out according to the methods described in study I at the same Clinical Pathology Laboratory of Federal Medical Center Yola, Nigeria. The parameters analyzed included red blood cell (RBC), packed cell volume (PCV), hemoglobin (Hb), white blood cell (WBC), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC), while serum enzymes included aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP) were analyzed at the Clinical Pathology Laboratory of ABU Zaria Teaching Hospital.

3.4.5 Identification and characterization of chemical compositions of the most preferred dry season feed recourses

(a) Samples identification and collection: At each study farm, information on dry season feeding resources were gathered with the aid of questionnaires, interviews and direct field observations. About 500 g of the most preferred and abundant feeding materials made up of crop residues, by-products and plant leaves browed by animals were collected fresh, sun dried for four days, packaged in labeled brown envelops and sent to the laboratory for analyses. The local names of the feed materials were collected and documented, while the browse species were identified at the Department of Botany, Adamawa State University, Mubi and samples deposited in the University herbarium. The samples submitted to the laboratory were analyzed for their proximate compositions and fiber partitions.

(b) Proximate analyses: The proximate compositions of the samples were analyzed at the Clinical Biochemical Laboratory of Ahmadu Bello University (ABU) Zaria, Nigeria, in percentages to determine their dry matter content (DM), crude protein (CP), crude fiber (CF), ether extract (EE), ash (AS) and nitrogen free extract (NFE). Feed samples were analyzed for their proximate compositions in accordance with the methods of AOAC (1995 & 2004).

Dry matter content of each sample was determined by oven-drying 3g at 105° C for 24 hours. Crude protein was determined in accordance with the Kjeldahl method (AOAC, 1995). This was done by determining the nitrogen content of the feed material and multiplying it by a factor 6.25. Samples were analyzed for ash by complete combustion at 550^0C in a furnace for 3 hours according to the methods of AOAC (2004). Fibre was analyzed by the trichloroacetic acid (TCA) digestion method as described by AOAC (2004), while ether extract was determined by the dry soxhlet method for fat extraction as also described by AOAC (2004). NFE was obtained by subtracting the sum of percentages of all the nutrients already determined from 100. This was done using the formulae %NFE = DM - (% Ash + %CF = %EE + %CP).

(c) Fiber partition: The fiber content of the materials were further partitioned to determine their percentage contents of neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and hemicelluloses (HEM), which separates cell contents from cell wall constituents (AOAC, 2004).

(i) Neutral Detergent Fiber (NDF): This was carried out by boiling a sample of dry forage feed and refluxing in a neutral detergent solution (consisting of sodium lauryl sulphate, disodium dihydrogen ethylene amine tetra-acetate and phosphate buffer) after which, soluble carbohydrates, proteins and fats were extracted as described by Van Soest *et al*. (1991). The residue, which is mainly hemicelluloses, cellulose and lignin are components of the plant cell wall and is referred to as “neutral detergent fiber” (NDF).

(ii) Acid Detergent Fiber (ADF): This was also carried out by boiling a sample of dry forage feed and refluxed in an acidified detergent solution (consisting mainly of cetyl trimethylammonium bromide in sulphuric acid); soluble carbohydrates, proteins, fats and hemicelluloses are extracted into solution as described by Van Soest, Robertson, and

Lewis (1991). The residue, which is mainly cellulose and lignocelluloses is referred to as "acid detergent fiber" (ADF).

(iii) Acid Detergent Lignin (ADL) and Hemicelluloses (HEM): Percentage ADL or lignin content was obtained according to the van Soests' detergent method by digesting the ADF with 72% H_2SO_4. Percentage HEM was obtained by finding the differences between NDF and ADF values as described by Church (1991).

3.4.6 Water resources quality analyses

Samples of water drank by cattle (hand pump borehole, well and stream) at each study farm were collected at random in clean sterile plastic containers and sent to Federal Medical Center (FMC), Biochemical Laboratory, Yola, Adamawa state within 24 hours for their mineral analyses. To avoid subsequent contamination, the samples were collected the same day and kept in a refrigerator at the temperature of 4^0C.

The water samples were analyzed for calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), Copper (Cu), and Lead (Pb), which are considered critical for water quality in Adamawa State (Kubkomawa and Williams, 2010b). The concentration of the alkali and alkaline metals (Na, Mg, K, Ca,) were determined in mg/litre. The trace elements (Cu and Pb) were also determined in Ug/litre due to their lower concentrations. Bulk 210 GP automatic absorption spectrophotometer was used for the major elements (Ca, Na, K, and mg), whereas Flame photometer was used for the minor elements (Cu and Pb) according to the methods of WHO (1993).

3.4.7 Data analysis

The morpho-physiological data were subjected to analyses of variance (ANOVA) and significant means separated using the LSD method as contained in statistix 9.1 package USA (2009). Furthermore, interaction between cattle breed and management system with the different study parameters (sex, season etc) on morpho-physiological parameters were determined using statistix 9.1 package (USA, 2009).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Characteristics of Production Components of Pastoral Cattle in Adamawa State

4.1.1 Socio - cultural characteristics of cattle producers

Table 4.1 highlighted the socio-cultural characteristics of cattle producers in the guinea savannah zone of Adamawa State, Nigeria. Livestock systems diagnostic research employed in this study involves detailed investigation of key stake holders, animals and the production environment (Roeleveld & van den Broek, 1996) of the guinea savannah zone in Adamawa State. As a component of this systems research, survey of the socio-cultural characteristics of livestock producers is necessary because cattle production in the area and Nigeria in general is predominantly controlled by pastoralists (Umar *et al*., 2008) and seems to have entered a transition period that has resulted in extensive movement of animals to new production zones (Blench, 1994; Okoli *et al*., 2012). Thus, redistribution of cattle ownership (Basset & Turnner, 2006), semi-sedentarization of nomadic pastoralists (Cisse, 1980; Anosike *et al*., 2003) and new diseases and production dynamics (Anosike *et al*., 2003; Okoli *et al*., 2012) are being experienced. Furthermore, since pastoral zones such as the guinea savannah are not isolated from national and international political and socio-economic dynamics frequently captured in the planning of development programmes, the interactions between the pastoral and broader sectors should be taken into account in order to generate holistic reliable data that would advice effective interventions (Bonfiglioli, 1992; Johnson, 1993).

(a) Sex distribution of cattle producers in Adamawa State

Table 4.1a showed that majority of cattle producers were male, with Mubi North LGA recording 90.00% followed by Jada (87.00%) and Gombi (75.00%).

Table 4.1: Socio - cultural characteristics of cattle producers in Adamawa State

Parameters	*Mubi North LGA*		*Gombi LGA*		*Jada LGA*	
	Freq	*%*	*Freq*	*%*	*Freq*	*%*
(a) Sex distribution						
Male	90	90.00	75	75.00	87	87.00
Female	10	10.00	25	25.00	13	13.00
(b) Marital status						
Married	75	75.00	85	85.00	88	88.00
Single	20	20.00	10	10.00	10	10.00
Divorced	5	5.00	5	5.00	2	2.00
(c) Age (years)						
10-20	10	10.00	15	15.00	10	10.00
21-30	15	15.00	15	15.00	30	30.00
31-40	55	55.00	50	50.00	48	48.00
41- above	20	20.00	20	20.00	12	12.00
(d) Educational qualifications						
W/Education	20	20.00	30	30.00	40	40.00
Nomadic/Arabic	80	80.00	70	70.00	60	60.00
(e) Farming experience						
5 -10	5	5.00	10	10.00	5	5.00
11 - 16	15	15.00	10	10.00	10	10.00
17 -22	40	40.00	40	40.00	40	40.00
22 - above	40	40.00	40	40.00	45	45.00
(f) Tribal distribution						
Fulani	70	70.00	65	65.00	95	95.00
Hausa	20	20.00	20	20.00	2	2.00
Others	10	10.00	15	15.00	3	3.00
(g) Religious affiliations						
Islam	75	75.00	50	50.00	80	80.00
Christianity	20	20.00	20	20.00	10	10.00
Traditional	5	5.00	30	30.00	10	10.00

Generally, men had the highest percentage of livestock holdings because they are the bread winners, having reservoir of wealth and taking the responsibility of managing herds to sustain the family's livelihood. However, women and children although relegated to the background, also control portions of the livestock holdings to support the family. These findings corroborate that of Okoli *et al*. (2012) who reported 100% ownership of pastoralist cattle by men in the humid rain forest of Imo State, Nigeria. Michael, Grindle, Nell, and Bachman (1991) had earlier reported that the management of herds rest on the men, but children and women, in their capacity as apprentices, also contribute to the family labor-force. Similarly, Adisa and Badmos (2009) in a study of the socio-economics of pastoral livelihood among cattle herdsmen in Kwara state, Nigeria, reported that cattle herding is entirely a male dominated business. Iro (1994) reported that cattle belong to individual family members and are usually herded together, with male family members assuming automatic rights to all cattle, making it difficult to determine cattle ownership by female family members. Swinton (1987) however, reported that women own most of the small ruminants and almost all of the poultry flocks.

Informal discussions during the present study revealed that men who ensure the corporate existence of the family, are the primary household providers and protect the animals from predators and theft. They also take animals to long-distance pasturelands, find fodder, dig wells, and make weapons such as guns, knives, swords, herding sticks, bows and arrows. The adult males also identify and locate grazing-sites, construct the tents, fences and perform soil and water tests to ensure good hygiene, safety and security.

(b) Marital status of cattle producers in Adamawa State, Nigeria

Table 4.1b showed that most of the cattle rearers at the study locations were married as represented by 88.00, 85.00 and 75.00% for Jada, Gombi and Mubi North LGAs respectively. These results also agree with that of Adisa and Badmos (2009) who reported that 87.5% of pastoralists surveyed in Kwara state were married. It was observed that early marriage is part of the culture of Fulani/Hausa pastoralists and allows setting up of family early in life to preserve family lineage through procreation. The few pastoralists that were found still single were confirmed to be under-aged not because they refused to marry. Some of them were still serving their masters as herdsmen and having their own share of holdings in the herds and are longing to get married as soon as the time is ripe. Another major reason for early marriages is that, women assist in taking care of calves, children and hawking milk to provide additional income to support the household in terms of purchase of grains and other valuables. The men are forbidden to enter the kitchen and find it difficult to eat in public eateries; therefore it is necessary to marry early.

(c) Age distribution of cattle producers in Adamawa State

Table 4.1c showed that most of the pastoralists were aged between 31 and 40 years, with Mubi North, Gobi and Jada LGAs recording 55.00, 50.00 and 48.00% respectively. Youths are therefore, the most engaged in cattle production business compared to elderly people. This is because as men get older and advanced in age, they try to share their inheritance among their children to prevent them from fighting over their wealth after their death. Elderly men and women keep only few cattle for daily supply of milk. This also has to be under the care of hired herdsmen in addition to family labor. These findings agree with Okoli *et al*. (2012) who reported 45% ownership of pastoralist cattle by youths within the age groups of 31 and 40 years in the humid rain forest of Imo State, Nigeria. Adisa and Badmos (2009) also reported modal age herders to range from 21- 35 years, accounting for 37.5%.

(d) Educational qualifications of cattle producers in Adamawa State

Table 4.1d revealed that, 80.00, 70.00 and 60.00% of the cattle producers had only Nomadic/Arabic education, while 20.00, 30.00 and 40.00% were privilege to have had western in addition to Nomadic/Arabic education in Mubi North, Gombi and Jada LGAs respectively. It was observed that the low level of western education was because, most of the cattle producers, especially the Fulani pastoralists are always on the move. There is therefore, a general belief that western education is a limited value since it is not needed in cattle rearing. The Fulani also believe that, western education encourages corruption and laziness with no guaranteed future in the pastoralist world. These results are again in agreement with the report of Okoli *et al*. (2012) that 86.4% of Fulani pastoralists have Arabic education whereas 13.6% have western education in addition to Arabic education in humid rain forest zone of Imo State, Nigeria. Niamir (1990) reported that even though formal schools provide literacy needed in modern times, their content remain too foreign to the pastoralists since it teach the value of sitting in offices behind desks, rather than the value of the land. Adisa and Badmos (2009) also reported that only 14% of herdsmen have formal education and about 64% of herdsmen interviewed in Kwara state have no education at all. This pathetically low level of western education among pastoralists in the study areas also supports the report of Aikman (2010) which revealed very low school enrollment rates and high drop-out rates among school-age pastoralists.

(e) Years of experience of cattle producers in Adamawa State

Table 4.1e showed that majority of the cattle producers had acquired enough experience in the profession even though most of them did not receive any formal training on livestock production. Most of them (40.00 to 45.00%) had experiences of 17 to 22 years in the industry. The results also corroborate that of Okoli *et al*. (2012) who reported similar years of experience (10 and 20 years) amongst the Fulani pastoralists herders in the humid rain forest zone of Imo State, Nigeria. Adisa and Badmos (2009) in their study also reported that 80% of respondents have herded cattle for at least 5 to 10 years indicating that older herdsmen with above 20 years of experience may have relinquished the grazing duty to the younger generation. These older men usually settle in the camp and acts as the chief adviser on family and herding matters.

(f) Tribal distribution of cattle producers in Adamawa State

The results in table 4.1f, showed that majority of the pastoralists were Fulani by tribe representing 95.00, 70.00 and 65.00% at Jada, Mubi North and Gombi LGAs respectively. A similar study conducted by Suleiman (1988) in the derived savanna of Oyo states, Nigeria revealed that cattle production is generally associated with pastoral Fulani race who are said to own approximately 90% of the national herd. Another study conducted by Mohammed (1990), showed that a sizeable population of agro-pastoralists in the same Oyo states were originally nomadic cattle pastoralists. It was found that the few Hausa and other tribes with cattle holdings in the research area were mostly absentee farmers, who hire the services of Fulani herdsmen to take care of the animals, while they reside and work in the cities. Olafadehan and Adewumi (2010) in their study of livestock management and production systems of agro-pastoralists in the derived savanna of south-western Nigeria reported that all the agro-pastoralists interviewed inherited their stock, while few (24%) engaged in care-taking of animals for others indicating that this may be an emerging trend in pastoral cattle ownership in Nigeria.

(g) Religious affiliations of cattle producers in Adamawa State

Table 4.1g revealed that more than half of the cattle keepers in the study locations were Muslims as compared to Christians and traditionalists. Jada LGA recorded 80.00% Muslims pastoralists followed by Mubi North LGA with 75.00% and Gombi LGA with 50.00%. Christianity and traditional religions are therefore not so popular amongst the cattle farmers in Jada and Mubi North LGAs. This finding butresses the high level of Nomadic/Arabic education found amongst the farmers. Most of these Muslims believe that Christianity is western and therefore resent the practice of this western way of life. These findings agree with the report of Adisa and Badmos (2009) that all of the pastoralists investigated in Kwara state were Muslims.

4.1.2 Cattle management characteristics of pastoralists in Adamawa State

(a) Cattle breeds distribution in Adamawa State

Data on breed characteristic, herd size and purpose of production at the three study locations are presented in table 4.2. The survey revealed that White Fulani (Bunaji) was the most predominant breed (50.00%) at Gombi LGA, while Red Bororo (Rahaji) (53.00%) and Adamawa Gudali (50.00%) were the most predominant in Mubi North and Jada LGAs respectively. Bunaji is the most popular because of characteristics such as good market value traits, good tolerance to a variety of harsh conditions, resistant to a host of diseases and parasites, easy fattening and good coat color traits (White & Wickens, 1976). However, Adamawa Gudali the second most popular is concentrated in southern senatorial zone and some parts of the central senatorial zone. The breed is said to be hardy and able to withstand hash conditions compared to red Bororo and Sokoto Gudali breeds because of their smaller stature (White & Wickens, 1976). Red Bororo and Sokoto Gudali are moderately distributed all over the state (White & Wickens, 1976). They are more predominant among itinerate transhumants in the state and beyond. The present findings are supported by Akabwai (1993) who reported that pastoralists keeping red Bororo and Sokoto Gudali breeds are highly mobile. Olafadehan and Adewumi (2010) reported that in south western Nigeria, agro-pastoralists cattle composition favors the Bunaji, followed by N’Dama and Keteku.

Table 4.2: Cattle management characteristics in Adamawa State

Parameters	*Mubi North LGA*		*Gombi LGA*		*Jada LGA*	
	Freq	%	Freq	%	Freq	%
(a) Breed						
White Fulani	27	27.00	50	50.00	30	30.00
Red Bororo	53	53.00	30	30.00	10	10.00
Sokoto Gudali	15	15.00	10	10.00	10	10.00
Adamawa Gudali	5	5.00	10	10.00	50	50.00
(b) Herd size						
20 - 30	20	20.00	25	25.00	10	10.00
31 - 40	25	25.00	25	25.00	15	15.00
41 - 50	50	50.00	45	45.00	40	40.00
51 and above	5	5.00	5	5.00	35	35.00
(c) Purpose of production						
Meat	-	-	-	-	-	-
Milk	-	-	-	-	-	-
Breeding	-	-	-	-	-	-
Traction	-	-	-	-	-	-
Multi-purpose	100	100.00	100	100.00	100	100.00

This also corroborate the reports of Waters-Bayer (1988), who noted that agro-pastoralists have preference for Bunaji cattle because of their reputation for higher milk production, faster growth rate, large body size and good temperament. Again, Iro (1994), Iyayi, Okoruwa, Babayemi, and Peters (2003) and Olanite, Busari, and Akinlade (2003) stated that the slow maturing Sokoto Gudali cow and the lyre-horned, white Fulani cattle are the mainstay of the pastoral Fulani holdings. White and Wickens (1976) disclosed that the white Fulani, though less hardy, has higher milk and beef yield compared to Sokoto Gudali.

(b) Cattle herd size distribution in Adamawa State

The results on herd size distribution showed that the cattle producers at Mubi North (50.00%), Gombi (45.00%) and Jada (40.00%) maintained herd size of 41 to 50 heads of cattle comprising both bulls, heifers and cows (Table 4.2b). The findings corroborate that of Okoli *et al*. (2012) who reported that majority of Fulani pastoralist (63.60%) maintained herd size of 41 to 70 heads in the humid rain forest zone of Imo State, Nigeria. In a related study, Adisa and Badmos (2009) reported an average cattle herd size of 41, while majority of herdsmen (46.4%) herded 41 - 60 cattle. Iro (1994) also reported optimum Fulani cattle herd size to be 80 - 100, while Cunnings (1966) found 100 - 150, which is far higher than what was obtained in the present study. The low herd sizes obtained in this study could be attributed to the effects of dwindling feed resources associated with shrinking land that forces the stake holders to maintain smaller herd sizes to march the natural pastures and available biomass (Okoli *et al.*, 2012).

(c) The production purposes of cattle producers in Adamawa State

The results of production purposes revealed that all the pastoralists at the three locations reared cattle for multiple purposes, chiefly for breeding, milk, meat and traction (Table 4.2c). There is therefore no specialty in the production systems. This may be because of lack of technical know- how and infrastructural facilities to support that, meaning that most of the cattle finally end up as beef after years of productive life span. This also agrees with Okoli *et al*. (2012) who reported that all Fulani pastoralist keep cattle for breeding and dual purpose (milk and meat production) in the rain forest zone of Imo state. However, according to Alphonsus *et al*. (2012), there is no tropical breed that can be seen as a specialized dairy or beef type, although some breeds may be preferred for milk production, while others for beef. The results of this study supports that of Corbet *et al*. (2005) and Anderson (2003) who reported that cattle provide draught animal power, social and cultural functions as well as serving as security and risk reduction in rural households. Adisa and Badmos (2009) also reported that pastoralists cattle in Kwara state are kept purely for income generation ranging from milk, draft, manure, beef to breeding purposes.

4.1.3 Reproductive practices of cattle producers in Adamawa State

Data on the reproductive practices of cattle producers in Adamawa State are presented in table 4.3. The reproductive performance of a herd has been shown to be a major starting point in any animal production package (Mukasa-Mugerwa *et al.,* 1992). Malau-Aduli *et al.* (1993) and Mukasa-Mugerwa *et al.* (1992) defined fertility as the ability of male and female animals to produce viable germ cells, mate, conceive and deliver normal living young. Thus, the lifetime productivity of a cow is influenced by age at puberty, age at first calving, calving interval and number of services per conception and calving to conception interval. Similarly, Oni *et al*. (1988) and Shehu *et al.* (2005) stated that reproductive ability is the primary source of all benefits derived from livestock so that any selective breeding should be tailored towards increasing animal production traits. Reproduction is therefore the most important factor in determining profitability in a cow calf enterprise.

(a) Breeding system

The study showed that all the farmers practiced uncontrolled breeding system, with animals being allowed to graze together and breed freely without restriction (Table 4.3a). Under this practice, cows become pregnant throughout the year, thus, spreading the income from sales of milk. These findings agree with Okoli *et al.* (2012) who reported that in the humid rain forest zone of south - eastern Nigeria, 77.30% of the Fulani pastoralists did not specifically control breeding rate in their flock, while only 22.70% of the respondents allow cross breeding. Similarly, Kubkomawa *et al*. (2011a) in their study of local breeds of livestock in northeastern Nigeria, reported that the practice of uncontrolled breeding and indiscriminate crossbreeding results to diminishing genetic resources. Under this practice calves usually wean themselves when the dam ceases milking, while the pastoralists may resort to artificial weaning when the dam is in an advanced stage of pregnancy and the previous calf is still suckling. This is done by smearing the dung of young calves on the dam's teats every day until the calf stops sucking. Non breeding bulls are not castrated unless they are troublesome, and usually not until they are 2 or more years of age. Castration is performed by crude surgical method, or by stretching the scrotum on a stick and crushing the spermatic cords with a mallet.

(b) Mating methods

The mating methods results showed that the respondents allowed free pasture mating in the three study locations (Table 4.3b) indicating that no form of hand mating or artificial insemination is practiced. This could be as a result their inability to adopt modern methods chiefly because of their low levels of education. The expensive nature of AI equipment and the technicalities involved may also be a hindrance and to specialization.

Table 4.3: Reproduction practices of cattle producers in Adamawa State

Parameters	*Mubi North LGA*		*Gombi LGA*		*Jada LGA*	
	Freq.	*%*	*Freq.*	*%*	*Freq.*	*%*
(a) Breeding system						
Cross breeding	-	-	-	-	-	-
In - breeding	-	-	-	-	-	-
Up - grading	-	-	-	-	-	-
Uncontrolled	100	100	100	100	100	100
(b) Mating method						
Hand mating	-	-	-	-	-	-
Pasture mating	100	100	100	100	100	100
Artificial insemination	-	-	-	-	-	-
(c) Bull to cow ratio						
1:10	75	75	50	50	20	20
1:50	25	25	40	40	40	40
1:100	-	-	10	10	40	40
(d) Age at first service						
Bull and heifer						
2 - 3 years	40	40	55	55	50	50
4 - 5years	60	60	45	45	50	50
(e) Age at first calving						
Heifer						
3 - 5 years	27	27	20	20	25	25
5 - 7 years	73	73	80	80	75	75
(f) Calving/ cow before culling						
1 - 5	74	74	70	70	60	60
6 - 11	26	26	30	30	40	40
12 - above	73	73	80	80	75	75
(g) Reproductive enhancement						
Use of ethno-vet approaches	65	65	60	60	55	55
Modern veterinary services	35	35	40	40	40	40
Special feeding	-	-	-	-	5	5

These findings agree with Okoli *et al.* (2012) who reported that all pastoralists in the rain forest zone of Imo state allow free pasture mating of their flocks implying again that there is uncontrolled cross breeding. Babayemi *et al*. (2014) also reported that pasture mating is common among the cattle reares in West Africa.

(c) Bull to cow ratio

The bull to cow ratio results (Table 4.3c) across cattle herds at the three study locations showed that majority of them allowed a sex ratio of 1:10, with Mubi North LGA having 75.00%, Gombi (50.00%) and Jada (20.00%). For the sex ratio of 1:50, Mubi North LGA had 25.00%, Gombi (40.00%) and Jada (40.00%). This is considerate since the recommended sex ratio by established cattle ranches is 1 bull to service 50 cows per year under controlled breeding system through hand mating or artificial insemination (Costa e Silva, Sereno, Nogueira Júnior, Nogueira, & Batistote, 1998).

However, in situations where breeding is not controlled, one bull may be over worked if it's to service more than 25 cows continually throughout the year. Again, having too many service bulls in a herd encourages fighting leading to injuries amongst the male animals (Costa e Silva *et al*., 1998). Thus, under ideal management, bulls not used for service should be castrated and fattened for sale or used for draught and transportation, especially during migration.

These results agree with Okoli *et al*. (2012) who examined bull to cow ratio in some herds of cattle reared by Fulani pastoralists in the humid rain forest of Imo State, Nigeria and found a gender imbalance, with a preponderance of the female stock. In their study, the female species constituted 60 to 73% of each herd. The advantages of keeping more female variety in the herd are obvious for fast herd growth and a simulation of herd dynamics proves that the rate of growth of the herd peaks when female cattle dominate (Costa e Silva *et al*., 1998). In his study, Iro (1994) reported a preponderance of female over male at ratio of 4:1 and that the Fulani pastoralists maintain balanced functional species composition that is made up of beefers, milkers, breeders, carriers, and stock beautifiers.

(d) Age at first mating of bull and heifers

Table 4.3d showed that 60.00, 50.00 and 45.00% of farmers in Mubi North, Jada and Gombi LGAs respectively allowed first mating and breeding at between 4 and 5 years, while another 55, 50 and 40% respectively confirmed that they mated and bred their animals between the ages of 2 and 3 years. This disparity in breeding ages across the three study locations could be as a result of differences in herd composition, sex ratio, feed availability and health care delivery. For example, it was observed that when there are more males in the herd, reproductive activities were more rampant with high incidence of early breeding. Availability of feed resources, space and health care also affect positively the animal's puberty age thereby creating room for early reproductive activity (MLA, 2006). Usually under good management practices cattle start sexual play and breed at 1 to 3 years old. However, disease conditions, malnutrition, overcrowding and social vices could hamper early sexual maturity among cattle breeds of tropical origin (Bertram, 2000; McCosker, 2006).

(e) Age at first calving for heifers

Age at first calving is important in the entire reproductive life of a heifer since the earlier the heifer starts to deliver young ones the more economic value the producers will attach to it (Costa e Silva *et al*., 1998). Table 4.3e revealed that majority of the heifers calved between the ages of 5 and 7 years, with Gombi LGA (80.00%) having the highest cases followed by Jada LGA (75.00%) and Mubi North LGA (73.00%). Only few cases of calving at 3 to 5 years of age were recorded at the three study locations. However, age at first calving of 3 to 7 years for tropical cattle should be considered adequate since the tropical livestock production environment, especially the limited feed resources may not support shorter first calving period.

(f) Number of calving before culling (productive life)

Table 4.3f showed that majority of cows at the three study locations delivered an average of 5 to 12 calves before they were culled off, with Adamawa Gudali having higher calving performance followed by the Bunaji. This is probably because Adamawa Gudali and the Bunaji breeds are indigenous to the study locations and tended to adapt better to hard conditions of the environment more than the Red Bororo and Sokoto Gudali breeds that usually loose a lot of body condition and weights during critical periods of the year. The results agree with Okoli *et al*. (2012) who reported in their survey of animal reproductive management practices of Fulani pastoralists in the humid rain forest of Imo state, Nigeria that 90.90% of the pastoralists allow 6 – 10 calving per cow within its reproductive life, while a limited 9.10% may allow up to 11 – 15 calving per cow implying that most of the female animals culled for sale are old animals. It was also observed that majority of the cattle producers in the study area select and cull mostly sick, weak and old animals that have finished their productive activities. Healthy and reproductively active animals are rarely sold even when the farmers need cash to solve a pressing problem.

(g) Reproductive enhancement of cows

The findings in table 4.3g revealed that majority of the pastoralists in Mubi North LGA (65.00%), Gombi LGA (60.00%) and Jada LGA (55.00%) used ethno -veterinary practices to enhance the reproductive performance of their herds with only 35 - 40% of the farmers having access to conventional veterinary services. Only 5.00% of the farmers, specifically at Jada LGA practiced special feeding of animals to enhance their reproductive performance. These special feeds for the breeding stocks include salt licks, molasses and potash, which supply minerals and energy to the stock for optimal productivity. It was also found that majority of farmers preferred ethno-veterinary approaches because it is readily available and cheap, while access to conventional veterinary health care is usually poor and exorbitant in rural northern Nigeria (Ibrahim, 1984).

(h) Seasonal calving rates of cattle in Adamawa State, Nigeria

Table 4.4 showed the seasonal calving rates of cattle in Adamawa State, Nigeria. High calving rates of 85.00, 80.00 and 75.00% were recorded in Mubi North, Gombi and Jada LGAs respectively during the late rainy season (LRS), while 85.00, 80.00 and 55.00% were reported respectively during the early dry season (EDS). These high rates are possible because of the availability of forages and crop residues during the periods, which coincide with high natural supply of nutrients to the animals and good atmospheric conditions for breeding and calving. Low calving rates were however recorded during late dry (25.00 - 40.00%) and early rainy (5.00 - 15.00%) seasons during which critical natural resources are limiting.

These critical periods are usually characterized by lean feed resources of poor quality as well as high wind and dust borne diseases. During these periods, the pasture and range lands become defunct, forages are dried up and bush fire clears large proportion of pastures leaving only forages along river banks, crop residues and by-products as the only sources of feed for cattle to scavenge. As a result of this, animals are unable to meet their protein and energy needs from available low-quality herbage with consequent marked weight loss and productivity (Adegbola, 1998).

Table 4.4: Seasonal calving rates of cattle in Adamawa State

Parameters	*Mubi North LGA*		*Gombi LGA*		*Jada LGA*	
	Freq.	*%*	*Freq.*	*%*	*Freq.*	*%*
Late Rainy Season (LRS July -September)						
High	85	85	80	80	75	75
Average	10	10	15	15	20	20
Low	5	5	5	5	5	5
Early Dry Season (EDR, October - December)						
High	55	55	85	85	80	80
Average	41	41	10	10	15	15
Low	4	4	5	5	5	5
Late Dry Season (LDS, January - March)						
High	25	25	30	30	40	40
Average	40	40	40	40	40	40
Low	35	35	30	30	20	20
Early Rainy Season (ERS, April - June)						
High	15	15	10	10	5	5
Average	25	25	20	20	25	25
Low	60	60	70	70	70	70

Key: LRS = Late Rainy Season, EDS = Early Dry Season, LDS = Late Dry Season, ERS = Early Rainy Season; Sample Size: N = 100/ LGA.

For example, studies have shown that the crude protein (CP) content of native grasses during the dry season is about 1.5 to 3% (Adamu *et al.,* 1993) and is far below the minimum level of 7% CP required in forages to enhance voluntary intake, digestibility and utilization by ruminants. Thus, the conservation and utilization of cheap and readily available feedstuff is a major challenge facing livestock farmers in northern Nigeria amidst feed crisis (Bogoro, 1997). These cheap feed resources include crop residues, agro-industrial by products, animal processing wastes, brewery waste and by-products, farm animal wastes (poultry litters, animal faeces) and other forms of fibre, protein and energy by-products suitable for ruminant feeding as well as browse plants (Adegbola, 1985; Alhassan *et al.*, 1987).

4.1.4 Ethno veterinary medicine approaches in Adamawa state

McCorke (1986) reported that ethno-veterinary medicine (EVM) is a scientific term for traditional animal health care that encompasses the knowledge, skills, methods, practices, and beliefs about animal health care found among community members. Similarly, Misra and Kumar (2004) stated that, EVM is the community-based local or indigenous knowledge and methods of caring for, healing and managing livestock. This also includes social practices and the ways in which livestock are incorporated into farming systems. Table 4.5 showed the common ethno veterinary medicines and ingredients in Adamawa state. It was observed that 12 different plant parts, such as roots, barks, leaves, flowers, juice or nectars, fruits, seeds, vegetable oils, castor oil, sugar, wood ash and charcoal are used in ethno-veterinary preparations. Fourteen (14) parts and products of animals, such as horns, skins and hides, bones, milk, butter, cod liver oil, fish oil, snake oil, old honey and even urine and dung also form the ingredients for ethno-veterinary preparations.

Table 4.5: Ethno veterinary medicine and ingredients in Adamawa State

S/N	*Plant parts*	*Animal parts*	*Earth material*	*Spiritual force*
1	Roots	Horns	Salt	Prayers
2	Barks	Hides/Skins	Edible earth	Dance
3	Leaves	Bones	Termite/anthills	Incantations
4	Flowers	Milk	Magic stones	Rituals
5	Juice/ Nectars	Butter	Limestone	Sacrifice
6	Fruits	Cod liver oil	Red potash	Koran slate
7	Seeds	Fish oil		Charms
8	Vegetable oils	snake oil		Hot iron
9	Ash/Charcoal	Urine/ Dung		
10	Castor oil	Spleen/Liver		
11	Palm oil	Rumen		
12	Sugar	Old honey		
13		Feathers		
14		Spines		
Total	12	14	6	8

Other ethno-veterinary ingredients include 6 earth materials such as edible earth, termite and anthills, magic black stones, limestone, salt and red potash, which are commonly used in decoctions and concoctions based on their healing and preservative properties. These findings support the report of Okoli *et al*. (2010) that ethno veterinary medicine in West Africa is usually made up of many components that may include ethno botany, ethno - practice and magic among others.

The common plant parts used were bark of *Vitex doniana*, fruit of *Hibiscus esculentus* and the leaves of *Carica papaya*, whole *Aloe vera* plant, *Glyphea brevis*, are used for high fever, bark of dargaza (draw) plant are used to formulate a draw solution which is used to remove retained placenta in cattle and treatment of bloat. Biter leaves, bark of acacia plant and its fruits, citrus plant and neem tree are used for the control of helminth in cattle. Ground nut and palm oil, salt and detergent solution are used for the treatment of constipation in calves and bloat treatment in adult, especially when polythene back is ingested.

Eight (8) spiritual practices were also employed, especially invocations and prayers during rituals. It was indeed found that rituals are important in the interaction between African livestock keepers and their animals. To ensure that the herd thrives and increases in size, animal husbandry is usually ritualized. For example, numerous rituals are performed, such as invoking the gods through dance or the sacrifice of an animal, while others may involve writing a phrase on the Koran slate and washing it into a calabash. The liquid is then used to drench the sick animal. Ritual incantations, human spit and prayers are sometimes connected with particular plants and special ingredients. Some protective charms are also hung on the neck of animals to protect them from theft and calamities, while hot iron is used in branding and tattooing the animals for the treatment of ailments (Ibrahim *et al*., 1983).

4.1.5 Seasonal cattle feed resources characteristic in Adamawa State, Nigeria

(a) Seasonal forage resources availability in Adamawa State

The results of seasonal feed resources availability in all the study locations are presented in table 4.6. The study revealed that 90.00% of the farmers at the three locations depended on natural pastures and range lands for feeding their cattle during late rainy (July to September) as against 10.00% dependence on crop residues, by-products and browses. During early dry (October to December), 70.00 - 80.00% of farmers depended on natural grasses against 20.00 - 30.00% dependence on other sources. It was observed that there are abundant forages and browses in the pasture and range lands during these seasons which gradually mature, as the seasons progress. During these periods, the Fulani herdsman makes excellent use of sign language, the cane or stick and verbal command to drive the animals, with faster animals occupying the front rows.

During the late dry (January to March) and early rainy (April to June) seasons, about 60.00 to 85.00% of cattle herds rely more on crop residues, by-products and browses to supply the nutrient needs of their animals. This is because, the annual forages have been grazed to defunct and where standing hay are common, the forages have lost their nutrient contents and bush fire may have consumed major grazing areas ((Smith, 1992; Adegbola, 1998; Aregheore, 2001). It was also observed that, during these periods, crop farmers have finished harvesting their crops, the residues and by-products are therefore, sold or given free of charge to cattle producers to graze their animals on. Movement and splitting of herds are also common methods adopted to solve the problem of lean feed resources during these critical periods of the year. However, scientific forage conservation is not a common practice amongst the cattle producers (Adegbola, 1998).

Table 4.6: Seasonal feed resources characterization in Adamawa State

Feed Resources	*Mubi North LGA*		*Gombi LGA*		*Jada LGA*	
	Freq.	*%*	*Freq.*	*%*	*Freq.*	*%*
Late Rainy Season (LRS July -September)						
Pasture and Range lands	90	90	90	90	90	90
Crop residues/ Browses	10	10	10	10	10	10
Concentrates	-	-	-	-	-	-
Early Dry Season (EDR, October - December)						
Pasture and Range lands	80	80	70	70	70	70
Crop residues/ Browses	20	20	30	30	30	30
Concentrates	-	-	-	-	-	-
Late Dry Season (LDS, January - March)						
Pasture and Range lands	15	15	20	20	40	40
Crop residues/ Browses	85	85	80	80	60	60
Concentrates	-	-	-	-	-	-
Early Rainy Season (ERS, April - June)						
Pasture and Range lands	10	10	15	15	10	10
Crop residues/ Browses	80	80	85	85	80	80
Concentrates	10	10	-	-	10	10

The results also showed that concentrates were not offered to cattle during the feed resources abundant seasons and only few pastoralists (10.00%) offered concentrate and salt lick to their cattle to supplement for nutrients and minerals obtained from forages during the early rainy season periods. This could be due to the fact that concentrates and salt licks are expensive. These results also corroborate that of Okoli *et al. (*2012) who reported pastoralist cattle production to be based on grazing natural pastures in synchrony to the rain fall regimes that drive biomass availability in south-eastern Nigeria. Nweze *et al*. (2012) reported similar findings that animals virtually depend on the naturally available pastures for nutrients supply and that feed resources of pastoralist cattle consists mainly of grasses, legumes, browses and cereal crop residues indigenous to the production zones.

However, Ogunbosoye and Babayemi (2010) reported that tropical grass fodder and crop by-products available during dry season have low nutritive values due to their low protein and fermentable energy. These plants grow rapidly during the period of heavy rainfall and high temperature and this leads to grass maturing early and so contains high level of lignin. The nutritive value of pastures fall rapidly with maturity and during the dry season, the available feed is lignified. It is therefore the search for better feed resources that drive the herding cycle of the Fulani. Describing this annual herding cycle of the Fulani during these periods, Fricke (1979), Vengroff (1980) and Iro (1994) stated that the herding season begins with southward movement of the herds and along rivers and stream valleys from October to December marking the end of rainy season and beginning of dry season as detected by the southly movement of winds. January to February is the harmattan season, characterized by longer grazing hours, herd splitting, and more frequent visits to stable water sources and marks increase in the southward movement of the herds. March and April are usually the toughest for the herdsmen and their cattle, as they are the hottest periods in the grazing calendar, making cattle herding possible only in the early morning hours and late evenings (Riesman, 1977). May and June signify the end of dry season and vegetation begins to appear. This also marks the beginning of northward movement of cattle herds as detected by northly movement of winds. From this period up till September, which is the peak of rainy season, is characterized by high cattle-breeding, more milk production and shorter grazing hours. According to Iro (1994), herding is a daunting task, with about 75% of sampled pastoralists maintaining that cattle herding is not only toilsome, but also becoming increasingly strenuous.

(b) Forage grasses distribution during wet periods in Adamawa State

The results of the distribution of common forage grasses grazed by cattle during the wet periods in the study areas are shown in table 4.7. The study adopted the aspects of the data published by Aregheore (2001) as a complement to the primary data generated during limited field visits to the study locations due to incessant terrorist activities that prevented a comprehensive survey. The results showed that 22 forage grasses were grazed by cattle during the wet periods across the three study locations.

The ranking of the forage resources were done based on their availability and uses. Those forages that were commonly available with multiple or more than two uses were ranked the most valuable making the list of 1 - 17, while 18 – 22 on the list with one to two uses only were ranked as the less valuable. Thus, some of the forage plants apart from being used as livestock feeds are also consumed by humans as food and medicine. Other uses of the forage plants by the pastoralists include construction of shelters, tents, roofing, beddings, mats and fuel. The findings support the report of Peters *et al*. (2001) who surveyed common forages in Central America and West Africa and their roles in reducing poverty and degradation of natural resources in tropical production systems.

Table 4.7: Commonly grazed forage grasses during wet period

S/n	*Botanical Name*	*Hausa Name*	*Mubi North LGA*	*Gombi LGA*	*Jada LGA*	*Freq*
1	*Panicum purpureum*	Ciyawan zana	+	+	+	3
2	*Panicum maximum*	Ciyawan tufaniya	+	+	+	3
3	*Andropogon gayanus*	Ciyawan jinka	+	+	+	3
4	*Cynodon plectostachyus*		+	+	+	3
5	*Chloris gayana*		+	+	+	3
6	*Brachiaria decumbens*		+	+	+	3
7	*Digitaria decumbens*		+	+	+	3
8	*Hyparrhenia rufa*		+	+	+	3
9	*Imperata cylindrica*		+	+	+	3
10	*Cenchrus ciliaris*		+	+	+	3
11	*Cynodon dactylon*		+	+	+	3
12	*Sorghum spp*	Dawa	+	+	+	3
13	*Sorghum bicolar*	Jigari	+	+	+	3
14	*Pennisetum americanum*	Maiwa	+	+	+	3
15	Zea mays	Masara	+	+	+	3
16	*Saccharum officinarum*	Rekke	+	+	+	3
17	*Oryza sativa*	Shinkafa	+	+	+	3
18	*Axonopus compressus*	Kirikiri	+	+	+	3
19	*Tripsacum laxum*		+	+	+	3
20	*Digitaria smutsii*		+	+	+	3
21	*Setaria anceps*		+	+	+	3
22	*Elusine indica*		+	+	+	3
Total			22	22	22	66

The results also agree with Babayemi *et al*. (2014) who enumerated some of the common grass forage resources in Nigeria. Smith (1992) and Aregheore (2001) surveyed available forage resources in the savannah zones of Nigeria and reported that forages grow rapidly during the wet season, becoming fibrous and coarse and are under-grazed because of the large amounts that become rapidly available. Their quality however, declines during the dry season when they become standing hay and are subject to overgrazing.

(c) Forage legumes distribution during wet period in Adamawa State

The results of common forage legumes grazed by cattle during the wet periods in the study areas are shown in table 4.8 and also represent an amalgamation of our limited field survey and the data published by Aregheore (2001). Nineteen (19) common forage legumes were grazed by cattle during the wet periods, with little differences in plant composition across the three study locations. Plants identified appeared at the three locations except *Stylosanthes guinensis, Stylosanthes hamata* and *Stylosanthes humilis,* which were not common to Jada LGA.

Also the ranking of the forage legume resources were done as described under the forage grasses. Those legumes that were commonly available with multiple or more than two uses were ranked the most valuable and making the list of 1 - 10, while 11 - 19 with one to two uses only were ranked as the less valuable. The results agree with that of Devendra (1990) who reported that, leguminous forages and the foliage of multipurpose trees found in Africa are promising sources of protein if used as a supplement to ruminants receiving low-quality forages. This result expectedly disagree with the report of Okoli *et al.* (2003) who reported much more browse resources in tropical humid rain forest of southeastern Nigeria than the few highlighted here, but agrees with Babayemi *et al*. (2014) who listed some of the common legume resources found in West Africa and Nigeria.

Table 4.8: Commonly grazed forage legumes during wet period

S/n	*Botanical Name*	*Hausa Name*	*Mubi North LGA*	*Gombi LGA*	*Jada LGA*	*Freq.*
1	*Stylosanthes guinensis*		+	+	-	2
2	*Stylosanthes hamata*		+	+	-	2
3	*Pueraria phaseoloides*		+	+	+	3
4	*Lablab purpureus*	Waken daji	+	+	+	3
5	*Glycine max*	Waken soya	+	+	+	3
6	*Arachis hypogaea*	Gweda	+	+	+	3
7	*Vigna unguiculata*	Wake	+	+	+	3
8	*Cajanus cajan*	Gyedan biri	+	+	+	3
9	*Centrosema pubescens*		+	+	+	3
10	*Stylosanthes humilis*		+	+	-	2
11	*Desmodium scorpiurus*		+	+	+	3
12	*Desmodium intortum*		+	+	+	3
13	*Gliricidia sepium*		+	+	+	3
14	*Macroptilium atropurpureum*		+	+	+	3
15	*Neonotonia wightii*		+	+	+	3
16	*Mucuna utilis*		+	+	+	3
17	*Stylosanthes gracilis*		+	+	+	3
18	*Macrotyloma axillare*		+	+	+	3
19	*Centrosema molle*		+	+	+	3
Total			19	19	16	54

(d) Crop residue and by-products distribution during dry periods in Adamawa State

Data in Table 4.9 revealed that 12 crop residues and 7 by-products were commonly offered to cattle during the dry periods as supplements to lean feed resources. The results also showed very few differences between residues and by-products used at the three study locations. Every dry season feed resource identified, appeared in all the three locations except some agro-industrial wastes such as sugar cane straw, molasses and cotton seed cake, which were common only in Jada LGA. This could be because of the location of the Savannah Sugar Company of Nigeria and African Cotton Company in the senatorial zone. The uniformity of geographic and ecological zone (guinea savannah), which is characterized by short duration of rainy seasons, low humidity and high sun intensity favors cereal crop production in the study area.

Grain residues were ranked low by the farmers even though they are commonly abundant and cheap to obtain but are not properly handled and poorly utilized by the animals, while by-products though scarce and expensive were ranked highest in the study area because of the animals' ability to utilize them better. The findings also supported that of Adegbola (1985) and Alhassan *et al.* (1987) who reported that cheap feed resources in Nigeria include crop residues, agro-industrial by products, animal processing wastes, brewery waste and by-products, farm animal wastes such as poultry litters, animal faeces and other forms of fibre, protein and energy by-products suitable for ruminant feeding as well as browse plants. In another report, Adegbola (1998) stated that these availability of crop residues are characterized by high content of fibre usually above 40%, low content of nitrogen (0.3 - 1.0%) and low content of essential minerals such as sodium, phosphorous and calcium.

Table 4.9: Commonly fed crop residues and by-products during dry period

S/N	English Name	Hausa Name	Mubi North LGA	Gombi LGA	Jada LGA	Frequency
Crop residues						
1	Maize Stover	Karan Masara	+	+	+	3
2	Sorghum Stover	Karan Jigari/ Dawa	+	+	+	3
3	Sorghum Shafts	Kaikaiyin Jigari/Dawa	+	+	+	3
4	Millet Stover	Karan Maiwa	+	+	+	3
5	Yam Peels	Bawon Doya	+	+	+	3
6	Cassava Peels	Bawon Rogo	+	+	+	3
7	Sweet Potato Peels	Bawon Dankali	+	+	+	3
8	Rice Straws	HarawanShinkafa	+	+	+	3
9	Groundnut Straws	Harawan Gyeda	+	+	+	3
10	Cowpea Husk	KaikaiyinWake	+	+	+	3
11	Cowpea Straw	Harawanwake	+	+	+	3
12	Sugarcane Straws	Harawan Reke	-	-	+	1
By-products						
1	Sorghum Bran	Dusan Jigari/Dawa	+	+	+	3
2	Maize Bran	Dusan Masara	+	+	+	3
3	Millet Bran	Dusan Maiwa	+	+	+	3
4	Rice Bran	DusanShinkafa	+	+	+	3
5	Brewers Waste	Dusan Giya	+	+	+	3
6	Molasses	Ruwan Reke	-	-	+	1
7	Cotton Seed Cake	Angurya	-	-	+	1
Total			16	16	19	51

Almost all crops cultivated for human consumption contain residual materials which can be consumed and converted to valuable products by livestock. Estimates in Africa alone show that more than 340 million tones of fibrous crop residues are produced annually (Kossila, 1984; Umunna & Iji, 1993). Research has shown that over 111.5 million tones of crop residues are produced in Nigeria each year. These consist of 24.6 million tonnes of millet, 17.2 million tonnes of guinea corn, 2.5 million tonnes of maize, 0.2 million tonnes of rice, 1.3 million tonnes of groundnut and 3.7 million tonnes of cowpea residues estimated at the major production areas of Sokoto, Kano, Bauchi, Adamawa, Kaduna, Benue, Borno and Anambra States of Nigeria (Alhassan, 1985).

It was observed in this study that most of the crop residues are abundant during the months of October to December (early dry season), while they are mostly needed and utilized between March and July (late dry and early rainy seasons), when the available pasture is low in quantity and quality. These abundant crop residues can supply enough roughage for the ruminant population in the country if properly harnessed, processed and preserved. When crop residues are fed to ruminants, their intake is low and their utilization is limited by the slow rate of total degradability and the rate at which particles are broken down to a critical size small enough to leave the rumen. There is therefore, the need for their further processing, especially grinding to smaller the particle sizes.

(e) Browsed tree resources distribution during dry season in Adamawa State

The results of this study revealed 10 common tree browses that serve as dry periods feed resources in the study locations (Table 4.10). The results support the report of Okoli *et al.* (2003) that there is an abundance of tropical browse plants available to ruminants in Nigeria. Earlier reports by Olayemi, Omokaye, Onifade, Lakpini, and Afolayan (1998) and Omokaye, Balogun, Onifade, Afolayan, and Olayemi (2001) have also highlighted the available browse resources in Nigeria,

Table 4.10: Commonly browsed tree resources during dry period

S/n	*Botanical Name*	*English Name*	*Hausa Name*	*Mubi North LGA*	*Gombi LGA*	*Jada LGA*	*Freq*
1	*Acacia xanthophloea*	Acacia	Madaji	+	+	+	3
2	*Leucaena leucocephala*	Leucaena		+	+	+	3
3	*Moringa oleifera*	Moringa	Zoggale	+	+	+	3
4	*Balanites aegyptica*		Adua	+	+	+	3
5	*Khaya senegalensis*			+	+	+	3
6	*Tamarindus indica*	Tamarine	Tsamiya	+	+	+	3
7	*Terminalia vicenoides*			+	+	+	3
8	*Mangifera indica*	Mango	Mangoro	+	+	+	3
9	*Afzelia Africana*			+	+	+	3
10	*Ficus polita*			+	+	+	3
Total				10	10	10	30

while Opara (1996) and Oji and Isilebo (2000) reported that such browse plants provide the vitamins and mineral elements, which are frequently lacking in grassland pastures. Their year round evergreen presentation and nutritional abundance provides for year round provision of fodder. The diversity and distribution of browse plants of northern Nigeria have also received attention in studies carried out in the north (Saleem *et al*., 1979) and middle belt (Ibeawuchi *et al.*, 2002) of Nigeria. Odoh and Adamu-Noma (2000) stated that browses enable standing feed reserve to be built so that herds can survive critical periods of shortfall, or even prolonged periods of drought, without remarkable weight losses.

In recent time however, deforestation, urbanization and bush burning have become major factors responsible for dwindling proceeds of browse feed resources for ruminant livestock, especially in northern Nigeria. For example, according to Yahya *et al.* (2000), traditional herdsmen and other pastoral groups habitually cut down branches from various tree species such as *Acacia, Adamasonia* and *Ficus spp,* making them available to livestock during the dry season, when no other forage is available. Browse plants, beside grasses, constitute one of the cheapest sources of feed for ruminants.

Many browse species have chemicals that appear to be produced for the purpose of deterring invasion or consumption of their leaves by microbes, insects and herbivorous animals (Njidda, 2010). However, Gidado, Kibon, Gwargwor, Mbaya, and Baba (2013) in their study of anti-nutritive factors and nutrient composition of some selected browse plants used as livestock feeds in neighboring Taraba State reported that the effects of high protein forage could override the effect of the toxic compounds when used in a right proportion as supplement in the diets.

(f) Seasonal livestock water resources characteristics in Adamawa State

Table 4.11 showed that 70.00 to 90.00% of the cattle producers in the three locations depended solely on natural flowing streams and rivers for the supply of water to their cattle during late rainy (July to September) and early dry (October to December) seasons. It was observed that during these periods, the streams and rivers still have abundant running waters. However, during the late dry (January to March) and early rainy (April to June) seasons, about 65.00 to 70.00% of cattle herds relied on ponds, dams and wells to meet their water requirements, with few having access to boreholes and tap water.

This is because streams and rivers dry out shortly after the rains have stopped since the duration of rainy season ranges from 3 to 4 months in the study area. Again, it was observed that the farmers did not make any effort to trap and preserve rain water for their cattle and other domestic needs. Building and construction of ponds, dams and wells are capital intensive projects for the individual cattle producers who mostly keep livestock for subsistence. The cost of drilling boreholes and fixing tap water is also beyond the reach of common livestock producers.

These results agree with Kubkomawa and Williams (2010b) who reported that shortages and scarcity of potable water supply in Yang ward of Lala District in Gombi LGA of Adamawa state is endemic and affects the people and their livestock, especially during the dry season. They also investigated alternatives to ground water sources and recommended rainwater harvesting as a viable alternative for solving the problem of water supply shortages for domestic and agricultural purposes in the area.

Table 4.11: Seasonal water resources characteristics in Adamawa State

Water resources	*Mubi North LGA*		*Gombi LGA*		*Jada LGA*	
	Freq.	*%*	*Freq.*	*%*	*Freq.*	*%*
Late Rainy Season (LRS July -September)						
Streams/Rivers	85	85	90	90	80	80
Ponds/Dams/Wells	10	10	5	5	15	15
Boreholes/Taps	5	5	5	5	5	5
Early Dry Season (EDR, October - December)						
Streams/Rivers	75	75	70	70	75	75
Ponds/Dams/Wells	15	15	15	15	15	15
Boreholes/Taps	10	10	15	15	10	10
Late Dry Season (LDS, January - March)						
Streams/Rivers	25	25	20	20	10	10
Ponds/Dams/Wells	65	65	60	60	70	70
Boreholes/Taps	10	10	20	20	20	20
Early Rainy Season (ERS, April - June)						
Streams/Rivers	15	15	10	10	10	10
Ponds/Dams/Wells	70	70	70	70	70	70
Boreholes/Taps	15	15	20	20	20	20

4.1.6 Constraints to cattle production in Adamawa State, Nigeria

The results of constraints to cattle production in Adamawa state are presented in table 4.12. Chief among the constraints identified by pastoralists was diminishing natural resources characterized by shrinking land due to expansion in arable farming, land excavations for construction, industrialization and mining activities (43.33%), which have resulted in shortage of natural forage lands for livestock grazing and seasonality in feed and water supply with Mubi North and Jada having 45.00% each followed by Gombi with 40.00%. These results corroborate that of Shiawoya and Tsado (2011) who reported similar findings in line with other reports by Hesse and MacGregor (2006), Okoli and Kalla (2008) and Ofuoku and Kife (2009) that shrinking pastoral land with the opportunities for pastoral people to make a viable living has put the industry in a serious crisis. Indeed, political and economic factors are combining to replace pastoral grazing land with other allegedly more beneficial land uses (Hesse & MacGregor, 2006). Eroding feeding resource has also been linked by farmers to changes in economy, inappropriate aid, conversion of range lands and mixed farming systems for crop production and game parks.

Second to diminishing nutritional resources, were environmental and health constraints characterizes by desertification, climate change, insecurity, conflicts and diseases that received a score of 33.33% from the cattle producers (Table 4.12). Across the three study locations, these problems were scored 35.00% at Mubi north and Gombi LGAs and 30.00% at Jada LGA. These conflicts between pastoralists and crop producers, insecurity, wars and other forms of socio-political problems have become more frequent and have led to livestock owners moving their stock out of their usual areas of operation, thus, increasing the possibility of mixing with other breeds thereby potentially losing location-

Table 4.12: Constraints to cattle production in Adamawa state

Major constraints	*Mubi North LGA*		*Gombi LGA*		*Jada LGA*		*%*
	Freq.	*%*	*Freq.*	*%*	*Freq.*	*%*	*Mean*
(a) Nutrition							
Seasonal feed and water shortage, shrinking pasture and range lands	45	45	40	40	45	45	43.33
(b) Environmental and Health							
Desertification and climate change, conflicts/ insecurity, diseases and parasites	35	35	35	35	30	30	33.33
(c) Government Policy							
Lack of govt. support, lack of good markets, activities of middle men	20	20	25	25	25	25	23.33
Total	100	100	100	100	100	100	100.00

specific breeds (Hansen, 1992). These findings also corroborate that of Okoli *et al*. (2014) who reported that pastoral communities in Nigeria are increasingly moving and settling southwards in the humid tropical rain forests in responses to changing sahelian and savannah environments traditionally occupied by them. This creates conflicts with crop farmers in the tropical rainforests and threatens pastoral access to shared natural resources, thus impacting on the sustainability and future of pastoralism in Nigeria (Okoli *et al.*, 2014). In addition, natural disasters such as flood, drought, famine, desertification, global warming, and livestock diseases and parasites have in numerous cases resulted to breeds of cattle dying out (Spore, 2005; Okoli & Kalla, 2008).

It has also been observed (Muhammad & Ardo, 2010) that lack of good government policies on pastoralism, lack of grazing reserves and grazing routes, lack of financial support from government and financial institutions; lack of good cattle markets and marketing strategies with too many middle men also form part of the problems of cattle production at the study sites. Interestingly government policy characterized by lack of support, good market and activities of middle men received a lowly overall score of 23.33% by the farmers as minor constraint to cattle production in the study area. This low score may be linked to the low literacy rate among the pastoraloists which may prevent them from appreciating the components of their rights as citizens of Nigeria. These results corroborate that of Mapiye *et al*. (2009) who stated similar impediments to cattle production and breeding efficiency on grazing rangelands of South Africa, especially during the dry season.

Pastoral livestock management is becoming increasingly difficult in northern Nigeria due to lack of access to enough land in the wake of rapid population growth and agricultural expansion which result in competitive demand for land resources (Nori & Davies, 2007). The current land use pattern and natural resource development and conservation in Nigeria show that pastoralism is at cross-roads with uncertain future. Livestock development and empowerment of pastoralists is plagued by a number of problems which, among those already listed may include low biomass yields, scarcities of water, poor carrying capacities of available land, concentration of endemic diseases and parasites, low literacy rates and physical isolation of pastoralists, absence of functional extension services, distorted agricultural development policies as well as an enduring disconnect between government and aspirations of the pastoralists (Okoli & Kalla, 2008; Muhammad & Ardo, 2010).

4.2 Morpho-physiological Characteristics of Cattle Grazing the Guinea Savannah Zone of Adamawa State, Nigeria

4.2.1 Body condition scores (BCS) of cattle of in Adamawa State, Nigeria

Body weights and condition scoring are the traditional methods used to assess nutritional status of animals (Ndlovu *et al*., 2007; Addass, 2011). This is because nutritional status of cattle is useful in quantifying the extent to which diseases or other environmental factors affect cattle, especially where seasonal fluctuations in the quantity and quality of forages occur, as is common during different seasons in tropical and sub-tropical areas (Flier & Maragos - Flier, 2000). The purpose of condition scoring therefore is to achieve a balance between economic feeding, good production and good welfare (Todd, 2008). Another objective of body condition scoring is to ensure that cows calve down safely whether on pastoral or semi-sedentary production system. According to the report of Akpa, Umar, and Alphonsus (2011), calving ease increases with age, parity and body condition score of a dam. Poor body condition is associated with reduced income per cow, increased post-partum interval, weak calves at birth, low quality and quantity of colostrums, reduced milk production, increased dystocia, and lower weaning weights (Akpa *et al*., 2011). This indicates that BCS is one of the most important factors in determining subsequent reproductive performance of cattle (Gatenby, 2002). The BCS of cattle in Adamawa state, Nigeria are shown in table 4.13, figures V, VI, VII and VIII.

(a) Location effects on BCS of cattle

Table 4.13a shows the results of mean body condition scores of cattle grazing the different study locations in the guinea savannah zone of Adamawa state. There were insignificant ($p > 0.05$) differences among the mean body condition scores of cattle at the three study locations although, higher BCS was recorded in Mubi North LGA followed by Jada and Gombi LGAs. This similarity in BCS could be linked to the similarity in climatic conditions of the zone which influenced forage productivity and biomass availability. The animals examined had body condition scores ranging from 2.0 to 4.0. These values are normal for Zebu cattle under pastoral and semi-sedentary systems of management in tropical environments like ours and are in agreement with the earlier reports of Stuth *et al*. (1998) that body condition score reflects the plane of nutrition on which an animal has been exposed over a reasonable length of time. Kubkomawa *et al*. (2010a) also reported mean body condition score of repeat breeder cows to be 3 in four Local Government Areas of Adamawa State, Nigeria. The present results also agree with the reports of 3.15 BCS by Alphonsus *et al*. (2012) for Bunaji and Friesian cows grazed at the National Animal Production Research Institute (NAPRI) Shika, Nigeria.

Table 4.13: Body condition scores (BCS) of cattle in Adamawa State, Nigeria

Distribution of mean BCS	Minimum	Maximum	Mean	SEM
(a) Effect of location on mean BCS				
Mubi North	2.000	4.000	3.0320	0.0169
Gombi	2.000	4.000	2.9980	
Jada	2.000	4.000	3.0245	
(b) Sex effects on mean BCS				
Male	2.000	4.000	3.0145	0.0138
Female	2.000	3.500	3.0218	
(c) Breed effects on mean BCS				
White Fulani	2.000	4.000	2.9326^{a}	0.0195
Red Bororo	2.000	4.000	3.0234^{b}	
Sokoto Gudali	2.000	3.500	3.0161^{b}	
Adamawa Gudali	2.000	4.000	3.1004^{c}	
(d) Mgt effects on mean BCS				
Pastoral	2.000	3.500	2.8564^{a}	0.0138
Semi - sedentary	2.000	4.000	3.1799^{b}	
(e) Seasonal effects on mean BCS				
Late Rainy Season (LRS)	2.000	4.000	3.1016^{a}	0.0195
Early Dry Season (EDS)	2.000	4.000	3.0342^{b}	
Late Dry Season (LDS)	2.000	4.000	3.0098^{b}	
Early Rainy Season (ERS)	2.000	3.500	2.9271^{c}	

abc means with different superscript(s) are significantly different ($p < 0.05$)

(b) Sex effects on BCS of cattle

Table 4.13b showed that there were no significant ($p > 0.05$) differences in the mean BCS of male and female cattle in the study area. However, it was observed that female animals had higher mean BCS than males, although on individual basis, the best BCS of 4 was found among the male cattle. This was likely because some of the bulls were more physically strong compared to cows and can compete better in terms of feeding. The physically strong bulls also have the tendency to bully weak ones, thereby giving them higher opportunity for more bites per square meter of pasture land compared to other animals. The size difference between male and female animals is usually not due to genes but hormonal differences. Androgen in the mature male has anabolic effect and is therefore, responsible for the bigger frame of the male animals (Lawrence & Fowler, 1997).

Several authors have associated body condition score with sex and fertility (Buckley *et al.*, 2003) and health (Roche & Berry, 2006) indicating that the higher the body conditions the better in terms of productivity. Addass (2011) also reported that bulls with body condition scores of 4 appeared in good conformation and had higher sperm reserves compared to those with lower body condition scores in Zebu cattle in the guinea savannah zone of Adamawa State. In breeding cows, heifers and bulls', body condition is closely related to fertility and forage convertibility, while in beef cattle, steers and heifers raised for beef production, BCS determines health, ability to gain and when the animals are ready for slaughter (Gatenby, 2002).

(c) Breed effects on BCS of cattle

Table 4.13c shows that the mean BCS of Adamawa Gudali was significantly ($p < 0.05$) higher than White Fulani, Red Bororo and Sokoto Gudali. Again, the mean body BCS of

Red Bororo and Sokoto Gudali were significantly ($p < 0.05$) higher than that of White Fulani cattle. The results also showed insignificant ($p > 0.05$) differences between the mean BCS of Red Bororo and that of Sokoto Gudali. This implies that Adamawa Gudali breed is the best cattle found as measured by BCS in the study area and could be attributed to genetic makeup of the cattle since it phenotypically resembles Muturu and Ndama breeds in body size and frame. Adamawa Gudali is known to be smaller in stature, withstands more hardship and would probably require fewer nutrients for maintenance and productivity compared to the larger framed breeds which may need a lot of reserve energy to maintain the body conformation and production (Katie & Alistair, 1986; Williamson & Payne, 1990). The results corroborate earlier study conducted by Wright and Russell (1984) who stated that although the BCS gives a good indication of fatness, breeds differ in the way they deposit fat reserves. Dairy cattle generally deposit more fat internally than do beef cattle.

(d) Management effects on BCS of cattle

The results of the mean body condition scores of cattle differed significantly ($p < 0.05$) between the two management systems investigated (Table 4.13d). Cattle raised under semi-sedentary system had higher body condition scores compared to those on pastoral system. This is probably because under semi-sedentary system, cattle had better access to crop residues and by-products, occasional feed supplementation, veterinary services and water supply (Okoli *et al.*, 2012). Pastoral cattle have been reported to face divers issues such as stress, shortages of forages, limited access to crop residues and by-products, limited veterinary facilities and water resources, especially during the dry periods (Oulun, 2005; Agenas *et al*., 2006). The results corroborated the earlier reports of Akpa *et al*. (2012) that body condition scores allow producers to group cattle according to their nutritional requirements, thereby improving the efficiency of nutrition programs. The results also agree with Oulun (2005) and Agenas *et al*. (2006) who reported that body condition score is an objective indicator of nutritional status, which could be reliably and routinely used to aid management of cattle in rural areas.

(e) Seasonal effects on BCS of cattle

The results of mean body condition scores of cattle differed significantly ($p < 0.05$) across four seasons as shown in table 4.13e. LRS recorded the highest mean body condition score followed by EDS, LDS and ERS respectively. This is not surprising because LRS coincides with the period of feed availability, especially luxuriant forages and browses. Water resources are also available with streams, ponds, dams, hand dug wells and surface run offs still flowing. At this period, migration of pastoralists is minimal because of the high intensity of crop farm lands in guinea savannah zones, while higher cases of crop farms destruction are common.

EDS (October - December) was another period where the animals had fair BCS because of the abundance of crop residues and by-products. At this period, pastures and range land forages have grown to maturity producing high lignin and fibre contents but low in protein and nitrogen. Even though the pastures may still be seen standing, they provide limited nutrients to the animals since the farmers do not usually harvest and process the matured forages to improve their palatability and digestibility (Adegbola, 1998). ERS (April to June) was another period when the animals had the lowest body condition scores. This is because the season is a critical period characterized by low feed availability and water resources. The pastures and crop residues obtained during the early dry season could not be sustained because of poor management and lack of proper handling procedures. Some crop residues and by-products are allowed to waste in the fields or consumed by straying animals and bush fire. Since this period marks the beginning of rains and rainstorms, the period is full of dust and heat that tends to contaminate and spoil the reminants of the crop residues and by- products (Adebayo, 1999).

The findings corroborated Odenyo *et al.* (1997), Shelton (2004) and Babayemi *et al.* (2004) who reported that during the dry periods in guinea savannah zones of Nigeria, diets for ruminant animals, especially forages, crop residues or by-products are limited by shortages in amount and quality which result in reduced livestock productivity in those arid and semi-arid zones of the country. The results also agree with Devendra (1989) who reported that in the Northern parts of the country, ruminants suffer greatly due to malnutrition because the nutrients available in the grass during the dry season do not meet their maintenance levels, making most animals to depend on other sources or non-conventional supplementary diets.

4.2.2 Rectal temperatures of cattle in Adamawa State, Nigeria

An animal's body temperature is the result of the balance between heat produced by basal metabolism and muscular activity of the body and the heat lost from the body (Jeffrey & Michael, 2010). Rectal temperatures have been used as reliable indicators of short term physical stress in animals (Oladimeji *et al.*, 1996; Ayo *et al.*, 1998). Cattle rectal temperatures have also been used in detection and management of diseases and changes in the state of estrus, heat stress and the onset of calving (Jeffrey & Michael, 2010). Attempts to measure body temperature of cattle have been made at various anatomical locations including rectum, ear (tympanic), vagina, reticulum-rumen and udder (milk) (Prendiville *et al*., 2002). The mean rectal temperatures (RT^{o}C) of cattle at Adamawa State, Nigeria are shown in table 4.14.

(a) Location effects on mean rectal temperatures of cattle

The results showed that the rectal temperatures of cattle from Mubi North and Gombi LGAs were significantly ($p < 0.05$) higher compared to cattle from Jada LGA, while there were no significant ($p > 0.05$) differences between means of those from Mubi North and that of Gombi LGAs (Table 4.14a). These variations in rectal temperatures of cattle within the same climatic zone could be due to individual animal physical activity, physiological status, solar radiation, environmental conditions, feeding and atmospheric humidity of the locations. However, despite the variations in the rectal temperatures of the cattle in this study, the results were within the normal range of 36.0 - 39.3^{0}C reported for tropical cattle (Hahn *et al*., 1990; Babayemi *et al*., 2014).

The results of the present studies also concur with that of Udeh, Akporhuarho, and Onogbe (2011), who reported similar rectal temperatures of Zebu and Muturu cattle to range from 38.96 to 39.96^{0}C in Delta State, Nigeria. When an animal's body temperature increases by at least 1°C above the normal upper limit, the animal is considered to have a fever and if it is below normal, it is called hypothermia (Prendiville *et al*., 2002). Although the measurement of temperature is one of the most characteristic and reliable methods for judging the degree of fever, it does not always have a direct relationship in animals, especially in cattle (Hahn *et al*., 1990). Other parameters such as chill, uneven distribution of the external temperature, pulse and respiration rates, appetite, digestion and morbidity (Babayemi *et al*., 2014), should also be considered. To use body temperature properly as a measure of illness, it is necessary to know what is normal (Babayemi *et al*., 2014). Unfortunately, normal temperatures for cattle rise during the day. In fact, body temperature in cattle follows a daily pattern where there is a period of increasing heat load and rising body temperature, then period of heat dissipation and falling body temperature. Cattle minimum body temperature usually occurs early in the morning and then steadily increases during the day (Amakiri & Funsho, 1979). They reported the mean morning (38·62°C) and late afternoon (39·19°C) rectal temperatures in cattle at Ibadan, Nigeria. In general, animal temperatures will vary, depending on breed, feeding, solar radiation, humidity, physical activity, stage of pregnancy, time of the day, and environmental surroundings (Babayemi *et al*., 2014).

Table 4.14: Rectal temperature (RT ^oC) of cattle in Adamawa State, Nigeria

Distribution of mean RT^o	Minimum	Maximum	Mean	SEM
(a) Effect of location on mean RT				
Mubi North	36.000	38.000	37.698^a	0.0378
Gombi	36.000	38.000	37.746^a	
Jada	36.000	38.000	37.411^b	
(b) Sex effects on mean RT				
Male	36.000	38.000	37.622	0.0309
Female	36.000	38.000	37.615	
(c) Breed effects on mean RT				
White Fulani	36.000	38.000	37.686^a	0.0436
Red Bororo	36.000	38.000	37.792^a	
Sokoto Gudali	36.000	38.000	37.760^a	
Adamawa Gudali	36.000	38.000	37.236^b	
(d) Mgt effects on mean RT				
Pastoral	36.000	38.000	37.180^a	0.0309
Semi - sedentary	36.000	38.000	36.057^b	
(e) Seasonal effects on mean RT				
Late Rainy Season (LRS)	36.000	38.000	37.719^a	0.0436
Early Dry Season (EDS)	36.000	38.000	37.728^a	
Late Dry Season (LDS)	36.000	38.000	37.768^a	
Early Rainy Season (ERS)	36.000	38.000	37.958^b	

abc means with different superscript(s) are significantly different ($p < 0.05$)

(b) Sex effects on rectal temperatures of cattle

The results showed no significant ($p>0.05$) differences between the mean rectal temperatures of male and that of female cattle at the study locations (Table 4.14b). However, males had higher values than the females. The similarity could be attributed to environmental conditions that the animals were exposed to. Those conditions may include nature of the climate, ambient temperatures, feed and water resources, handling and restraining methods, housing, grazing systems, diseases and parasite infestations. It could also be that majority of the female animals were open and not on estrus during the survey which resulted to their temperatures not being elevated beyond that of the males (Gaughan *et al*., 1999).

(c) Breed effects on rectal temperatures of cattle

The results of the study indicated that there were no significant ($p > 0.05$) differences in the mean rectal temperatures of White Fulani, Red Bororo and Sokoto Gudali breeds but that of Adamawa Gudali differed significantly ($p < 0.05$) from the other three breeds as shown in table 4.14c. Red Bororo had the highest value followed by Sokoto Gudali, White Fulani and Adamawa Gudali breeds in that order. The similarity observed in White Fulani, Red Bororo and Sokoto Gudali breeds could be because of their similar body size, since all of them have larger body frames compared to Adamwa Guadali breed which has smaller body frame (Adebayo, 1999). The differences could also be associated with differences in coat type and colour. Fadare, Peters, Adeleke, and Ozoje (2012) reported that coat color contributes to physiological adaptation in mammals and mediates response to thermal stress. Animals with light colored silk coats absorb less heat from the environment than dark colored woolly-coated animals. Coat color is a qualitative trait and an indicator of genetic superiority or productive adaptability of animals to heat tolerance (Helal, Hashem, Abdel-Fattah, & El-Shaer, 2010; McManus *et al*., 2011).

(d) Management effects on rectal temperatures of cattle

The results of the study showed significant ($p < 0.05$) variations between the mean rectal temperatures of cattle reared under the two management systems (Table 4.14d). Pastoral cattle recorded significantly higher mean rectal temperatures than those under semi-sedentary management system. This significant variation may be due to the management and handling or restraining methods used during the survey. The herdsmen under the pastoral system had to chase some of the animals around to catch them because of the nature of their kraals, while cattle in semi-sedentary management were restrained without much struggle because of their well constructed kraals with fitted strong crutches. The findings supported that of Clarke, Jeffery, and Kelly (1994) who reported that cattle gain heat from metabolic activity and the environment and acute elevations in body temperature occur directly after feeding or exercise.

(e) Seasonal effects on rectal temperatures of cattle

The results of the study showed no significant ($p > 0.05$) disparities in the mean rectal temperatures of cattle during the LRS, EDS and LDS respectively. However, the mean rectal temperature of cattle in ERS (April to June) was significantly ($p < 0.05$) higher than others (table 4.14e). This is probably a reflection of the effects of higher temperature and increasing humidity characteristic of this period of the year because of the return of the rains. Air temperature, solar radiation, relative humidity and wind speed are the important climatic variables that distinguish one season from the other (Clarke *et al*., 1994).

These results agree with Musa-Azara, Ogah, and Yakubu (2010), who reported mean morning rectal temperature of 38.2^0C during cold and 38.87^0C in the hot dry season and the mean afternoon temperature of 38.8^0C during the cold season, while 39.05^0 C during the hot-dry season in Holstein x Friesian in the guinea savannah zone of Nigeria. The values are however lower than that of Concepta, Helder, Tiago, Flávia, and Francisco

(2014), who reported higher rectal temperatures (38.5 to 39.5 ºC) in crossbred cattle in Central Brazil as compared with those of European animals in cold weather.

4.2.3 Respiratory rates of cattle in Adamawa State, Nigeria

Respiration is the act of breathing or taking in oxygen, using it in the body tissues and giving off carbon dioxide (Lu, 1989; Becker *et al.*, 1989). Respiration consists of inspiration, or the expansion of the chest or thorax and expiration, or the expulsion of air from the lungs. The normal respiratory rate in mature cattle at rest ranges from 10 to 30 breaths per minute (Gaughan *et al.*, 2000). Any deviation from the normal respiratory rates is frequently attributed to primary and secondary disease in cattle. Respiratory rates have been used as reliable indicators of physical stress in animals (Plyaschenko and Sidorov, 1987; Verstergen, 1987). Many diseases that affect all classes of farm animals spread and settle in areas of the respiratory system (Oladimeji *et al.*, 1996; Ayo *et al.*, 1998). The mean respiratory rates of cattle in Adamawa state are shown in table 4.15.

(a) Effect of location on mean respiratory rates of cattle in Adamawa State

Table 4.15a shows the mean respiratory rates of cattle grazing the guinea savannah zone of Adamawa state. The results showed that there were significant ($p < 0.05$) distinctions in the respiratory rates of cattle from Mubi North, Gombi and that of Jada LGAs respectively. However, Jada LGA had the highest value followed by Mubi North and Gombi LGAs that recorded the least rates. In any case, the respiratory rates of cattle obtained in this study fell within the normal range of 10 to 30 breathings per minute (Gaughan *et al*., 2000).

The values were higher than that of Babayemi *et al*. (2014) who reported in their text book that normal respiratory rate of cattle breeds in Nigeria ranges from 8 to 12 breathings per minute. These variations could be linked to factors such as body size, age, breed, exercise, excitement, ambient temperature, atmospheric conditions, pregnancy, and fullness of the digestive tract. It was also observed that, small framed animals tend to

Table 4.15: Respiratory rate (RR, beats/ minute) of cattle in Adamawa State, Nigeria

Distribution of mean RR	Minimum	Maximum	Mean	SEM
(a) Effect of location on mean RR				
Mubi North	24.000	28.000	26.066^{a}	0.0332
Gombi	24.000	28.000	25.972^{b}	
Jada	24.000	28.000	26.159^{c}	
(b) Sex effects on mean RR				
Male	24.000	28.000	26.108^{a}	0.0271
Female	24.000	28.000	26.023^{b}	
(c) Breed effects on mean RR				
White Fulani	24.000	28.000	25.996^{b}	0.0384
Red Bororo	24.000	28.000	26.214^{a}	
Sokoto Gudali	24.000	28.000	26.041^{a}	
Adamawa Gudali	24.000	28.000	26.013^{a}	
(d) Mgt effects on mean RR				
Pastoral	24.000	28.000	26.062	0.0271
Semi - sedentary	24.000	28.000	26.069	
(e) Seasonal effects on mean RR				
Late Rainy Season (LRS)	24.000	28.000	26.073	0.0384
Early Dry Season (EDS)	24.000	28.000	26.032	
Late Dry Season (LDS)	24.000	28.000	26.038	
Early Rainy Season (ERS)	24.000	28.000	26.120	

abc means with different superscript(s) are significantly different ($p < 0.05$)

exhibit slower, quieter and fewer rates compared to larger sized animals which respire faster with a great deal of sound. This could also be attributed to the size of their lungs, other organs and rumen contents which influence the act.

(b) Sex effects on respiratory rate of cattle

Table 4.15b shows the mean respiratory rates of cattle on sex basis. The results showed that there were insignificant ($p > 0.05$) differences between the respiratory rates of male and female cattle. The male had higher values as compared to the female cattle implying that majority of the female animals are probably not pregnant or in early stage pregnancies. Another reason could be that all the cattle were Zebu (*Bos indicus*) which agrees with the findings of Concepta *et al*. (2014) that the genetic make-up had significant influence on respiratory rates of cattle.

(c) Breed effects on respiratory rate of cattle

Table 4.15c shows the mean respiratory rates of cattle on breed basis. The results showed that there was significant ($p < 0.05$) difference between the respiratory rates of White Fulani and that of the other breeds. Red Bororo had the highest values followed by Sokoto Gudali, Adamawa Gudali and White Fulani breeds of cattle. The values obtained in the present study are lower than that of Concepta *et al*. (2014), who reported higher respiratory rates (24-50 per minute) in crossbred cattle in Central Brazil as compared to those of European animals in cold weather. Swenson and Reece (1996) and Blood *et al*. (1983) also reported similar rates in Zebu cattle in the same region. The higher rates reported by Concepta *et al*. (2014) could be because of the environmental conditions of the study location which was cooler compared to the present location. However, the results of the present studies corroborate that of Udeh *et al*. (2011), who reported respiratory rates of Zebu (20.36) and Muturu (22.86) cattle in Delta State, Nigeria.

(d) Management effects on respiratory rate of cattle

Table 4.15d shows the mean respiratory rates of cattle on management system basis. The results showed that there were no significant ($p > 0.05$) differences in the respiratory rates of cattle under the two systems of management. However, cattle under semi-sedentary system had higher values compared to pastoral cattle. Respiratory rate is the first physiological measure that increases when the animal undergoes heat stress or exercise, showing greater variation than other physiological measures such as rectal temperature and this agrees with the findings of McManus *et al*. (2009) on heat tolerance in local cattle breeds in Central Brazil.

(e) Seasonal effects on respiratory rate of cattle

Table 4.15e shows the seasonal mean respiratory rates of cattle. The results showed that there were again no significant ($p > 0.05$) differences in the respiratory rates of cattle during the four seasons. Cattle had highest values during early rainy season (April to June) followed by late rainy season (July to September), late dry season (January to March) and then early dry season (October to December). During periods of stress, an animal when exposed to the sun would have higher radiating heat load than its metabolic heat production.

Studies show that respiratory rates of animals exposed to the sun are significantly higher than those in the shade (Faria *et al*., 1988; McManus *et al*., 2009). The studies of Gaughan *et al*. (2000) demonstrated that, the effect of ambient temperature on respiratory rate is not constant and is subject to a number of influencing factors. Under hot conditions, the increase in respiratory rate varied from 2.8 to 3.3 BPM for every 1^0C temperature increase and the animal's response changes over time.

4.2.4 Pulse rates of cattle in Adamawa State, Nigeria

Pulse rate is the regular beat of arteries as the blood is pumped through them from the heart and is an important indicator of stress and disease in cattle (Heath and Olusanya, 1985). It is an easy way to count the heart rate. Pulse rate which is expressed in beats per minute can be altered rapidly due to external factors such as temperature or biological activities by the animal itself. Atmospheric conditions, time of the day, exercise, eating and excitement are likely factors that influence pulse rate. The normal pulse frequency varies in different species and individual animals with increased secretion of adrenalin and noradrenalin from the core of the adrenal gland into blood results in an accelerated heart rate.

(a) Location effect on mean pulse rate of cattle in Adamawa state

Table 4.16a shows the mean pulse rates of cattle in Adamawas State. The results indicated that cattle from Mubi North LGA had significantly ($p < 0.05$) higher pulse rates than cattle from Gombi and Jada LGAs. However, there were insignificant ($p > 0.05$) differences between the pulse rates of cattle from Gombi and Jada LGAs. Most importantly, the results fall within the reference values of normal pulse rate of 40 to 70 as reported by Heath and Olusanya (1985). The results agree with Babayemi *et al*. (2014), who reported normal pulse rate of cattle to be 55 beats per minute and Fasoro (1999), who reported a normal range of 40 - 70 beats per minute.

(b) Sex effects on pulse rate of cattle

There were insignificant ($p > 0.05$) differences between the pulse rates of male and female cattle in the study areas (Table 4.16b). In spite of this, the male had higher mean values compared to female animals and again, the values were within the recommended normal range.

Table 4.16: Pulse rate (PR, beats/ minute) of cattle in Adamawa state, Nigeria

Distribution of mean PR	Minimum	Maximum	Mean	SEM
(a) Effect of location on mean PR				
Mubi North	52.000	60.000	56.023[a]	0.0583
Gombi	52.000	60.000	55.520[b]	
Jada	52.000	60.000	55.568 [b]	
(b) Sex effects on mean PR				
Male	52.000	60.000	55.756	0.0476
Female	52.000	60.000	55.651	
(c) Breed effects on mean PR				
White Fulani	52.000	60.000	55.902[a]	0.0673
Red Bororo	52.000	60.000	55.742 [a]	
Sokoto Gudali	52.000	60.000	55.738 [a]	
Adamawa Gudali	52.000	60.000	55.432[b]	
(d) Mgt effects on mean PR				
Pastoral	52.000	60.000	55.705	0.0476
Semi-sedentary	52.000	60.000	55.702	
(e) Seasonal effects on mean PR				
Late Rainy Season (LRS)	52.000	60.000	55.765[a]	0.0673
Early Dry Season (EDS)	52.000	60.000	55.804 [a]	
Late Dry Season (LDS)	52.000	60.000	55.704 [a]	
Early Rainy Season (ERS)	52.000	60.000	55.541[b]	

abc means with different superscript(s) are significantly different ($p < 0.05$)

Under normal condition, heart rate is inversely proportional to the weight of the animal and this is observed directly by counting the heart beat through listening or by feeling with the index finger at particular point of the body (Ameen *et al*., 2010).

(c) Breed effects on pulse rate of cattle

Table 4.16c showed the effects of breed on pulse rates of cattle. The results showed that White Fulani, Red Bororo and Sokoto Gudali cattle had significantly ($p < 0.05$) higher pulse rates than that of Adamawa Gudali, while the value for the three breeds did not differ significantly ($p > 0.05$). The values also fell within the acceptable normal range. The findings of this study however, were lower than that of Concepta *et al*. (2014), who reported higher pulse rates of 60 - 80 beats per minute in crossbred cattle in Central Brazil as compared with those of European animals during cold weather. The results of the present study also corroborates the earlier reports of Udeh *et al*. (2011) on pulse rates of Zebu and Muturu cattle (51.52 and 55.68 beats / minute respectively) in Delta state, Nigeria. The results also agree with that of Hutchinson *et al*. (1976) and John *et al*. (2013) that factors that elevate pulse rates include heat stress and coat color. Heat flow from the environment into the body of a black animal on a hot sunny day is usually 30% greater than that of a white colored animal.

(d) Management effects on pulse rate of cattle

Table 4.16d shows the pulse rates of cattle under the two management systems. The results showed that there were no significant ($p > 0.05$) differences in the pulse rates of cattle under the two production systems. However, cattle under the pastoral system had higher rates compared to those under semi-sedentary system. This implies that cattle in the pastoral system might have been exposed to greater stress and activities that increased their pulse rates.

(e) Seasonal effects on pulse rate of cattle

Table 4.16e shows the effect of season on pulse rates of cattle in Adamawa State. The results showed insignificant ($p > 0.05$) variations in the pulse rates of cattle across three seasons (LRS, EDS and LDS). However, there were significantly ($p < 0.05$) lower pulse rates in cattle during ERS (April to June) characterized by serious shortage of feed, water resources and nutrient-deficiency-related disease conditions. Most of the cattle spend the hot periods of the day lying down quietly under tree shades ruminating occasionally, looking physically weak and emaciated. However, the values were within the normal range recommended in literature (Fasoro, 1999).

4.3 Hematological Characteristics of Cattle Grazing the Guinea Savannah Zone Adamawa State, Nigeria

Hematological studies are useful in science and diagnosis of many diseases of livestock as well as investigation of the extent of damage to blood (Onyeyili, Egwu, Jibike, Pepple, & Ohaegbulam, 1992; Togun *et al.,* 2007). Blood indices are good indicators of physiological status of animals (Khan & Zafar, 2005) and those parameters that are related to blood and blood forming organs (Waugh, Grant, & Ross, 2001; Bamishaiye, Muhammad, & Bamishaiye, 2009). Blood acts as a pathological reflector of the status of animals exposed to toxicants and other conditions (Olafedehan *et al.,* 2010). Thus, laboratory blood tests are vital tools that help detect any deviation from normal values in the animal body (Ogunbajo, Alemede, Adama, & Abdullahi, 2009). Many of these parameters are influenced by factors such as age, breed, sex, seasonal variations, lactation, pregnancy, health and nutritional status of animals (Schalm *et al.*, 1975; Rekwot, Oyedipe, Akerejola, & Dawuda, 1989). Hematological values of many breeds of cattle in Nigeria have been determined (Akerejola, Umunna, & Denis, 1980; Gbodi & Chechet, 1981; Oyedipe, Saror, Osori, & Akerejola, 1984; Rekwot *et al.*, 1989; Gbodi, Atawodi, & Salifu, 1989; Rekwot, Kumi-Diaka, Akerejola, & Oyedipe, 1997).

4.3.1 Red blood cell (RBC× 10^6/ mm^3) counts of cattle in Adamawa State, Nigeria

(a) Location effects on mean RBC of cattle at Adamawa State

Table 4.17a presents the mean RBC counts of cattle from the three study locations. The results showed that there were significant ($p < 0.05$) differences in the mean RBC counts, with Mubi North LGA having the highest value, followed by Gombi and Jada LGAs. However, the results of the present study fell within the normal reference values of 5 to $10 \times 10^6/mm^3$ reported by Etim, Williams, Akpabio, and Offiong (2014). The results also corroborate that of Daramola, Adeloye, Fatoba, and Soladoye (2005) and Afolabi (2010) who reported that age, sex, breed, climate, geographical location, season, day length, time of the day, nutritional status and life habit of species influence variations in haematological values of farm animals. Similarly, genetic and non-genetic factors affecting haematological parameters of farm animals have been studied (Xie *et al.*, 2013) and these include physiological factors (Alodan & Mashaly, 1999), age (Seiser *et al.*, 2000), administration of drugs (Khan, 1994), anti-aflatoxin treatment (Oguz, 2000) and continuous supplementation of vitamin (Tras *et al.*, 2000), which have been shown to affect the blood profiles of healthy animals. Therefore, normal haematological values could play important roles and usually serve as baseline information for comparison in conditions of nutrient deficiency, physiology and health status of farm animals (Daramola *et al.*, 2005).

(b) Sex effects on red blood cell (RBC× 10^6/ mm^3) counts of cattle

Table 4.17b depicts the mean red blood cell counts of cattle based on sex and showed that there were significant ($p < 0.05$) differences between mean red blood cells of the two sexes with the male recording higher values than the female cattle. The results were in agreement with earlier reports by David (2012) and Addass, David, Edward, Zira, and

Midau (2012), who also observed sex differences in blood profiles of farm animals in Northern Nigeria.

Table 4.17: Red blood cell (RBC× 10^6/ mm^3) of cattle in Adamawa State, Nigeria

Distribution of mean RBC	Minimum	Maximum	Mean	SEM
(a) Effect of location on mean RBC				
Mubi North	5.0600	8.5600	6.5404^a	0.0280
Gombi	5.0600	8.5600	6.7608^b	
Jada	5.0600	8.5600	6.6212^c	
(b) Sex effects on mean RBC				
Male	5.1400	8.5600	6.7361^a	0.0228
Female	5.0600	8.2800	6.5455^b	
(c) Breed effects on mean RBC				
White Fulani	5.0600	8.5600	6.6091	0.0323
Red Bororo	5.0600	8.5600	6.6423	
Sokoto Gudali	5.0600	8.2800	6.6908	
Adamawa Gudali	5.0600	8.2800	6.6210	
(d) Mgt effects on mean RBC				
Pastoral	5.0600	8.2800	6.6400	0.0228
Semi - sedentary	5.0600	8.5600	6.6416	
(e) Seasonal effects on mean RBC				
Late Rainy Season (LRS)	5.0600	8.2800	6.7454^a	0.0323
Early Dry Season (EDS)	5.0600	8.5600	6.6140^b	
Late Dry Season (LDS)	5.0600	8.2800	6.6114^b	
Early Rainy Season (ERS)	5.0600	8.5600	6.5924^b	

abc means with different superscript(s) are significantly different ($p < 0.05$)

However, the present results disagree with Olayemi *et al*. (2007), who reported similarity in the erythrocyte values of male and female Sokoto Gudali cattle in Nigeria. In addition, other studies have shown insignificant sex differences in RBC values of Keteku (Awolaja, Antia, & Oyejide, 1997) and Kuri cattle (Olayemi, Akinsiku, Ojo, & Azeez, 2006) in Southwestern Nigeria. Olayemi (2004) also reported that there were no sex differences in erythrocyte values of White Fulani cattle, while in Pakistan, Farooq *et al*. (2012) reported similar mean RBC of $6.42 \times 10^6/\ mm^3$ in Cholistani cattle and Aengwanich *et al.* (2009) reported a similar mean RBC of $6.34 \times 10^6/\ mm^3$ in cattle.

The significant variations observed could be attributed to physiological status, genetic make-up, differences in age, health status and feeding activities of the animals. However, Farooq *et al*. (2012) also reported bull to bull variation in the same Cholistani breeding bulls. Alina and Goh (2010) reported variations in hematology indices of cows with reproductive troubles and that of healthy cows at different stages of lactation in Iaşi County. They recorded higher RBC in normal healthy cows than those with puerperal genital infections. The decrease in values of RBC shows a sign of anemia in the animals with chronic genital infections. Highest RBC count was recorded in non-pregnant heifers while the lowest values were observed in pregnant dry cows (Sattar & Mirza, 2009). Neelu, Chauhan, Khan, and Gupta (1996) reported significantly higher values for RBC count in heifers than other groups, while Ahmad (1995) reported RBC count of 4.7 to 7.0 $\times 10^6/\ mm^3$ in Sahiwal cows during last trimester of pregnancy, which are closely related to the values of the present study.

(c) Breed effects on red blood cell (RBC$\times 10^6/\ mm^3$) counts of cattle

Table 4.17c shows the mean red blood cell counts of cattle based on breed. The results showed that, there were insignificant ($p > 0.05$) differences in the mean RBC counts of the different breeds of cattle. However, Sokoto Gudali had the highest values followed by the Red Bororo, Adamawa Gudali and Bunaji respectively. This observation agrees with the findings of Awolaja *et al.* (1997), who also reported similar values of RBC in Keteku and White Fulani breed of cattle. Similarly, the RBC value obtained for Kuri cattle (Olayemi *et al*., 2006) was comparable to the value of $9.90 \times 10^6/\ mm^3$ obtained for White Fulani cattle (Olbrich, Martz, Tumbleson, & Johnson, 1971) but much higher than the values ($5.46 \times 10^6/\ mm^3$) obtained for N'dama cattle (Olayemi & Oyewale, 2002) and also the values obtained in the present study.

These variations may be explained by differences in feed resources at the different locations, sampling interval, methods used, numbers of animals sampled and degree of metabolic disturbances. Furthermore, genetic differences between cattle, tropical conditions of the present study, management, feeding and changes in hormonal levels may be involved which, also, corroborate the reports of Mallard *et al.* (1998) and Meglia, Johannisson, Agenas, Holtenius, and Waller (2005).

(d) Management effects on RBC counts of cattle

Table 4.17d, shows the mean RBC counts of cattle based on management system. The results indicated insignificant ($p > 0.05$) differences in the mean RBC counts under the two management systems. However, the cattle managed under semi-sedentary system had higher mean values than those under pastoral system. The results of the present study disagree with some earlier reports that intensively managed White Fulani cattle (Olayemi & Oyewale, 2002) and WAD sheep (Olayemi, Farotimi, & Fagbohun, 2000) had significantly higher haematological values than those managed extensively. It is therefore, probable that many reported cases of anemia earlier thought to be due to diseases may have been caused by poor management practices (Olayemi & Oyewale, 2000).

Rekwot *et al*. (1987) observed that White Fulani fed with high protein diet (14.45% crude protein) had higher erythrocyte values than those on low protein diet (8.51%). Other workers such as Carlson (1996) and Johnston and Morris (1996) reported that besides physiological and environmental factors that might affect blood values, estrus cycle, pregnancy, parturition, genetics, method of breeding, breeds of animal, housing, feeding, fasting, extreme climatic conditions, stress, exercises, transport, castration and diseases could cause variations in hematological values in cattle.

(e) Seasonal effects on RBC counts of cattle

Table 4.17e, shows the mean RBC counts of cattle based on seasons. The results showed that there were significantly ($p < 0.05$) higher mean RBC counts in cattle during LRS (July to September) than the other seasons. This is possible because this period coincides with the period of abundant forage and water supply. The findings corroborate some earlier reports that environmental condition and seasons (Graczyk, Pliszczak-Król, Kotonski, Wilczek, & Chmielak, 2003), dietary content (Celik, 2005) and fasting (Zeman, 2004) affect hematological values of cattle. The results also concur with Mohammed, Mohammed, and Akerejola (2007), who reported similar RBC in Bunaji work bulls before farmland ridging exercise during rainy season in Kaduna, northwestern Nigeria.

4.3.2 Packed cell volume (PCV %) of cattle in Adamawa State, Nigeria

(a) Effect of location on (PCV %) of cattle in Adamawa State

The overall mean PCV of cattle at the three study locations are presented in table 4.18a. The results showed significantly ($p < 0.005$) higher mean PCV in cattle from Mubi North LGA than those recorded at Gombi and Jada LGAs. There were no significant ($p > 0.05$) differences in the mean values from Gombi and Jada LGAs. The variations observed could be attributed to micro environmental effects, natural occurrences and some human factors. However, the PCV values obtained in this studies fell within the lower normal range of 24 to 48% (RAR, 2009), indicating the need for improvements in nutrition of the animals.

Table 4.18: Packed cell volume (PCV %) of cattle in Adamawa State, Nigeria

Distribution of mean PCV	Minimum	Maximum	Mean	SEM
(a) Effect of location on mean PCV				
Mubi North	20.380	34.320	25.152[a]	0.0643
Gombi	20.380	28.410	24.837[b]	
Jada	20.380	34.320	24.756[b]	
(b) Sex effects on mean PCV				
Male	20.380	34.320	24.991[a]	0.0525
Female	20.380	32.500	24.840[b]	
(c) Breed effects on mean PCV				
White Fulani	20.380	34.320	24.822	0.0743
Red Bororo	20.380	32.050	24.866	
Sokoto Gudali	20.380	33.460	24.981	
Adamawa Gudali	20.380	34.320	24.991	
(d) Mgt effects on mean PCV				
Pastoral	20.380	28.410	24.875	0.0525
Semi-sedentary	20.380	34.320	24.955	
(e) Seasonal effects on mean PCV				
Late Rainy Season (LRS)	20.380	33.460	25.087[a]	0.0743
Early Dry Season (EDS)	20.380	34.320	24.702[b]	
Late Dry Season (LDS)	20.380	32.510	25.082[a]	
Early Rainy Season (ERS)	20.380	34.320	24.789[b]	

abc means with different superscript(s) are significantly different ($p < 0.05$)

Higher PCV than the reference values could be attributed to the differences in ages of the animals (Grunwaldt *et al*., 2005). However, Otto *et al*. (2000) reported no age effect on PCV values. According to Akinrinmade and Akinrinde (2012), the mean PCV of 24.81% were significantly lower in cattle with foreign body rumen impaction than normal cattle without such pathologies in Ibadan, Nigeria. Low PCV could indicate anemia, hemorrhage, bone marrow failure, destruction of erythrocytes, leukemia, malnutrition or specific nutritional deficiency, multiple myeloma and rheumatoid arthritis (Jain, 1993; Kaneko, 1997). Higher than the reference value PCV on the other hand may indicate dehydration due to diarrhea, erythrosis and polycythermiavera (Ndlovu *et al*., 2007).

(b) Sex effects on packed cell volume (PCV %) of cattle

The mean PCV of cattle based on sex are presented in table 4.18b. There were significant ($p < 0.05$) differences between male and female values with male having higher mean PCV than female cattle. This could be because of gender differences, reproductive activities, nutrient availability and health status of the animals. The higher male PCV value is expected and could be a reflection the earlier reported higher RBC counts in males. Again, the values fell within the reference values and are in agreement with Ahmad (1995), who reported PCV of 28.4 to 31.4% in Sahiwal cows during last trimester of pregnancy.

(c) Breed effects on packed cell volume (PCV %) of cattle

The mean PCV of cattle based on breeds are presented in table 4.18c. There were no significant ($p > 0.05$) differences in mean PCV of the four breeds of cattle studied in Adamawa state. However, Adamawa Gudali had the highest mean PCV values, followed by Sokoto Gudali, Red Bororo and White Fulani in that order. The results agree with Mirzadeh *et al.* (2010), who reported a similar mean PCV of 28.45% for Semental cattle in Iran. Meanwhile, the PCV values obtained in this study are lower than those reported by Merck (2012) and Olayemi *et al*. (2007) at 30 to 45% and 34.65 to 35.20%, respectively, in Sokoto Gudali and White Fulani cattle in Southwestern Nigeria. A higher PCV value of 41.8% was also obtained in Kuri cattle (Olayemi *et al*., 2006) when compared to the values of 37.13% (Olayemi & Oyewale, 2002), 38.7% (Hill and Esuruoso, 1976) and 37.7% (Oduye & Okunaiya (1971) obtained for the N'dama breed and 29.92% (Awolaya et *al.*, 1997) for the Keteku breed of cattle.

There were no breed effects observed between the PCV values of Aberdeen Angus and that of Criollo Argentino (Grunwaldt *et al*., 2005). Otto *et al*. (2000) however, observed a PCV value of 32% for Anguni cattle of Mozambique, which tends to be lower than that of Aberdeen Angus cattle, thus showing breed differences.

(d) Management effects on packed cell volume (PCV %) of cattle

The mean PCV of cattle based on management systems are presented in table 4.18d. There were again, no significant ($p > 0.05$) differences in the mean PCV of cattle raised under pastoral and semi-sedentary systems in Adamawa state. However, cattle raised under semi-sedentary system recorded higher mean PCV compared to those under pastoral cattle. The results agree with Thahar, Moran, and Wood (1983), who reported higher PCV in bulls fed high concentrate diet than the controlled animals in India. Addass *et al.* (2012) reported that management system had significant effect on PCV with intensively kept chickens recording higher values of haematological parameters than semi-intensively kept chickens. Olayemi *et al*. (2000) in support of Addass *et al.* (2012) also reported that intensively reared WAD sheep have higher PCV than those reared under extensive management systems in Nigeria. Similarly, in a study conducted by Olayemi *et al.* (2000) on the influence of management on the hematology of the White Fulani cattle, the intensively reared animals recorded higher PCV than those under extensive management.

(e) Seasonal effects on packed cell volume (PCV %) of cattle

The mean PCV of cattle based on season are presented in table 4.18e. The values were significantly ($p < 0.05$) higher during the LRS and LDS than during the EDS and ERS periods. The seasonal variations in PCV of the cattle may be linked to seasonal feed and water availability. Late dry season (LDS) coincided with the critical period when there are no surplus forage and crop residues for the animals. Animals scavenge on the remnants and some browses to maintain them and are seen emaciated because of hunger, thirst and starvation resulting probably to concentration of blood. The results of the present study agree with Mohammed *et al.* (2007), who reported similar PCV values before farming activity of the bulls but disagree with the elevated PCV immediately after ridging exercise during cropping season in Bunaji work bulls at Kaduna, northwestern Nigeria.

4.3.3 Hemoglobin (Hb gm/dl) concentrations of cattle in Adamawa State, Nigeria

(a) Location effects on mean Hb concentrations of cattle in Adamawa state

The mean hemoglobin (Hb) concentrations of cattle based on sampling locations are presented in table 4.19a. The results show that there was significantly ($p < 0.05$) higher mean Hb concentration in cattle from Mubi North LGA than Gombi and Jada LGAs. These results however fall within reference values and the variations observed could be linked to environmental differences, natural tendencies and age effects on the animals. In an earlier study, Awolaja *et al.* (1997) reported that variability in age, physical status of the animal, feeding pattern, geological location of the farm and difference in laboratory protocol adopted can influence the Hb results. Akinrinmade and Akinrinde (2012) also reported that cattle suffering from foreign body rumen impaction had lower Hb than the normal cattle in Ibadan, Nigeria.

Table 4.19: Hemoglobin (Hb gm/dl) concentrations of cattle in Adamawa state

Distribution of mean Hb	Minimum	Maximum	Mean	SEM
(a) Effect of location on mean Hb				
Mubi North	9.5600	11.680	10.474^{a}	0.0192
Gombi	9.5600	11.580	10.411^{b}	
Jada	9.5600	11.580	10.366^{b}	
(b) Sex effects on mean Hb				
Male	9.5600	11.580	10.438	0.0156
Female	9.5600	11.580	10.397	
(c) Breed effects on mean Hb				
White Fulani	9.5600	11.580	10.425	0.0221
Red Bororo	9.5600	11.580	10.426	
Sokoto Gudali	9.5600	11.570	10.432	
Adamawa Gudali	9.5600	11.580	10.386	
(d) Mgt effects on mean Hb				
Pastoral	9.5600	11.580	10.419	0.0156
Semi - sedentary	9.5600	11.580	10.416	
(e) Seasonal effects on mean Hb				
Late Rainy Season (LRS)	9.5600	11.780	10.424	0.0221
Early Dry Season (EDS)	9.5600	11.580	10.407	
Late Dry Season (LDS)	9.5600	11.580	10.427	
Early Rainy Season (ERS)	9.5600	11.580	10.411	

abc means with different superscript(s) are significantly different ($p< 0.05$)

(b) Sex effects on hemoglobin (Hb gm/dl) concentrations of cattle

The mean hemoglobin (Hb) concentrations of cattle based on sex are presented in table 4.19b. The results indicated that there were no significant ($p > 0.05$) differences in the mean Hb of male and female cattle. However, male cattle recorded higher Hb values. The results supported that of Oyewale, Olayemi, and Oke (1997) and Olayemi *et al*. (2006) who also reported that male Kuri cattle has higher Hb values than the females. Similar Hb concentration of 10.9 gm/dl was reported for Iranian bulls (Mirzadeh et al., 2010), while Farooq *et al.* (2012) reported higher overall mean Hb concentrations of 12.50 gm/dl in Cholistani breeding bulls in Pakistan. Similarly, Aengwanich *et al.* (2009) reported Hb concentration of 10.36 gm/dm for male cross-bred beef cattle in Thailand, while Olayemi *et al*. (2007) reported higher mean value of 11.18 gm/dl for indigenous African Sokoto bulls. Sattar and Mirza (2009) reported higher Hb concentration in non-pregnant exotic heifers during gestation and lactation under sub-tropical conditions of Pakistan. Again, Steinhardt *et al.* (1994), reported decrease in Hb with advancing lactation and pregnancy, which increased at parturient stage.

(c) Breed effects on hemoglobin (Hb gm/dl) concentrations of cattle

The mean hemoglobin (Hb) concentrations of cattle based on breed are presented in table 4.19c. There were no significant ($p > 0.05$) differences in the mean Hb concentrations of the four breeds of cattle studied. However, Sokoto Gudali recorded the highest Hb values followed by the Red Bororo, White Fulani and Adamawa Gudali cattle, in that order. The results did not agree with the findings of Olayemi *et al*. (2007), who earlier reported significantly higher Hb concentration in Sokoto Gudali than Bunaji cattle. Olayemi *et al*. (2006) also, reported significantly higher Hb values in Kuri than White Fulani cattle, while Oduye and Okunaiya (1971) observed that Hb value was higher in N'dama than White Fulani cattle. However, the present findings agree with the Hb concentration value of 10.66 gm/dl obtained in Kuri cattle and the values of 9.88 gm/dl obtained for N'dama by Olayemi and Oyewale (2002).

(d) Management effects on hemoglobin (Hb gm/dl) concentrations of cattle

The mean hemoglobin (Hb) concentrations of cattle based on management as presented in table 4.19d shows that there were no significant ($p > 0.05$) differences in the mean Hb of cattle raised under the two management systems. However, pastoral cattle recorded higher mean Hb values than those managed under semi-sedentary system. This slight variation could be as a result of differences in collection and handling of samples before transportation to the laboratory. According to Addass *et al.* (2012), intensively kept chickens recorded higher values for most haematological parameters than semi-intensively kept chickens and Olayemi *et al*. (2000) reported higher Hb in intensively managed WAD sheep than those under extensive system.

(e) Seasonal effects on hemoglobin (Hb gm/dl) concentrations of cattle

The mean hemoglobin (Hb) concentrations of cattle based on season are presented in table 4.19e. There were again no significant ($p > 0.05$) differences in the mean Hb of all the cattle raised during the four seasons in the study area. However, cattle recorded highest mean Hb values during LDS followed by LRS, ERS and then EDS. The little variations could be because of the changing environment, seasonality in feed and water supply, weather conditions, nature of the nutrient consumed and breed effects. The results corroborate the findings of Koubkova *et al.* (2002) who reported that the Hb concentration is mainly affected by the season, being higher in hot seasons. The present findings also correspond to that of Mohammed *et al.* (2007), who reported similar value of Hb concentrations before ridging but higher value immediately after work in Bunaji bulls in Kaduna.

4.3.4 White blood cell (WBC×10^3/μl) counts of cattle in Adamawa State, Nigeria

(a) Effect of location on mean WBC counts of cattle in Adamawa state

The WBC values of cattle based on study locations are presented in table 4.20a and shows that there was significantly ($p < 0.05$) higher mean WBC in cattle from Mubi North LGA than Gombi and Jada LGAs. Mubi North LGA had the highest values followed by Gombi and Jada LGAs, respectively. However, the results were within the referenced values of 4.0 to 12.0×10^3/μl reported for cattle by Jain (1998). The results did not agree with those of Akinrinmade and Akinrinde (2012), who reported mean WBC values to be 20.41×10^3 μl in normal cattle in Ibadan, Nigeria

(b) Sex effects on white blood cell (WBC×10^3/μl) counts of cattle

The mean WBC counts of cattle based on sex distribution are presented in table 4.20b and did not show significant ($p > 0.05$) differences in male and female cattle values, although female cattle recorded higher values than the males. These results corroborate that of Olayemi (2004) and Olayemi *et al.* (2006) who reported that male and female White Fulani and Kuri cattle have similar total WBC values. Farooq *et al*. (2012) also reported mean WBC for Cholistani breeding bulls to be 7.80 ×10^3/μl, while Al-Shami (2003) and Aengwanich *et al.* (2009) reported much higher values of 14.6 and 13.71 ×10^3/μl for Hassawi in Saudi Arabia and cross-bred beef cattle in Thailand, respectively. Pereira *et al.* (1987) also reported that there was an increase in the number of leukocytes during gestation whereas Mallard *et al.* (1998) and Meglia *et al.* (2005) reported higher WBC and lower lymphocytes in parturient cows than earlier in the dry period.

Table 4.20: White blood cell (WBC×10^3/µl) counts of cattle in Adamawa state

Distribution of mean WBC	Minimum	Maximum	Mean	SEM
(a) Effect of location on mean WBC				
Mubi North	5.0500	8.5800	7.0861[a]	0.0267
Gombi	5.0500	8.5800	6.7169[b]	
Jada	5.0500	8.5800	6.6611[b]	
(b) Sex effects on mean WBC				
Male	5.0500	8.5800	6.8001	0.0218
Female	5.1200	8.4900	6.8426	
(c) Breed effects on mean WBC				
White Fulani	5.0500	8.5800	6.8005	0.0308
Red Bororo	5.0500	8.5800	6.8067	
Sokoto Gudali	5.0500	8.5800	6.8792	
Adamawa Gudali	5.0500	8.5800	6.7991	
(d) Mgt effects on mean WBC				
Pastoral	5.0500	8.5800	6.8223	0.0218
Semi-sedentary	5.0500	8.5800	6.8204	
(e) Seasonal effects on mean WBC				
Late Rainy Season (LRS)	5.0500	8.5800	6.8409	0.0308
Early Dry Season (EDS)	5.0500	8.5800	6.8037	
Late Dry Season (LDS)	5.0500	8.5800	6.8418	
Early Rainy Season (ERS)	5.0500	8.5800	6.7990	

abc means with different superscript(s) are significantly different ($p < 0.05$)

(c) Breed effects on white blood cell (WBC×10^3/µl) counts of cattle

The mean WBC counts of cattle based on breed are presented in table 4.20c. The results indicate that there were again no significant ($p > 0.05$) differences in the mean WBC of all the four cattle breeds studied, although, Sokoto Gudali recorded the highest value followed by Adamawa Gudali, Red Bororo and White Fulani, in that order. The slight variations could be because of genetic differences, health status and breed effects on the animals. The results agree with the report of Monke, Kociba, DeJarnette, Anderson, and Ayers Jr (1998), who in their study of age related effects on white blood cell indices of Holstein bulls kept at AI Centra, USA, reported a decrease in absolute number of lymphocytes in yearling bulls as compared to adults. Differences in breed, age, physiological status or stress prior to handling have been reported to influence leukocytic indices (Farooq, Samad, Khurshid, & Sajjad, 2011).

(d) Management effects on white blood cell (WBC×10^3/µl) counts of cattle

The mean WBC counts of cattle based on management as presented in table 4.20d indicates that there were again no significant ($p > 0.05$) differences in the values for all cattle kept under the two management systems. However, cattle raised under pastoral management recorded the higher WBC values than those under semi-sedentary management system. This variation could be attributed to stress, feeding and breed effects. The results were within the normal values of healthy animals which were in agreement with that of Saror and Coles (1973), who reported that White Fulani cattle managed extensively, had higher WBC values than those managed intensively. The results also corresponded with that of Ahmad (1995), who reported similar WBC values of 6.8 to 8.3 ×10^3/µl.

(e) Seasonal effects on white blood cell (WBC×10^3/µl) counts of cattle

The mean WBC counts of cattle based on season are presented in table 4.20e. The results indicate that there were also no significant ($p > 0.05$) disparities in the mean values in all the cattle during the four seasons. However, cattle recorded higher WBC values during LDS followed by LRS, EDS and ERS, in that order. The variations in seasonal WBC values could be due to the fluctuations in seasonal nutrient supply which may affect the animal's immune response. The results corroborated that of Mohammed *et al.* (2007), who reported comparable WBC values in Bunaji work bulls in Kaduna before ridging exercise but WBC values skyrocketed immediately after farm land ridging exercise. Muscular exercise also influences total and differential leukocytes counts (Kaneko, 1989). Vigorous exercise in working bulls is reported to provoke the release of endogenous glucocorticoids, particularly, cortisol and adrenaline (Bush, 1994), which produces a response of temporary leukocytosis with neutrophilia, lymphopenia and eosinopenia similar to what was observed in race horses (Rossdale, Burgeut, & Cash,1982) indicating stressful conditions (Tietz, 1976).

4.3.5 Mean corpuscular volume (MCV fl) of cattle in Adamawa State, Nigeria

(a) Effect of location on MCV values of cattle in Adamawa State

MCV is a measure of the actual volume of individual red cells expressed in femtoliter (fl). It is derived from RBC and PCV values. Normal cell volume is indicative of mature cells in circulation (Nomocytia) and such cells are able to carry out normal RBC functions, especially oxygen transport. Usually, immature cells are not of normal size and their presence in circulation is evidence that the marrow is compromised, for example, during cancer or hemorrhage, hemorrhagic anemia and leukemia.

The mean corpuscular volume (MCV) of cattle based on LGA are presented in table 4.21a and shows no significant ($p > 0.05$) differences between cattle from Mubi LGA and Gombi LGA, while there was significantly ($p < 0.05$) lower MCV in cattle from Jada LGA than those from Mubi North and Gombi LGAs. In any case, Gombi LGA recorded the highest values followed by Mubi north and Jada LGAs, in that order.

The results of this study fell within the normal values reported by Jain (1998) and agree with that of Mirzadeh *et al.* (2010), who reported MCV values of 51.83 fl in cattle. The insignificant variations observed may be connected with the common environmental conditions of the study area, especially, similarities in feed resources and health conditions.

(b) Sex effects on mean corpuscular volume (MCV fl) values of cattle

The mean corpuscular volume (MCV) of cattle based on sex is presented in table 4.21b. The results indicate that there were significant ($p < 0.05$) differences between male and female cattle with the male having significantly higher MCV values. This variation has been linked to sex differences, animal activities, nutrition and environmental conditions. The values were within the reference range reported by Jain (1998) and are in agreement with that of Farooq *et al*. (2012), who reported MCV values of Cholistani breeding bulls to be 58.05 fl. Ahmad (1995) also reported MCV of 46.0 to 69.7 fl in Sahiwal cows during last trimester of pregnancy. On the contrarily, Kumar and Pachauri (2000) reported higher MCV in non-pregnant dry cows compared to other groups.

(c) Breed effects on mean corpuscular volume (MCV fl) of cattle

The mean corpuscular volume (MCV) values of cattle based on breed are presented in table 4.21c. Red Bororo and Adamawa Gudali returned significantly ($p < 0.05$) higher MCV than the other breeds, while White Fulani also recorded significantly ($p < 0.05$) higher values than Sokoto Gudali. The results did not agree with that of Olayemi *et al*. (2007) who reported that Sokoto Gudali and White Fulani cattle had similar MCV values. The MCV values were also similar in the Kuri and the White Fulani cattle (Olayemi *et al*., 2006).

Table 4.21: Mean corpuscular volume (MCV fl) values of cattle in Adamawa state

Distribution of mean MCV	Minimum	Maximum	Mean	SEM
(a) Effect of location on mean MCV				
Mubi North	50.120	58.950	54.383[a]	0.0731
Gombi	50.120	58.950	54.481[a]	
Jada	50.120	58.950	54.027[b]	
(b) Sex effects on mean MCV				
Male	50.120	58.950	54.452[a]	0.0597
Female	50.120	58.950	54.142[b]	
(c) Breed effects on mean MCV				
White Fulani	50.120	58.950	54.262[a]	0.0844
Red Bororo	50.120	58.950	54.386[b]	
Sokoto Gudali	50.120	58.950	54.090[c]	
Adamawa Gudali	50.120	58.950	54.449[b]	
(d) Mgt effects on mean MCV				
Pastoral	50.120	58.950	54.297	0.0597
Semi - sedentary	50.120	58.950	54.297	
(e) Seasonal effects on mean MCV				
Late Rainy Season (LRS)	50.120	58.950	54.380	0.0844
Early Dry Season (EDS)	50.120	58.950	54.249	
Late Dry Season (LDS)	50.120	58.950	54.367	
Early Rainy Season (ERS)	50.120	58.950	54.192	

abc means with different superscript(s) are significantly different ($p < 0.05$)

(d) Management effects on mean corpuscular volume (MCV fl) values of cattle

The mean corpuscular volume (MCV) values of cattle based on management as presented in table 4.21d shows that, there were no significant ($p > 0.05$) differences in the MCV of cattle under pastoral and semi-sedentary systems. However, cattle under semi-sedentary management recorded higher MCV values than those under pastoral system. Olayemi *et al.* (2000) who reported that the intensively reared WAD sheep have higher MCV than those under extensive management support this. This higher MCV may be attributed to better management medications and nutrition linked to this system of management.

(e) Season effects on mean corpuscular volume (MCV fl) values of cattle

The mean corpuscular volume (MCV) values of cattle based on season as presented in table 4.21e shows that there were no significant ($p > 0.05$) seasonal differences between the MCV of cattle. However, cattle recorded highest MCV during the LRS followed by LDS, EDS and ERS, in that order. The results agree with that of Mohammed *et al.* (2007) who also reported similar MCV values in resting cattle but disagrees with their findings of decreased MCV in Bunaji work bulls after farmland ridging exercise in Kaduna during wet season.

4.3.6 Mean corpuscular hemoglobin (MCH pg) values of cattle in Adamawa state

(a) Location effect on MCH values of cattle in Adamawa State

Mean corpuscular hemoglobin (MCH) is a measure of the Hb concentration of each red blood cell and is thus a measure of the oxygen carrying efficiency of each RBC since, the major function of Hb is oxygen exchange. It is expressed in picograms (pg). MCH usually indicate blood level conditions of an animal and a lower than normal level is an indication of anemia (Aster, 2004). Therefore, abnormal MCH value means that the RBC numbers may be normal (normocytic) but the concentration of Hb in each cell is low (hypochromic). There is poor oxygen carrying capacity of such blood because of this hypochromic situation (Normocytic hypochromic anemia). Iron deficiency situation and diseases leading to high iron demand can cause the situation. Release of immature blood cells (Megatocytes) into circulation can also lead to this, especially in diseases that compromise bone marrow functions in which iron loss from the body is very high (Jain, 1998).

The MCH values of cattle based on location of study are presented in table 4.22a. The results show that cattle from Gombi and Jada LGAs recorded significantly ($p < 0.05$) higher MCH than cattle from Mubi North. There were however no significant ($p > 0.05$) differences in values from Gombi and Jada LGAs. Comparably, the results were within the normal referenced values for cattle (Jain, 1998).

(b) Sex effects on mean corpuscular hemoglobin (MCH pg) values of cattle

The mean corpuscular hemoglobin (MCH) values of cattle based on sex are presented in table 4.22b. The results show that there were significant ($p < 0.05$) differences between male and female MCH values in the study area. Although male cattle had higher MCH than the female cattle, the results were within the normal values given by Jain (1998). Such sexual dimorphism may be reflecting variations in nutrients access and other peculiar physiological conditions across sexes. The finding agrees with Farooq *et al*. (2012) who reported mean MCH values of Cholistani breeding bulls to range from 19.52 to 33.65 pg. Variable results have been reported in the literature regarding MCH indices with Mirzadeh *et al.* (2010) reporting value ranges of 19.15 to 36.90 pg and Ahmad (1995) reporting values of 15.0 to 23.2 pg in Sahiwal cows during last trimester of pregnancy. However, the results contradict the findings of Kumar and Pachauri (2000), who reported higher MCH values in non-pregnant dry cows compared to other groups.

Table 4.22: Mean corpuscular hemoglobin (MCH pg) values of cattle in Adamawa state

Distribution of mean MCH	Minimum	Maximum	Mean	SEM
(a) Effect of location on mean MCH				
Mubi North	18.520	25.070	22.320^{a}	0.0546
Gombi	18.520	25.070	22.602^{b}	
Jada	18.520	25.070	22.728^{b}	
(b) Sex effects on mean MCH				
Male	18.520	25.070	22.617^{a}	0.0446
Female	18.520	25.070	22.483^{b}	
(c) Breed effects on mean MCH				
White Fulani	18.520	25.070	22.614	0.0631
Red Bororo	18.520	25.070	22.536	
Sokoto Gudali	18.520	25.070	22.558	
Adamawa Gudali	18.520	25.070	22.492	
(d) Mgt effects on mean MCH				
Pastoral	18.520	25.070	22.550	0.0446
Semi - sedentary	18.520	25.070	22.550	
(e) Seasonal effects on mean MCH				
Late Rainy Season (LRS)	18.520	25.070	22.595	0.0631
Early Dry Season (EDS)	18.520	25.070	22.534	
Late Dry Season (LDS)	18.520	25.070	22.571	
Early Rainy Season (ERS)	18.520	25.070	22.500	

abc means with different superscript(s) are significantly different ($p < 0.05$)

(c) Breed effects on mean corpuscular hemoglobin (MCH pg) values of cattle

The mean corpuscular hemoglobin (MCH) values of cattle based on breed are presented in table 4.22c. There was no significant breed ($p > 0.05$) effect on the reported values, however, White Fulani cattle had the highest mean corpuscular hemoglobin (MCH) followed by Sokoto Gudali and Red Bororo, while Adamawa Gudali recorded the least value. The results are in agreement with Olayemi *et al.* (2007) who studied hematological parameters of Sokoto Gudali and White Fulani breeds of cattle in Ibadan, Nigeria and reported similarity in their MCH values. The mean values of the MCH were also, reported to be similar in Kuri and White Fulani cattle (Olayemi *et al.*, 2006).

(d) Management effects on MCH (pg) values of cattle in Adamawa state

The mean corpuscular hemoglobin (MCH) values of cattle based on management as presented in table 4.22d indicates that there were again no significant ($p > 0.05$) differences across pastoral and that of semi-sedentary systems derived means. The results support that of Addass *et al.* (2012) who reported that intensively kept chickens had similar MCH to that of semi-intensive birds in Mubi, Adamawa State, whereas Olayemi *et al.* (2000) reported that intensively reared White Fulani cattle have lower MCH than those under extensive management.

(e) Seasonal effects on mean corpuscular hemoglobin (MCH pg) values of cattle

The MCH values of cattle based on season are presented in table 4.22e. The results show that there were also no significant ($p > 0.05$) differences in recorded values across four seasons in the study area. In spite of this, cattle recorded highest values during LRS followed by LDS, EDS and ERS. This slight variation may be due to the changing environmental conditions, feeds and water supply during the different seasons. The results agree with that of Mohammed *et al.* (2007), who found insignificant decreases in values of in Bunaji work bulls before and even after farmland ridging exercise in Kaduna, Nigeria.

4.3.7 Mean corpuscular Hemoglobin Concentration (MCHC g/dl) values of Cattle in Adamawa State, Nigeria

(a) Location effects on MCHC (g/dl) values of cattle in Adamawa state

MCHC is the measure of the amount of Hb in a known PCV. It is calculated by dividing the Hb value with the PCV value. The MCHC is lowered during microcytic anemia i.e. microcytic hypochromic situation. It is expressed in grams per deciliter (g/dl).

The MCHC values of cattle based on study locations are presented in table 4.23a. The results indicated that cattle from Mubi North and Jada LGAs recorded significantly ($p < 0.05$) higher MCHC values than those from Gombi LGA. However, there were no significant ($p > 0.05$) differences in the mean MCHC values of cattle from Mubi North and Jada LGAs. These variations in MCHC values could be because of environmental conditions of the study areas.

(b) Sex effects on MCHC (g/dl) values of cattle

The mean corpuscular hemoglobin concentration (MCHC) values of cattle based on sex as presented in table 4.23b show that male cattle recorded significantly ($p < 0.05$) higher MCHC values than their female counterparts. The results agree with Isaac *et al.* (2013), who on their study of haematological properties of different sexes of rabbits, observed that males have higher MCHC values than female rabbits. The results also corroborate that of Farooq *et al*. (2012), who reported mean MCHC values of Cholistani breeding bulls to be 33.65 g/dl and higher than that of females (32.56 g/dl). Also, Ahmad (1995) reported MCHC values of 32.5 to 38.1 g/dl in Sahiwal cows during last trimester of pregnancy. However, contrary to the present study, Neelu *et al.* (1996) reported significantly higher MCHC values in pregnant cows than the other groups, while Kumar and Pachauri (2000) reported lowest MCHC in non-pregnant dry cows compared to other groups.

Table 4.23: MCHC (g/dl) values of cattle in Adamawa state

Distribution of mean MCHC	Minimum	Maximum	Mean	SEM
(a) Effect of location on mean MCHC				
Mubi North	30.070	35.490	33.300^{a}	0.0500
Gombi	30.070	35.490	33.021^{b}	
Jada	30.070	35.490	33.215^{a}	
(b) Sex effects on mean MCHC				
Male	30.070	35.490	33.239^{a}	0.0408
Female	30.070	35.490	33.118^{b}	
(c) Breed effects on mean MCHC				
White Fulani	30.070	35.490	33.231	0.0577
Red Bororo	30.070	35.490	33.192	
Sokoto Gudali	30.070	35.490	33.154	
Adamawa Gudali	30.070	35.490	33.137	
(d) Management effects on mean MCHC				
Pastoral	30.070	35.490	33.171	0.0408
Semi - sedentary	30.070	35.490	33.186	
(e) Seasonal effects on mean MCHC				
Late Rainy Season (LRS)	30.070	35.490	33.273^{a}	0.0577
Early Dry Season (EDS)	30.070	35.490	33.221^{b}	
Late Dry Season (LDS)	30.070	35.490	33.123^{b}	
Early Rainy Season (ERS)	30.070	35.490	33.097^{c}	

abc means with different superscript(s) are significantly different ($p< 0.05$)

(c) Breed effects on MCHC (gm/dl) values of cattle

The MCHC values of cattle based on breed are presented in table 4.23c. The results show that there were no significant ($p > 0.05$) differences across MCHC values of cattle breeds in Adamawa state. However, White Fulani cattle recorded the highest MCHC values followed by Red Bororo, Sokoto Gudali and Adamawa Gudali, in that order. The results agree with Olayemi *et al*. (2006), who reported the mean values of MCHC to be similar in Kuri and the White Fulani cattle. Contrarily, Olayemi *et al*. (2007) reported significantly higher MCHC values in Sokoto Gudali than White Fulani cattle in Ibadan, Nigeria.

(d) Management effects on MCHC (g/dl) values of cattle

The MCHC values of cattle based on management system as presented in table 4.23d show that there were no significant ($p > 0.05$) differences between cattle under the two management systems in Adamawa State. However, cattle under semi-sedentary management system recorded higher MCHC values as compared to those under pastoral system. This may be connected with better feed resource availability and environmental conditions found in the semi-sedentary system. These findings were in agreement with Olayemi *et al*. (2000), who investigated the hematology of WAD sheep under intensive and extensive management systems in Nigeria and found that both groups of animals had similar MCHC.

(e) Seasonal effects on MCHC (g/dl) values of cattle

The MCHC values of cattle based on season are presented in table 4.23e. The results indicate that, cattle recorded significantly ($p < 0.05$) higher values of MCHC during late rainy season (July - September) than during other seasons of the year in Adamawa State. However, cattle had similar MCHC values during early dry season (October - December) and late dry season (January - March) which again were significantly ($p < 0.05$) higher than values obtained during early rainy season (April - June). This could be because of seasonality in feed and water supply, natural tendencies, ages of the animals and genetic compositions of the animals. The results, also, corroborate that of Mohammed *et al.* (2007) who reported similar MCHC in Bunaji work bulls before and 10 minutes after farmland cultivation during rainy season in Kaduna.

4.4 Serum Enzymes Characteristics of Cattle Grazing the Guinea Savannah Zone of Adamawa State, Nigeria

Enzymes play vital roles in biological systems by acting as catalysts in such systems because at the temperature and pH of the human and animal body, reactions would not occur at a rate sufficient to support rapid muscular activity, nerve impulse generation and all the other processes required to support life (Devlin, 1986; Palmer, 2001). The investigation and interpretation of changes in serum enzymes in diseases and physiological status of animals form part of the most rapidly expanding fields in clinical biochemistry (Chatterjea & Shinde, 2002). While in health, all biochemical and physiological processes occur in an ordered and regulated manner, the maintain homeostasis can be profoundly disturbed in pathologic states. For example, severe tissue injuries that characterize liver cirrhosis can profoundly impair the ability of cells to form the enzymes that catalyze key metabolic processes such as urea synthesis. The resultant inability to convert toxic ammonia to non toxic urea is then followed by ammonia intoxication and ultimately hepatic coma (Murray, Granner, Mayes, & Rodwell, 2000).

A series of rare but frequently debilitating and often fatal genetic diseases are additional examples of the drastic physiologic consequences that can follow impairment of the activity of a single enzyme. Following severe tissue injury (e.g. cardiac or lung infarct, crushed limb, liver damage or trauma to the liver) or uncontrolled cell growth (e.g. prostatic carcinoma), enzymes that may be unique to specific tissues are released into the blood. Measurement of these intracellular enzymes in blood serum therefore provides medical and veterinary information on the diagnosis and prognosis of diseases in the human and animal body systems (Murray *et al*., 2000). It is expressed in micro liter (µl).

4.4.1 Aspartate Amino transferase (AST µl) values of cattle in Adamawa state

(a) Location effect on mean AST values of cattle in Adamawa state

The mean AST values of cattle in Adamawa state as shown in table 4.24a were not significantly ($p > 0.05$) different at the three study locations. However, cattle from Mubi North LGA recorded the highest value, followed by Jada and Gombi LGAs, in that order. The AST values obtained in the present study fell within the normal range of 10 - 100 µl (Adedibu *et al*., 2013). The similarity observed in AST values could be due to the uniform environmental conditions, feed and water resource availability and other natural phenomena in the study area.

The presence of AST in so many tissues makes their serum level a good marker of such tissue degradation but precludes its use as an organ specific enzyme (Boyd, 1983). Red blood cells contain large amounts of AST which leaks into plasma before haemolysis is seen (Kaneko, 1989). Therefore, determining AST activities in dairy cows is most often connected with fatty liver syndrome (Cebra, Gerry, Getzy, & Fettman, 1997), low appetite and the appearance of ketosis in dairy cows during early lactation (Steen, 2001). Increased AST activity in the serum is a sensitive marker of liver damage, even if the damage is of a sub clinical nature (Kauppinen, 1984; Meyer & Harvey, 1998). According to Tainturier, Braun, Rico, and Thouvenot (1984), the activity of AST enzyme shows occasional irregular small changes during pregnancy and early lactation. El-Ghoul, Hofmann, Khamis, and Hassanein (2000) determined significant differences in the activity of AST in late pregnancy, with AST activity at this period being much higher than in the first week after birth.

Table 4.24: Aspartate Amino transferase (AST µl) values of cattle in Adamawa state

Distribution of mean AST	*Minimum*	*Maximum*	*Mean*	*SEM*
(a) Effect of location on mean AST				
Mubi North	60.200	85.000	72.395	0.1734
Gombi	60.200	85.000	71.934	
Jada	60.200	85.000	72.276	
(b) Sex effects on mean AST				
Male	60.200	85.000	72.750^{a}	0.1416
Female	60.200	85.000	71.654^{b}	
(c) Breed effects on mean AST				
White Fulani	60.200	85.000	71.809^{a}	0.2002
Red Bororo	60.200	85.000	72.044^{b}	
Sokoto Gudali	60.200	85.000	72.544^{b}	
Adamawa Gudali	60.200	85.000	72.410^{b}	
(d) Mgt effects on mean AST				
Pastoral	60.200	85.000	72.207	0.1416
Semi - sedentary	60.200	85.000	72.197	
(e) Seasonal effects on mean AST				
Late Rainy Season (LRS)	60.200	85.000	72.129	0.2002
Early Dry Season (EDS)	60.200	85.000	72.334	
Late Dry Season (LDS)	60.200	85.000	72.091	
Early Rainy Season (ERS)	60.200	85.000	72.252	

abc means with different superscript(s) are significantly different ($p < 0.05$)

(b) Sex effects on AST values of cattle

The mean AST values of cattle based on sex are shown in table 4.24b. The findings show that there were significant ($p < 0.05$) differences in the mean AST of male and female cattle, with male values being higher than the female ones. The variations observed could be due to the sex differences, ages of the animals, health and physiological status of the cattle. The results agree with that of Adedibu *et al*. (2013), who reported similar AST value in Friesian x Bunaji cows at the National Animal Production Research Institute (NAPRI), Shika, Kaduna State, Nigeria. The results were also in agreement with Osman and Al-Busadah (2003), who reported AST values of cows to be 72.40 µl in Saudi Arabia. Adedibu *et al*. (2013) in their study of Friesian x Bunaji cows, also reported concentration of AST to be significantly higher in the dry cows (80.80 µl) than in lactating cows (73.80 µl).

Blood constituents such as serum enzymes have been reported (Otto *et al.*, 2000; El – Sherif and Assad, 2001) to be affected by physiological status of cows. Ling, Jaakson, Samarutel, and Leesmac (2003) for example, reported that, AST was low in dry periods but increased during day 117 and 151 of lactation in Estonian Holstein cows. However, the enzyme has been reported (Yildiz, Balikci, & Kaygusuzoglu, 2005) to increase in concentration during the dry period in cows. AST catalyses the creation of the structural components of the body of the fetus in pregnant animals, hence are important for pregnancy. According to Milinkovic–Tur *et al*. (2005), the activities of AST in the blood are associated with implantation, embryo survival, growth, uterine carbohydrate metabolism, amino acid metabolism and glycogen deposition. However, the results of the present study did not agree with Ihedioha and Agina (2013), who reported that there were no significant sex-related differences in the serum AST activities of horses in Enugu State, Nigeria. Ibrahim *et al*. (2012) also reported quite lower and insignificant sex variations in the mean values of AST in turkeys (*Meleagris gallopavo*) reared in the semi- arid environment of Nigeria.

(c) Breed effects on AST values of cattle

The mean AST values of cattle based on breed are shown in table 4.24c. Red Bororo, Sokoto Gudali and Adamawa Gudali breeds of cattle recorded significantly ($p < 0.05$) higher mean AST than White Fulani cattle. The variation could be due to breed differences, ages and physiological status of the cattle. The present study recorded higher AST values compared to that of Jóźwik *et al*. (2012), who reported lower values in their study in relation to milk yield and stage of lactation in Polish Holstein-Friesian Black and White dairy cows. Stojević, Piršljin, Milinković-Tur, Zdelar-Tuk, and Beer Ljubić (2005) again reported lower activities of AST in the plasma of 120 dairy Holstein breed cows in Croatia.

(d) Management effects on AST values of cattle

The mean AST values of cattle based on management system are shown in table 4.24d. There were no significant ($p > 0.05$) differences in the mean AST values of cattle under the two management systems. However, cattle raised under pastoral system had higher values of AST compared to those under semi-sedentary system. The slight variations could be due to differences in health and physiological status and nutrient resources available to the cattle. Jóźwik *et al*. (2012), reported lower AST values in dairy cows under intensive management in Warsaw, Poland. Stojević *et al*. (2005) also reported lower activities of AST in the plasma of dairy Holstein breed cows under intensive system in Croatia. Nonetheless, the results of the activity of AST in this study were within the accepted reference intervals 58 –100 (Mordak, 2008). Jóźwik *et al*. (2012) also reported that biochemical blood indicators, such as AST could be used to evaluate metabolic balance.

(e) Seasonal effects on AST values of cattle

The mean AST values of cattle based on season as shown in table 4.24e indicates that there were no seasonal significant ($p > 0.05$) differences in the mean AST values of cattle in the study areas. However, cattle recorded highest values during the EDS, followed by ERS, LRS and LDS, in that order. The variations could be attributed to the effects of physiological status and seasonal nutrient availability to the cattle. The results differ from the report of Ihedioha and Agina (2013) that there is significantly higher serum AST activity during the rainy season as compared to the dry season in horses in Enugu state southeastern Nigeria; in agreement with earlier reports of seasonal variations in the serum activity of AST in cattle (Hadzimusic & Krnic, 2010), goats (Tibbo *et al*., 2008a; Gwaze, Chimonyo, & Dzama, 2012), rabbits (Okab *et al*., 2008), sheep (Tibbo, Woldemeskel, Aragaw, & Rege, 2008b) and humans (Miyake *et al*., 2009) in Nigeria.

4.4.2 Alanine Amino transferase (ALT µl) values of cattle in Adamawa State

(a) location effect on mean ALT values of cattle in Adamawa State

The mean ALT values of cattle based on LGA are shown in table 4.25a. Cattle from Mubi North and Gombi LGAs recorded significantly ($p < 0.05$) higher mean ALT than those from Jada LGA. These variations could be due to physiological status and environmental conditions at the different locations. The serum ALT values are lower than those reported for horses by Coles (1986), Radostits, Gay, Hinchcliff, and Constable (2007), Krimer (2011), Egbe-Nwiyi, Kalu, and Naphtali (2012) in Maiduguri and Ihedioha and Agina (2013) in Enugu state, Nigeria. Some studies show that there is high activity of ALT in the liver of cattle and are most often determined if there is a suspicion of acute and chronic liver disease. Unlike AST, horse, pig, and cattle liver cells do not show high ALT activity, and the increased activity of the enzyme in the serum during liver damage, even in necrosis, is insignificant (Forenbacher, 1993). ALT can be found in the liver, skeletal muscle and the heart (Nduka, 1999).

Table 4.25: Alanine Amino transferase (ALT µl) values of cattle in Adamawa state

Distribution of mean ALT	*Minimum*	*Maximum*	*Mean*	*SEM*
(a) Effect of location on mean ALT				
Mubi North	30.000	49.600	41.770^{a}	0.1713
Gombi	30.000	49.600	42.009^{a}	
Jada	30.000	49.600	41.267^{b}	
(b) Sex effects on mean ALT				
Male	30.000	49.600	40.925^{a}	0.1399
Female	30.000	49.600	42.440^{b}	
(c) Breed effects on mean ALT				
White Fulani	30.000	49.600	41.607	0.1978
Red Bororo	30.000	49.600	41.598	
Sokoto Gudali	30.000	49.600	41.539	
Adamawa Gudali	30.000	49.600	41.984	
(d) Mgt effects on mean ALT				
Pastoral	30.000	49.600	41.667	0.1399
Semi - sedentary	30.000	49.600	41.698	
(e) Seasonal effects on mean ALT				
Late Rainy Season (LRS)	30.000	49.600	41.527	0.1978
Early Dry Season (EDS)	30.000	49.600	42.002	
Late Dry Season (LDS)	30.000	49.600	41.577	
Early Rainy Season (ERS)	30.000	49.600	41.623	

abc means with different superscript(s) are significantly different ($p < 0.05$)

(b) Sex effects on ALT values of cattle

The mean ALT values of cattle based on sex are shown in table 4.25b. The findings show that, female cattle recorded significantly ($p < 0.05$) higher mean ALT values than their male counterparts did. The findings agree with that of Adedibu *et al*. (2013), who found concentration of ALT to be significantly higher in the lactating Friesian x Bunaji cows (28.70 µl) than in the dry cows (28.40 µl) at the National Animal Production Research Institute (NAPRI), Shika, Kaduna State, Nigeria. The values were however higher than 34.00 µl reported by Osman and Al-Busadah (2003) in cattle in Saudi Arabia. Tainturier *et al*. (1984) reported that ALT in cows decreased significantly in the seventh and eighth month of pregnancy and at the beginning of lactation. However, their findings were lower than the present values and according to them physiological status did not significantly influence concentration of ALT in cattle.

(c) Breed effects on ALT values of cattle

The mean ALT values of cattle based on breed are shown in table 4.25c. There were no significant ($p > 0.05$) differences in the mean ALT values of all the breed of cattle in the study areas. However, Adamawa Gudali recorded the highest values followed by White Fulani, Red Bororo and Sokoto Gudali with the least values. The results of this study were in agreement with Jóźwik *et al*. (2012), who reported similar ALT values on Polish Holstein-Friesian Black and White dairy cows with two different milk yield levels in Warsaw, Poland. In another study, Stojević *et al*. (2005) recorded lower ALT values in the plasma of dairy Holstein breed cows in Croatia.

(d) Management effects on ALT values of cattle

The mean ALT values of cattle based on management system as shown in table 4.25d indicates that there were again no significant ($p > 0.05$) differences in the mean ALT values of cattle reared under the two management systems. However, those under semi-sedentary system recorded higher values than those in pastoral system. The results of the present study were in agreement with Jóźwik *et al*. (2012), who reported similar ALT values of dairy cows under intensive management in Poland. The findings fell within the accepted reference intervals of 25 –74 µl for cattle (Mordak, 2008).

(e) Seasonal effects on ALT values of cattle

The mean ALT values of cattle on seasonal basis are shown in table 4.25e. There were no seasonally significant ($p > 0.05$) differences in the mean ALT of cattle in the study areas. However, cattle recorded highest values during the ERS followed by LDS LRS and the least was recorded in the EDS. This diversity could be because of seasonality in nutrient supply to the cattle. The results are in agreement with Hadzimusic and Krnic (2010), who reported similar findings in cattle.

4.4.3 Alkaline Phosphatase (ALP µl) Values of Cattle in Adamawa State, Nigeria

According to Kaneko (1989), ALP was the earliest serum enzymes to be recognized to have clinical significance, when in the 1920s, it was discovered that it increases in bone and liver diseases. Ever since then, ALP has been the subject of more research than any other enzyme (Soetan, Aiyelaagbe, & Olaiya, 2010). Serum ALP activity has been used as diagnostic value in the hepatic and bone diseases in dogs and cats (Kaneko, 1989). It is of limited value in hepatic diseases of horses and cattle because of the broad range of reference values against which the patients' values must be compared. The range of serum ALP value in goats may be 40 to 80 µl with no evidence of hepatic damage. ALP values within the individual animals are however constant for sequential evaluation (Kaneko, 1989).

(a) Effect of location on ALP values of cattle in Adamawa State

The mean ALP values of cattle on LGA basis are shown in table 4.26a. There were significant ($p < 0.05$) differences in mean ALP values of cattle in the three study areas, with cattle from Gombi LGA recording the highest values followed by Jada and Mubi North LGAs. These significant variations could be due to environmental differences, health and physiological status of the animals and seasonality in nutrient supply. The ALP values in this study were lower than those reported for horses by Coles (1986), Radostits *et al*. (2007), Krimer (2011) and Egbe-Nwiyi *et al*. (2012) in Borno state and Ihedioha and Agina (2013) in Enugu State, Nigeria.

(b) Sex effects on ALP values of cattle

The mean ALP values of cattle on sex basis are shown in table 4.26b. The results showed that there were significant ($p < 0.05$) differences in the mean ALP of male and female cattle in the study area, with male cattle recording higher values than the females. The findings were not in agreement with Osman and Al-Busadah, 2003), who reported higher ALP of 49.80 µl in cows in Saudi Arabia. Adedibu *et al*. (2013) in their study of serum biochemical properties of Friesian x Bunaji cows at NAPRI, Kaduna State, Nigeria reported that ALP values were significantly higher in dry cows (132.60 µl) than in the lactating cows (89.50 µl). Their values were much higher than the values recorded in the present study. This disparity could be due to environmental differences, physiological status and nutrient availability for the cattle. Pednekar, Swarup, and Srivastava (1992) also found the ALP values to increase in cows with subclinical mastitis, while Grun, Furll, and Eicher (1993) reported that the activities of ALP was highest in milk than serum and blood plasma.

(c) Breed effects on ALP values of cattle

The mean ALP values of cattle on breed basis as shown in table 4.26c indicates that there were no significant ($p > 0.05$) variations in the mean ALP of White Fulani, Red Bororo and that of Sokoto Gudali cattle in the study area. However, Adamawa Gudali recorded significantly ($p < 0.05$) higher mean ALP than the other breeds. This significant variations observed also could be because of age differences, breed, health and physiological status, seasonality in nutrient availability and environmental fluctuations.

Table 4.26: Alkaline Phosphatase (ALP µl) values of cattle in Adamawa state

Distribution of mean ALP	*Minimum*	*Maximum*	*Mean*	*SEM*
(a) Effect of location on mean ALP				
Mubi North	40.100	59.000	45.292^{c}	0.0937
Gombi	40.100	59.000	47.500^{a}	
Jada	40.100	59.000	46.375^{b}	
(b) Sex effects on mean ALP				
Male	40.100	59.000	46.664^{a}	0.0765
Female	40.100	59.000	46.114^{b}	
(c) Breed effects on mean ALP				
White Fulani	40.100	59.000	46.172^{b}	0.1082
Red Bororo	40.100	59.000	46.362^{b}	
Sokoto Gudali	40.100	59.000	46.440^{b}	
Adamawa Gudali	40.100	59.000	46.582^{a}	
(d) Mgt effects on mean ALP				
Pastoral	40.100	59.000	46.384	0.0765
Semi - sedentary	40.100	59.000	46.394	
(e) Seasonal effects on mean ALP				
Late Rainy Season (LRS)	40.100	59.000	46.697^{a}	0.1082
Early Dry Season (EDS)	40.100	59.000	46.137^{b}	
Late Dry Season (LDS)	40.100	59.000	46.337^{b}	
Early Rainy Season (ERS)	40.100	59.000	46.386^{b}	

abc means with different superscript(s) are significantly different ($p < 0.05$)

(d) Management effects on ALP values of cattle

The mean ALP values of cattle based on management systems are shown in table 4.26d. There were no significant ($p > 0.05$) differences in the mean ALP of cattle across management systems employed in the study area. However, cattle recorded higher values under semi-sedentary system than under the pastoral system. Alterations in hematological and biochemical blood parameters under the influence of management, breed, sex, age, season, gestation and several diseases have been demonstrated in several domestic animal species (Strasser, Seiser, Heizmann, & Niedermuller, 2001; Altunok, Yazar, & Yuksek, 2007). Sharma and Bisoi (1995), reported differences in the ALP values among different age and management groups of cattle.

(e) Seasonal effects on ALP values of cattle

The mean ALP values of cattle on seasonal basis are shown in table 4.26e. The results show that, cattle recorded significantly ($p < 0.05$) higher mean ALP during LRS than other seasons of the year, while there were no significant differences in the mean values of cattle during EDS, LDS and ERS. These significant discrepancies could be due to physiological status and seasonality in nutrient availability for the cattle. These also corroborate the report of Hadzimusic and Krnic (2010), who obtained similar ALP values in cattle.

4.5 Breed and Management Interactions with Different Morpho-physiological Parameters in Cattle Grazing the Guinea Savannah Zone of Adamawa State

Variations in morpho-physiological conditions across breeds of cattle in northeastern Nigeria may be influenced by broad genetic diversity of cattle which provides opportunity for the selection of animals of superior performance in specific desirable traits such as calving rate, milk yield, meat quality, resistance to disease and parasites, and resilience to harsh weather conditions and seasonality in feed and water supply. Adedibu *et al*. (2013) made similar observations in their study of associations between milk yield, parity, physiological status and certain serum biochemical properties of Friesian x Bunaji cows in Nigeria.

4.5.1 Breed and management interactions with various parameters on BCS of cattle

(a) Breed and parameters interaction on BCS of cattle

i. Breed and management interaction: The results of breed and management associations as presented in table 4.27i showed insignificant ($p > 0.05$) interactions as indicated by the mean BCS values under pastoral and semi-sedentary systems of production. Red Bororo and Adamawa Gudali recorded higher BCS means under the semi-sedentary management system of production, while White Fulani and Sokoto Gudali recording lower mean BCS values under the pastoral management system of production. This implies that all breeds of cattle had equal opportunities and chances to thrive better in semi-sedentary system than in pastoral management system. This could also, mean that pastoral system may not be the best option in a changing environment like the study area. These results support that of Maciej (2013) who reported changes in body condition of cows as direct influence of feeding management and their health status.

ii Breed and sex interaction: The results of breed and sex interactions again recorded insignificant ($p > 0.05$) differences as shown in table 4.27ii. Although male and female Adamawa Gudali, Red Bororo and female Sokoto Gudali had higher breed association compared to male White Fulani, Sokoto Gudali and female White Fulani which recorded lower mean BCS values.

iii Breed and season interaction: The results of breed and seasonal relationship as presented in table 4.27iii showed insignificant ($p > 0.05$) interactions in all the four seasons. The results agree with Spiers, Spain, Sampson, and Rhoads (2004), who reported that physiological parameters are used to predict performance traits in farm animals under different environmental and management conditions.

Table 4.27: Breed and parameter interactions on BCS of cattle in Adamawa state

Parameter interactions		*Mean*	*SEM*
(i) Breed ×	Management		
White Fulani	Pastoral	2.8277	0.0390
Red Bororo	Pastoral	2.9271	
Sokoto Gudali	Pastoral	2.8052	
Adamawa Gudali	Pastoral	2.8654	
White Fulani	Semi-sedentary	3.0375	
Red Bororo	Semi-sedentary	3.1198	
Sokoto Gudali	Semi-sedentary	3.2271	
Adamawa Gudali	Semi-sedentary	3.3354	
(ii) Breed ×	Sex		
White Fulani	Male	2.9527	0.0390
Red Bororo	Male	3.0219	
Sokoto Gudali	Male	2.9833	
Adamawa Gudali	Male	3.1000	
White Fulani	Female	2.9125	
Red Bororo	Female	3.0250	
Sokoto Gudali	Female	3.0490	
Adamawa Gudali	Female	3.1008	
(iii) Breed ×	Season		
White Fulani	LRS	3.0604	0.0552
Red Bororo	LRS	3.0708	
Sokoto Gudali	LRS	3.1271	
Adamawa Gudali	LRS	3.1479	
White Fulani	EDS	3.0158	
Red Bororo	EDS	3.0125	
Sokoto Gudali	EDS	3.0000	
Adamawa Gudali	EDS	3.1083	
White Fulani	LDS	2.7854	
Red Bororo	LDS	2.9292	
Sokoto Gudali	LDS	2.9646	
Adamawa Gudali	LDS	3.0292	
White Fulani	ERS	2.8687	
Red Bororo	ERS	3.0813	
Sokoto Gudali	ERS	2.9729	
Adamawa Gudali	ERS	3.1162	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

Thus, research on indigenous breeds that are well adapted to the harsh semi arid environment with low feed supply and quality, through understanding of their physical body characteristics and physiological parameters (Spiers *et al*., 2004) would yield ideas on how to improve the production potentials of these breeds.

(b) Management and parameters interactions on BCS of cattle

Table 4.28 shows management and other parameters interactions in the cattle at Adamawa State.

i. Management and sex interaction: The results indicate insignificant ($p > 0.05$) variations in the mean BCS of cattle in relation to management practices and sexes of the animals as shown in table 4.28i. However, all cattle had better BCS under semi-sedentary system of production. This could be due to few privileges offered to animals under this system such as better access to more crop residues and by-products, occasional veterinary services and regular water supply. The results also agree with Matthias *et al*. (2013), who reported high influence of breed, grazing system and concentrate level on fattening performance, carcass value and meat quality of 96 German Simmental and German Holstein steers reared under sedentary system in Nigeria.

ii Management and season interaction: The results of management and season interactions again showed no significant ($p > 0.05$) differences as demonstrated by the mean BCS values of cattle in table 4.28ii. However, cattle performed better under the semi-sedentary production system during the four seasons.

iii Sex and season interaction: Table 4.28iii showed that both sexes performed better during the LRS, EDS and ERS, while males performed better during LDS. This implies that the seasons favor the males more than the females in the study area.

Table 4.28: Management and Parameter Interactions BCS of Cattle in Adamawa State

Parameter interactions		*Mean*	*SEM*
(i) Management ×	Sex		
Pastoral	Male	2.8644	0.0276
Pastoral	Female	2.8483	
Semi-sedentary	Male	3.1646	
Semi-sedentary	Female	3.1953	
(ii) Management ×	Season		
Pastoral	LRS	2.9875	0.0390
Pastoral	EDS	2.9110	
Pastoral	LDS	2.6937	
Pastoral	ERS	2.8331	
Semi-sedentary	LRS	3.2156	
Semi-sedentary	EDS	3.1573	
Semi-sedentary	LDS	3.1604	
Semi-sedentary	ERS	3.1865	
(iii) Sex ×	Season		
Male	LRS	3.1083	0.0390
Male	EDS	3.0329	
Male	LDS	2.8969	
Male	ERS	3.0198	
Female	LRS	3.0948	
Female	EDS	3.0354	
Female	LDS	2.9573	
Female	ERS	2.9998	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

This could be linked to gender differences in terms of feeding mode, as males are likely to have more bites than females per square meter of pasture and range lands. The results also corroborate that of Alphonsus *et al*. (2010), who reported positive relationships between the genetic, phenotypic, milk yield and body conformation traits of Friesian X Bunaji cows in Zaria, Nigeria.

4.52 Effect of Different Parameter Interactions on Rectal Temperature (RT ^{o}C) of Cattle in Adamawa State

(a) Breed and other parameters interactions on cattle RT

Table 4.29 shows the breed and other parameters interactions in respect to cattle RT in Adamawa State.

i Breed and management interaction: There were no significant ($p > 0.05$) differences of breed and management interactions as indicated by mean rectal temperature of cattle in table 4.29i. However, animals had higher rectal temperatures under the pastoral than in semi-sedentary system of production. This may be due to the extensive chasing around of animals to restrain them for rectal temperature collection which subjected the animals to excessive exercise.

ii. Breed and sex interactions: Table 4.29ii shows that breed and sex interactions did not yield significant ($p > 0.05$) differences in their rectal temperature. However, White Fulani, Red Bororo, Sokoto Gudali males and White Fulani, Red Bororo, Sokoto Gudali females had higher rectal temperatures than Adamawa Gudali males and females.

iii. Breed and season interaction: Again there were insignificant ($p > 0.05$) variations in breed and seasonal interactions as reflected by mean rectal temperatures of animals in table 4.29iii. This similarity may be related to breed, sex and body sizes and frames of the animals. The results disagree with Chandra (2012), who reported significant fluctuations in morning RT of growing and adult Sahiwal cattle during different seasons, with physiological parameters recording significantly higher values during the afternoon compared to forenoon values.

(b) Management and other parameters interactions on rectal temperature

Table 4.30 shows management and other parameters interactions on rectal temperatures of cattle in Adamawa State. The results of management and sex relationship indicated that both male and female cattle had significantly ($p < 0.05$) higher mean rectal temperatures under pastoral system than under semi-sedentary system of production as shown in table 4.30i. The results of management and season relationship also yielded significantly ($p < 0.05$) higher mean rectal temperatures during all the four seasons under the pastoral system than the values recorded under the semi-sedentary system of production as shown in table 4.30ii. The results of sex and season relationship however showed that male and female cattle had similar mean rectal temperatures across all the four seasons (Table 4.30iii).

Table 4.29: Breed and parameter interactions on rectal temperature (RT ^{o}C) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Breed ×	Management		
White Fulani	Pastoral	37.359	0.0873
Red Bororo	Pastoral	37.427	
Sokoto Gudali	Pastoral	37.446	
Adamawa Gudali	Pastoral	36.488	
White Fulani	Semi-sedentary	36.013	
Red Bororo	Semi-sedentary	36.156	
Sokoto Gudali	Semi-sedentary	36.075	
Adamawa Gudali	Semi-sedentary	35.983	
(ii) Breed ×	Sex		
White Fulani	Male	31.697	0.0873
Red Bororo	Male	31.785	
Sokoto Gudali	Male	31.779	
Adamawa Gudali	Male	31.226	
White Fulani	Female	31.674	
Red Bororo	Female	31.799	
Sokoto Gudali	Female	31.742	
Adamawa Gudali	Female	31.246	
(iii) Breed ×	Season		
White Fulani	LRS	31.683	0.1234
Red Bororo	LRS	31.744	
Sokoto Gudali	LRS	31.685	
Adamawa Gudali	LRS	31.764	
White Fulani	EDS	31.674	
Red Bororo	EDS	31.835	
Sokoto Gudali	EDS	31.697	
Adamawa Gudali	EDS	31.707	
White Fulani	LDS	31.670	
Red Bororo	LDS	31.888	
Sokoto Gudali	LDS	31.822	
Adamawa Gudali	LDS	31.693	
White Fulani	ERS	31.716	
Red Bororo	ERS	31.700	
Sokoto Gudali	ERS	31.837	
Adamawa Gudali	ERS	30.780	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

Table 4.30: Management and other parameters interactions on RT (^oC) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Management ×	Sex		
Pastoral	Male	37.130 [a]	0.0617
Pastoral	Female	37.230 [a]	
Semi-sedentary	Male	36.114 [b]	
Semi-sedentary	Female	36.000 [b]	
(ii) Management ×	Season		
Pastoral	LRS	37.401 [a]	0.0873
Pastoral	EDS	37.423 [a]	
Pastoral	LDS	37.430 [a]	
Pastoral	ERS	36.466 [a]	
Semi-sedentary	LRS	36.038 [b]	
Semi-sedentary	EDS	36.033 [b]	
Semi-sedentary	LDS	36.106 [b]	
Semi-sedentary	ERS	36.050 [b]	
(iii) Sex ×	Season		
Male	LRS	31.730	0.0873
Male	EDS	31.727	
Male	LDS	31.772	
Male	ERS	31.257	
Female	LRS	31.708	
Female	EDS	31.729	
Female	LDS	31.764	
Female	ERS	31.259	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

4.5.3 Effect of Different Parameter Interactions on Respiration Rate (RR/ beats/ min) of Cattle in Adamawa State

(a) Breed and other parameters interactions on RR

Table 4.31 shows breed and other parameters interactions on RR of cattle in Adamawa State.

i. Breed and management interactions: The results showed insignificant ($p > 0.05$) differences in breed and management interactions as indicated by mean RR in table 4.31i. The RR values recorded in the animals were within the normal range. However, Red Bororo had the highest RR under the two production systems than other breeds. This may be due to the breed effect, genetic and coat color influences.

ii. Breed and sex interaction: Table 4.31ii shows breed and sex interactions on respiratory rate of cattle. The results also indicated insignificant ($p > 0.05$) differences in respect to breeds and sex interactions. But Red Bororo males and females recorded higher values than other breeds. However, the values were within the normal range indicating that the slight disparity may be related to differences in the body sizes and frames of the animals.

iii. Breed and season interaction: Table 4.31iii shows breed and season interactions on respiratory rate of cattle. There were again no significant ($p > 0.05$) variations in relation RR of different breeds during the different seasons. In spite of this, Red Bororo cattle recorded the highest values across four seasons. These disagree with the report of Chandra (2012) for morning RR of growing and adult Sahiwal cattle during different seasons, in which RR became higher during hot humid season compared to summer over the spring season.

Table 4.31: Breed and parameter interactions on respiratory rate (RR/Beats/Minute) of Cattle

Parameter Interactions		*Mean*	*SEM*
(i) Breed ×	Management		
White Fulani	Pastoral	25.983	0.0767
Red Bororo	Pastoral	26.215	
Sokoto Gudali	Pastoral	26.035	
Adamawa Gudali	Pastoral	26.017	
White Fulani	Semi-sedentary	26.008	
Red Bororo	Semi-sedentary	26.213	
Sokoto Gudali	Semi-sedentary	26.046	
Adamawa Gudali	Semi-sedentary	26.008	
(ii) Breed ×	Sex		
White Fulani	Male	26.008	0.0767
Red Bororo	Male	26.302	
Sokoto Gudali	Male	26.069	
Adamawa Gudali	Male	26.054	
White Fulani	Female	25.983	
Red Bororo	Female	26.125	
Sokoto Gudali	Female	26.013	
Adamawa Gudali	Female	25.971	
(iii) Breed ×	Season		
White Fulani	LRS	25.963	0.1085
Red Bororo	LRS	26.229	
Sokoto Gudali	LRS	25.900	
Adamawa Gudali	LRS	26.200	
White Fulani	EDS	26.004	
Red Bororo	EDS	26.117	
Sokoto Gudali	EDS	26.004	
Adamawa Gudali	EDS	26.004	
White Fulani	LDS	26.008	
Red Bororo	LDS	26.208	
Sokoto Gudali	LDS	26.067	
Adamawa Gudali	LDS	25.867	
White Fulani	ERS	26.008	
Red Bororo	ERS	26.300	
Sokoto Gudali	ERS	26.192	
Adamawa Gudali	ERS	25.979	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

(b) Management and other parameters interactions on RR

Table 4.32 showed the management and other parameters interactions on respiratory rate of cattle in Adamawa State. There were insignificant ($p > 0.05$) differences in the mean RR values of both males and females in the study area. But male cattle had higher mean respiratory rate under both pastoral and under semi-sedentary systems of production as shown in table 4.32i. The results of management and seasonal relationship again showed that there were insignificant ($p > 0.05$) differences in mean respiratory rate during the four seasons under the two production systems. However, cattle recorded higher values during ERS under both the pastoral and semi-sedentary systems as shown in table 4.33ii. The results of sex and seasonal relationship showed that male and female cattle had similar mean RR values across four seasons as seen in table 4.32iii. However, males recorded higher values during ERS and LRS. This similarity may be related to breed, season, feeding, environmental conditions and health status of the animals.

Table 4.32: Management and parameter interactions on RR (Beats/Min) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Management ×	Sex		
Pastoral	Male	26.100	0.0542
Pastoral	Female	26.025	
Semi-sedentary	Male	26.117	
Semi-sedentary	Female	26.021	
(ii) Management ×	Season		
Pastoral	LRS	26.075	0.0767
Pastoral	EDS	26.027	
Pastoral	LDS	26.035	
Pastoral	ERS	26.112	
Semi-sedentary	LRS	26.071	
Semi-sedentary	EDS	26.038	
Semi-sedentary	LDS	26.040	
Semi-sedentary	ERS	26.127	
(iii) Sex ×	Season		
Male	LRS	26.129	0.0767
Male	EDS	26.081	
Male	LDS	26.062	
Male	ERS	26.160	
Female	LRS	26.017	
Female	EDS	25.983	
Female	LDS	26.013	
Female	ERS	26.079	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

4.5.4 Effect of Different Parameter Interactions on Pulse Rate (PR/ Beats/ Minute) of Cattle in Adamawa State

(a) Breed and other parameters interactions on pulse rate (PR) of cattle

Table 4.33 shows breed and other parameters interactions on pulse rate (PR) of cattle in Adamawa state. The PR of Adamawa Gudali was significantly ($p < 0.05$) lower than that of the other cattle breeds across pastoral and semi-sedentary management systems as shown in table 4.33i. Similarly, the breed and sex interactions on PR of cattle (Table 4.33ii) showed that expectedly Adamawa Gudali males and females cattle had significant ($p < 0.05$) lower PRs than both sexes in other breeds, indicating that this variation in PR is influenced by physiological peculiarities of that breed. Again, the lowest seasonal influence on PR (Table 4.33iii) was shown by the significantly ($p < 0.05$) lower value recorded in Adamawa Gudali during the LDS, followed by values recorded by White Fulani during the LRS, which was also significantly ($p < 0.05$) lower than values recorded during the other seasons in the other breeds.

(b) Management and other parameters interactions on PR of cattle

Table 4.34 shows management and other parameters interactions on PR of cattle in Adamawa State.

i. Management and sex interaction: The results yielded insignificant ($p > 0.05$) differences in the mean pulse rate of males and females cattle under both pastoral and under semi-sedentary systems of production as showing table 4.34i.

ii Management and season interaction: The results of management and seasonal relationship showed that cattle had significantly ($p < 0.05$) higher mean pulse rate during LRS, EDS and LDS than during ERS where animals recorded significantly ($p < 0.05$) lower values as shown in table 4.34ii.

Table 4.33: Breed and parameter interactions on pulse rate (PR/Beats/Minute) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Breed ×	Management		
White Fulani	Pastoral	55.944 [a]	0.1347
Red Bororo	Pastoral	55.735 [a]	
Sokoto Gudali	Pastoral	55.773 [a]	
Adamawa Gudali	Pastoral	55.369 [b]	
White Fulani	Semi-sedentary	55.860 [a]	
Red Bororo	Semi-sedentary	55.748 [a]	
Sokoto Gudali	Semi-sedentary	55.702 [a]	
Adamawa Gudali	Semi-sedentary	55.496 [a]	
(ii) Breed ×	Sex		
White Fulani	Male	55.937 [a]	0.1347
Red Bororo	Male	55.712 [a]	
Sokoto Gudali	Male	55.856 [a]	
Adamawa Gudali	Male	55.517 [b]	
White Fulani	Female	55.867 [a]	
Red Bororo	Female	55.771 [a]	
Sokoto Gudali	Female	55.619 [a]	
Adamawa Gudali	Female	55.348 [b]	
(iii) Breed ×	Season		
White Fulani	LRS	56.054 [b]	0.1904
Red Bororo	LRS	55.508 [a]	
Sokoto Gudali	LRS	55.679 [a]	
Adamawa Gudali	LRS	55.817 [a]	
White Fulani	EDS	55.954 [a]	
Red Bororo	EDS	55.925 [a]	
Sokoto Gudali	EDS	55.742 [a]	
Adamawa Gudali	EDS	55.596 [a]	
White Fulani	LDS	55.662 [a]	
Red Bororo	LDS	55.875 [a]	
Sokoto Gudali	LDS	55.888 [a]	
Adamawa Gudali	LDS	55.392 [c]	
White Fulani	ERS	55.938 [a]	
Red Bororo	ERS	55.658 [a]	
Sokoto Gudali	ERS	55.642 [a]	
Adamawa Gudali	ERS	54.925 [a]	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

Table 4.34: Management and parameter interactions PR (beats/ minute) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Management ×	Sex		
Pastoral	Male	55.767	0.0952
Pastoral	Female	55.644	
Semi-sedentary	Male	55.745	
Semi-sedentary	Female	55.658	
(ii) Management ×	Season		
Pastoral	LRS	55.790 [a]	0.1347
Pastoral	EDS	55.821 [a]	
Pastoral	LDS	55.679 [a]	
Pastoral	ERS	55.550 [b]	
Semi-sedentary	LRS	55.740 [a]	
Semi-sedentary	EDS	55.787 [a]	
Semi-sedentary	LDS	55.729 [a]	
Semi-sedentary	ERS	55.550 [b]	
(iii) Sex ×	Season		
Male	LRS	55.879 [a]	0.1347
Male	EDS	55.804 [a]	
Male	LDS	55.752 [a]	
Male	ERS	55.588 [b]	
Female	LRS	55.650 [a]	
Female	EDS	55.804 [a]	
Female	LDS	55.656 [a]	
Female	ERS	55.494 [b]	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

iii Sex and season interaction: The results of sex and seasonal relationship also showed that male and female cattle had significantly ($p < 0.05$) higher mean pulse rate during LRS, EDS and LDS except during ERS where animals recorded significantly ($p < 0.05$) lower values (Table 4.34iii). Thus, irrespective of management and sex influences, ERS resulted in the lowering of PR of cattle in the study area, probably due to the lowering of environmental temperature with sudden unset of rains and the return of abundant pasture and water supply during this period.

4.6 Effect of Different Parameter Interactions on the Hematology of Cattle in Adamawa State

4.6.1 Effect of different parameter interactions on red blood cell (RBC$\times 10^6/ mm^3$) counts of cattle in Adamawa state

(a) Breed and other parameters interactions on RBC of cattle

Table 4.35 shows breed and other parameters interactions on RBC of cattle in Adamawa State.

i. Breeds and management interaction: The results showed that there were insignificant ($p > 0.05$) differences in RBC of all the breeds under the two management systems as shown in table 4.35i. However, the RBC values recorded in the animals were again, within the normal range. The slight variations observed are in agreement with Tibbo *et al*. (2008), who reported that breed, management system, feeding, genetic and other environmental conditions influence hematological values of animals.

ii. Breed and sex interactions: Table 4.35ii shows breed and sex interactions on RBC of cattle. The results indicated that Red Bororo and Adamawa Gudali females recorded significantly ($p < 0.05$) lower mean RBC counts than the other animals. This variation corroborates that of Cetin, Bekyurek, and Cetin (2009) who again reported sex as one of the factors that affects hematological parameters in cattle.

Table 4.35: Breed and parameter interactions on red blood (RBC× 10^6/ mm^3) counts of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Breed ×	Management		
White Fulani	Pastoral	6.6071	0.0646
Red Bororo	Pastoral	6.6412	
Sokoto Gudali	Pastoral	6.6905	
Adamawa Gudali	Pastoral	6.6210	
White Fulani	Semi-sedentary	6.6111	
Red Bororo	Semi-sedentary	6.6435	
Sokoto Gudali	Semi-sedentary	6.6910	
Adamawa Gudali	Semi-sedentary	6.6210	
(ii) Breed ×	Sex		
White Fulani	Male	6.6628 [a]	0.0646
Red Bororo	Male	6.8073 [a]	
Sokoto Gudali	Male	6.7322 [a]	
Adamawa Gudali	Male	6.7421 [a]	
White Fulani	Female	6.5554 [a]	
Red Bororo	Female	6.4773 [b]	
Sokoto Gudali	Female	6.6493 [a]	
Adamawa Gudali	Female	6.4999 [b]	
(iii) Breed ×	Season		
White Fulani	LRS	6.7995 [a]	0.0913
Red Bororo	LRS	6.7106 [a]	
Sokoto Gudali	LRS	6.7096 [a]	
Adamawa Gudali	LRS	6.7620 [a]	
White Fulani	EDS	6.4312 [b]	
Red Bororo	EDS	6.6346 [a]	
Sokoto Gudali	EDS	6.5588 [a]	
Adamawa Gudali	EDS	6.8314 [a]	
White Fulani	LDS	6.7170 [a]	
Red Bororo	LDS	6.5657 [a]	
Sokoto Gudali	LDS	6.7067 [a]	
Adamawa Gudali	LDS	6.4561 [b]	
White Fulani	ERS	6.4888 [b]	
Red Bororo	ERS	6.6584 [a]	
Sokoto Gudali	ERS	6.7880 [a]	
Adamawa Gudali	ERS	6.4345 [b]	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

iii. Breed season interaction: Table 4.35iii also showed that White Fulani cattle recorded significantly ($p < 0.05$) lower RBC counts during EDS and ERS periods, while Adamawa Gudali recorded significantly ($p < 0.05$) lower values during LDS and ERS periods. This agrees with Oladele, Ayo, Ogundipe, and Esievo (2005) who found season to play a vital role in hematological conditions of cattle. However, the variation observed in Adamawa Gudali breed with respect to RR, PR and RBC may indicate adaptive changes in this breed that are particularly native to the study environment (Adebayo, 1999).

(b) Management and other parameters interactions on RBC of cattle

Table 4.36 shows management and other parameters interactions on RBC of cattle in Adamawa State. There was significantly ($p < 0.05$) higher mean RBC in males than female cattle under both pastoral and under semi-sedentary systems of production as shown in table 4.36i. The results of management and seasonal relationship also showed that cattle had significantly ($p < 0.05$) higher means RBC during LRS under pastoral and semi-sedentary management systems (Table 4.36ii).

These results support the earlier reports that factors that affect the hematology of animals include, age (Devi and Kumar, 2012), pregnancy (Farooq *et al*., 2011) and nutritional status (Iyayi, 2001). The results of sex and season relationship showed that female cattle had significantly ($p < 0.05$) lower mean RBC counts during EDS, LDS and ERS (Table 4.36iii). Generally, haematological profiles are important indicators of physiological changes in animals (Kumar and Pachaura, 2000). Seasonal changes in the thermal environment influence the physiological responses of animals. Thus, changes in haematological parameters such as total RBC count are of value in determining the adaptation of animals to the environment (Koubkova *et al.,* 2002).

Table 4.36: Management and parameter interactions on RBC ($\times10^6$/Mm^3) counts of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Management ×	Sex		
Pastoral	Male	6.7344 ^{a}	0.0457
Pastoral	Female	6.5455 ^{b}	
Semi-sedentary	Male	6.7378 ^{a}	
Semi-sedentary	Female	6.5455 ^{b}	
(ii) Management ×	Season		
Pastoral	LRS	6.7451 ^{a}	0.0646
Pastoral	EDS	6.6126 ^{b}	
Pastoral	LDS	6.6105 ^{b}	
Pastoral	ERS	6.5916 ^{b}	
Semi-sedentary	LRS	6.7458 ^{a}	
Semi-sedentary	EDS	6.6154 ^{b}	
Semi-sedentary	LDS	6.6122 ^{b}	
Semi-sedentary	ERS	6.5932 ^{b}	
(iii) Sex ×	Season		
Male	LRS	6.8325 ^{a}	0.0646
Male	EDS	6.7073 ^{a}	
Male	LDS	6.7001 ^{a}	
Male	ERS	6.7045 ^{a}	
Female	LRS	6.6583 ^{a}	
Female	EDS	6.5207 ^{b}	
Female	LDS	6.5226 ^{b}	
Female	ERS	6.4803 ^{b}	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

4.6.2 Effect of different parameter interactions on packed cell volume (PCV %) of cattle in Adamawa State

(a) Breed and other parameters interactions on PCV of cattle

Table 4.37 shows breed and other parameters interactions on PCV of cattle in Adamawa State.

i. Breed management interaction: The results showed that there were insignificant ($p > 0.05$) differences in the PCV of all the breeds under both pastoral and semi-sedentary management systems as shown in table 4.37i. However, the PCV recorded by the animals were within the normal recommended values for tropical cattle (Harewood *et al*., 2000; Alavi-Shoushtari, Asri-Rezai, & Abshenas, 2006) with Adamawa Gudali and Sokoto Gudali having higher values under semi-sedentary system than other breeds. These two breeds are relatively larger sized animals and under the better semi-sedentary management, they express the physiological attributes that drive attainment of better growth and body conformation.

ii. Breed and sex interaction: The results showed that Sokoto Gudali and Adamawa Gudali males recorded significantly ($p < 0.05$) higher mean PCV than both sexes of other breeds. This result indicates that the male populations of these breeds influenced the higher values obtained for the overall breed values. These sex effects on PCV of relatively larger sized animals managed under semi-sedentary system show the need to formulate different diets for male and female animals under this system, since both sexes may not show the same performance indicator values under the same feeding regimes as a result of different physiological functions (Harewood *et al*., 2000; Alavi-Shoustari *et al*., 2006). Again, the higher values recorded by Adamawa Gudali reflects the better adaptation of the breed to the production environment as shown in table 4.37ii.

Table 4.37: Breed and parameter interactions on PCV (%) of Cattle in Adamawa state

Parameter Interactions		*Mean*	*SEM*
(i) Breed ×	Management		
White Fulani	Pastoral	24.769	0.1486
Red Bororo	Pastoral	24.838	
Sokoto Gudali	Pastoral	24.945	
Adamawa Gudali	Pastoral	24.949	
White Fulani	Semi-sedentary	24.875	
Red Bororo	Semi-sedentary	24.894	
Sokoto Gudali	Semi-sedentary	25.018	
Adamawa Gudali	Semi-sedentary	25.033	
(ii) Breed ×	Sex		
White Fulani	Male	24.881 [b]	0.1486
Red Bororo	Male	24.959 [b]	
Sokoto Gudali	Male	25.028 [a]	
Adamawa Gudali	Male	25.094 [a]	
White Fulani	Female	24.764 [b]	
Red Bororo	Female	24.773 [b]	
Sokoto Gudali	Female	24.934 [b]	
Adamawa Gudali	Female	24.888 [b]	
(iii) Breed ×	Season		
White Fulani	LRS	25.205 [a]	0.2101
Red Bororo	LRS	25.084 [a]	
Sokoto Gudali	LRS	25.001 [a]	
Adamawa Gudali	LRS	25.060 [a]	
White Fulani	EDS	24.392 [b]	
Red Bororo	EDS	24.503 [a]	
Sokoto Gudali	EDS	24.734 [a]	
Adamawa Gudali	EDS	25.179 [a]	
White Fulani	LDS	25.200 [a]	
Red Bororo	LDS	24.924 [a]	
Sokoto Gudali	LDS	25.005 [a]	
Adamawa Gudali	LDS	25.198 [a]	
White Fulani	ERS	24.492 [b]	
Red Bororo	ERS	24.952 [a]	
Sokoto Gudali	ERS	25.185 [a]	
Adamawa Gudali	ERS	24.528 [a]	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

iii. Breed and season interaction: Table 4.37iii shows breed and season interactions on PCV of cattle. The results indicate that there were significantly ($p < 0.05$) lower mean PCV in White Fulani breed during the EDS and ERS, while the other breeds recorded similar values across all seasons. This may again be attributed to biological rhythms (Azeez, Oyagbemi, & Oyewale, 2009) indicating that White Fulani does not adapt as much as other breeds during certain periods of the year. The PCV values were however within the normal range for tropical cattle (Wickler & Aderson, 2000).

(b) Management and other parameters interactions on PCV of cattle

Table 4.38 shows management and other parameters interactions on PCV of cattle in Adamawa state.

i. Sex and management interaction: The results showed that there were no significant ($p > 0.05$) differences in the mean PCV of male and female cattle under both pastoral and under semi-sedentary systems of production (Table 4.38i). However, male animals recorded higher values under the semi-sedentary system of production.

ii. Management and season interaction: Similarly, the management and seasonal relationship results showed significant ($p < 0.05$) differences in mean PCV across four seasons under pastoral and semi-sedentary management systems. However, animals recorded highest values during LRS and LDS under both systems of production as shown in table 4.38ii.

iii. Sex and season interaction: The results of sex and season relationship again showed that male and female cattle values were not significantly ($p > 0.05$) different in their mean PCV during the four seasons. However, male and female cattle recorded highest values during LRS and LDS as shown in table 4.38iii. This may also be related to breed, season, feeding, environmental conditions and physiological status of the animals.

Table 4.38 Management and parameter interactions on PCV (%) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Management ×	Sex		
Pastoral	Male	24.917	0.1050
Pastoral	Female	24.834	
Semi-sedentary	Male	25.064	
Semi-sedentary	Female	24.846	
(ii) Management ×	Season		
Pastoral	LRS	25.022	0.1486
Pastoral	EDS	24.668	
Pastoral	LDS	25.039	
Pastoral	ERS	24.772	
Semi-sedentary	LRS	25.153	
Semi-sedentary	EDS	24.737	
Semi-sedentary	LDS	25.124	
Semi-sedentary	ERS	24.806	
(iii) Sex ×	Season		
Male	LRS	25.194	0.1486
Male	EDS	24.793	
Male	LDS	25.136	
Male	ERS	24.840	
Female	LRS	24.981	
Female	EDS	24.611	
Female	LDS	25.027	
Female	ERS	24.739	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

The results support El-Nouty *et al*. (1990), who reported that changes in haematological parameters such as PCV determine the adaptation of animals to the environment.

Indeed haematological profiles are important indicators of physiological changes in animals especially during seasonal changes in the thermal environment when such profiles exert a lot of influence on physiological responses of animals (Kumar & Pachaura, 2000). These results therefore, indicate that Adamawa Gudali and to a lesser extent Red Bororo may be better adapted to the general production environment of Adamawa State and respond better to the improved condition provided under semi-sedentary management system.

4.6.3 Effect of Different parameter interactions on hemoglobin concentration (Hb gm/dl) of cattle in Adamawa State

(a) Breed and other parameters interactions on Hb of cattle

Table 4.39 shows breed and other parameters interactions on Hb of cattle in Adamawa State.

i. Breed and management interaction: There were generally no significant ($p > 0.05$) differences in Hb of all the breeds of cattle under both pastoral and semi-sedentary management systems as shown in table 4.39i. However, White Fulani, Red Bororo and Sokoto Gudali had higher values than Adamawa Gudali cattle under both pastoral and semi-sedentary systems. The Hb values recorded by the animals were again, within the normal recommended values for tropical cattle (Wickler & Aderson, 2000). The slight variations observed may be due to daily management, feeding, and other environmental influences incidental to the different study locations.

ii. Breed and sex interaction: Table 4.39ii shows breed and sex interactions on Hb of cattle. There were no significant ($p > 0.05$) differences in the mean Hb of male and female animals, however, White Fulani, Red Bororo, Sokoto Gudali and Adamawa Gudali males had higher Hb values than Red Bororo and Adamawa Gudali females.

Table 4.39 Breed and parameter interactions on Hb (gm/dl) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Breed ×	Management		
White Fulani	Pastoral	10.428	0.0442
Red Bororo	Pastoral	10.428	
Sokoto Gudali	Pastoral	10.430	
Adamawa Gudali	Pastoral	10.389	
White Fulani	Semi-sedentary	10.422	
Red Bororo	Semi-sedentary	10.425	
Sokoto Gudali	Semi-sedentary	10.434	
Adamawa Gudali	Semi-sedentary	10.382	
(ii) Breed ×	Sex		
White Fulani	Male	10.422	0.0442
Red Bororo	Male	10.468	
Sokoto Gudali	Male	10.427	
Adamawa Gudali	Male	10.436	
White Fulani	Female	10.428	
Red Bororo	Female	10.385	
Sokoto Gudali	Female	10.438	
Adamawa Gudali	Female	10.336	
(iii) Breed ×	Season		
White Fulani	LRS	10.357	0.0626
Red Bororo	LRS	10.484	
Sokoto Gudali	LRS	10.484	
Adamawa Gudali	LRS	10.372	
White Fulani	EDS	10.427	
Red Bororo	EDS	10.408	
Sokoto Gudali	EDS	10.397	
Adamawa Gudali	EDS	10.397	
White Fulani	LDS	10.520	
Red Bororo	LDS	10.422	
Sokoto Gudali	LDS	10.407	
Adamawa Gudali	LDS	10.359	
White Fulani	ERS	10.396	
Red Bororo	ERS	10.391	
Sokoto Gudali	ERS	10.442	
Adamawa Gudali	ERS	10.415	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

iii. Breed and seasonal interaction: Breed and seasonal interactions on Hb of cattle were again not statistically significant ($p > 0.05$). However, White Fulani recorded the highest value during the LDS followed by Red Bororo and Sokoto Gudali during the LRS respectively (Table 4.39iii).

(b) Management and parameter interactions on Hb of cattle

Table 4.40 shows management and parameter interactions on Hb of cattle in Adamawa state. There were no significant ($p > 0.05$) differences in the mean Hb of male and female cattle under both two systems of production as shown table 4.40i. However, male animals recorded higher values than female ones under the semi-sedentary system of production. The results of management and season interactions also showed no significant ($p > 0.05$) differences in Hb means during the four seasons under pastoral and semi-sedentary management systems. However, animals recorded highest values during LRS and LDS under the two systems of production as shown in table 4.40ii. The results of sex and seasonal relationship showed that there were insignificant ($p > 0.05$) differences in the Hb means of male and female cattle during the four seasons. However, female cattle recorded highest values during LRS and LDS as shown in table 4.40iii.

This also, may be related to breed, season, feeding, environmental conditions and health status of the animals. The results were not in agreement with Chandra (2012), who reported significantly higher hematological parameters during winter season than other seasons, whereas Hb levels were lower during summer as compared to spring season in both groups of animals.

Table 4.40: Management and parameter interactions on Hb (gm/dl) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Management ×	Sex		
Pastoral	Male	10.441	0.0313
Pastoral	Female	10.396	
Semi-sedentary	Male	10.435	
Semi-sedentary	Female	10.397	
(ii) Management ×	Season		
Pastoral	LRS	10.426	0.0442
Pastoral	EDS	10.404	
Pastoral	LDS	10.424	
Pastoral	ERS	10.421	
Semi-sedentary	LRS	10.422	
Semi-sedentary	EDS	10.410	
Semi-sedentary	LDS	10.430	
Semi-sedentary	ERS	10.402	
(iii) Sex ×	Season		
Male	LRS	10.396	0.0442
Male	EDS	10.447	
Male	LDS	10.447	
Male	ERS	10.461	
Female	LRS	10.452	
Female	EDS	10.367	
Female	LDS	10.406	
Female	ERS	10.361	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

4.6.4 Effect of different parameter interactions on white blood cell (WBC×10^3/ µl) counts of cattle in Adamawa state

(a) Breed and other parameters interactions on WBC of cattle

Table 4.41 shows breed and other parameters interactions on WBC of cattle in Adamawa state.

i. Breed and management interaction: There were no significant ($p > 0.05$) differences in WBC of all the breeds of cattle under pastoral and semi-sedentary management systems as shown in table 4.41i. However, Sokoto Gudali had the highest WBC values, while White Fulani and Adamawa Gudali recorded the lowest under pastoral and semi-sedentary systems. The WBC values were again within the normal recommended values for tropical cattle (Wickler & Aderson, 2000). The slight variations observed may be due to breed, management system, feeding and other environmental influences.

ii. Breed and sex interaction: Table 4.41ii shows again that there were no significant ($p > 0.05$) differences in the mean WBC values of male and female animals across the different breeds studied. However, Sokoto Gudali females had the highest values, while White Fulani males recorded the lowest.

iii. Breed and season interaction: Table 4.41iii also shows that there were no significant ($p > 0.05$) differences in the breed and season interactions in WBC values of cattle. Sokoto Gudali recorded the highest values during the ERS and LRS, followed by Adamawa Gudali during the LDS. Aengwanich *et al*. (2009) also reported lack of seasonal effects on the haematological profiles of slaughtered cattle in Northern Thailand. WBC counts have been also used to predict the level of adaptation in cattle produced under adverse environmental conditions such as obtainable during the LDS and ERS periods in Northern Nigeria (Kumar & Pachaura, 2000).

Table 4.41: Breed and parameter interactions on WBC×10^3/ μl of cattle

Parameter Interactions		Mean	SEM
(i) Breed ×	Management		
White Fulani	Pastoral	6.7994	0.0617
Red Bororo	Pastoral	6.8067	
Sokoto Gudali	Pastoral	6.8792	
Adamawa Gudali	Pastoral	6.8039	
White Fulani	Semi-sedentary	6.8015	
Red Bororo	Semi-sedentary	6.8067	
Sokoto Gudali	Semi-sedentary	6.8792	
Adamawa Gudali	Semi-sedentary	6.7942	
(ii) Breed ×	Sex		
White Fulani	Male	6.7605	0.0617
Red Bororo	Male	6.8053	
Sokoto Gudali	Male	6.8414	
Adamawa Gudali	Male	6.7931	
White Fulani	Female	6.8404	
Red Bororo	Female	6.8081	
Sokoto Gudali	Female	6.9171	
Adamawa Gudali	Female	6.8050	
(iii) Breed ×	Season		
White Fulani	LRS	6.8657	0.0872
Red Bororo	LRS	6.8538	
Sokoto Gudali	LRS	6.9041	
Adamawa Gudali	LRS	6.7402	
White Fulani	EDS	6.7411	
Red Bororo	EDS	6.8493	
Sokoto Gudali	EDS	6.7833	
Adamawa Gudali	EDS	6.8412	
White Fulani	LDS	6.8598	
Red Bororo	LDS	6.7387	
Sokoto Gudali	LDS	6.8583	
Adamawa Gudali	LDS	6.9103	
White Fulani	ERS	6.7353	
Red Bororo	ERS	6.7850	
Sokoto Gudali	ERS	6.9713	
Adamawa Gudali	ERS	6.7044	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

(b) Management and other parameters interactions on WBC of cattle

Table 4.42 shows management and other parameters interactions on WBC of cattle in Adamawa state.

i. Sex and management interaction: The results did not reveal any significant ($p > 0.05$) differences in the mean WBC of male and female cattle under both pastoral and semi-sedentary systems of production as shown in table 4.42i. However, female animals recorded higher values than their male counterparts did.

ii. Management and season interaction: The results of management and seasonal relationships again did not show significant ($p > 0.05$) differences in mean WBC values during the four seasons under pastoral and semi-sedentary management systems. However, animals recorded the highest value during LRS under the semi-sedentary system, while the least values were recorded during ERS under the same system as shown in table 4.42ii. The results did not agree with Shaffer, Roussel, and Koonce (1981), who observed a highly significant impact of temperature/season on blood profiles of dairy cattle in Brazil.

iii. Sex and season interaction: The results of sex and season relationship show that male and female cattle had no significant ($p > 0.05$) differences in mean WBC values during the four seasons. However, female cattle recorded the highest values during ERS, whereas male animals recorded the least value during ERS as shown in table 4.42iii. The result agree with Ajuogu, Yahaya, and Ndubuisi (2014), who reported that, lymphocytes profile of cattle was not significantly affected by breed in Nigeria.

Table 4.42 Management and parameter interactions on WBC×10^3/ µl of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Management ×	Sex		
Pastoral	Male	6.7985	0.0436
Pastoral	Female	6.8461	
Semi-sedentary	Male	6.8016	
Semi-sedentary	Female	6.8392	
(ii) Management ×	Season		
Pastoral	LRS	6.8399	0.0617
Pastoral	EDS	6.8037	
Pastoral	LDS	6.8418	
Pastoral	ERS	6.8039	
Semi-sedentary	LRS	6.8420	
Semi-sedentary	EDS	6.8037	
Semi-sedentary	LDS	6.8418	
Semi-sedentary	ERS	6.7941	
(iii) Sex ×	Season		
Male	LRS	6.8400	0.0617
Male	EDS	6.7704	
Male	LDS	6.8506	
Male	ERS	6.7393	
Female	LRS	6.8419	
Female	EDS	6.8370	
Female	LDS	6.8329	
Female	ERS	6.8587	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

4.6.5 Effect of different parameter interactions on mean corpuscular volume (MCV fl) of cattle in Adamawa state

(a) Breed and other parameters interactions on MCV of cattle

Table 4.43 shows breed and other parameters interactions on MCV of cattle in Adamawa State.

i. Breed and management interaction: Sokoto Gudali recorded significantly ($p < 0.05$) lower MCV than the other breeds under both pastoral and semi-sedentary management systems (Table 4.43i). The MCV values were however within the normal recommended values for tropical cattle (Ajuogu *et al*., 2014). The MCV score of Sokoto Gudali may indicate that it is less adapted to the production environment.

ii. Breed and sex interaction: Table 4.43ii shows breed and sex interactions on MCV of cattle. The White Fulani females recorded significantly ($p < 0.05$) lower mean MCV than both sexes of the other breeds. These results are reflective of the earlier RBC values obtained in this study that showed minimal dimorphisms of MCV values across breeds.

iii. Breed and season interaction: Table 4.43iii shows breed and season interactions on MCV of cattle. Sokoto Gudali recorded significantly ($p < 0.05$) lower MCV values during EDS, LDS and ERS, while Red Bororo also recorded similar lower values during EDS, even though, the MCV values were within the normal range for tropical cattle. These results show distinct profile response of the Sokoto Gudali breed to seasonal changes in the production environment.

Table 4.43: Breed and parameter interactions on MCV (fl) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Breed ×	Management		
White Fulani	Pastoral	54.262 [a]	0.1689
Red Bororo	Pastoral	54.386 [a]	
Sokoto Gudali	Pastoral	54.090 [b]	
Adamawa Gudali	Pastoral	54.449 [a]	
White Fulani	Semi-sedentary	54.262 [a]	
Red Bororo	Semi-sedentary	54.387 [a]	
Sokoto Gudali	Semi-sedentary	54.090 [b]	
Adamawa Gudali	Semi-sedentary	54.449 [a]	
(ii) Breed ×	Sex		
White Fulani	Male	54.424 [a]	0.1689
Red Bororo	Male	54.457 [a]	
Sokoto Gudali	Male	54.409 [a]	
Adamawa Gudali	Male	54.519 [a]	
White Fulani	Female	54.100 [b]	
Red Bororo	Female	54.316 [a]	
Sokoto Gudali	Female	53.772 [a]	
Adamawa Gudali	Female	54.379 [a]	
(iii) Breed ×	Season		
White Fulani	LRS	54.237 [a]	0.2388
Red Bororo	LRS	54.381 [a]	
Sokoto Gudali	LRS	54.249 [a]	
Adamawa Gudali	LRS	54.653 [a]	
White Fulani	EDS	54.370 [a]	
Red Bororo	EDS	54.106 [b]	
Sokoto Gudali	EDS	54.144 [b]	
Adamawa Gudali	EDS	54.375 [a]	
White Fulani	LDS	54.239 [a]	
Red Bororo	LDS	54.528 [a]	
Sokoto Gudali	LDS	54.131 [b]	
Adamawa Gudali	LDS	54.571 [a]	
White Fulani	ERS	54.202 [a]	
Red Bororo	ERS	54.530 [a]	
Sokoto Gudali	ERS	53.837 [b]	
Adamawa Gudali	ERS	54.197 [a]	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

(b) Management and other parameters interactions on MCV of cattle

Table 4.44 shows the management and other parameters interactions on MCV of cattle in Adamawa state. The male animals recorded significantly ($p < 0.05$) higher mean MCV than female cattle under both pastoral and under semi-sedentary systems of production as shown in Table 4.44i. However, the results of management and seasonal relationship did not show any significant ($p > 0.05$) differences in mean MCV during the four seasons under pastoral and semi-sedentary management systems. Animals recorded highest values during LRS under the pastoral and semi-sedentary systems and the least values were during ERS as shown in table 4.44ii.

The results of sex and season relationship showed that male cattle had significantly ($p < 0.05$) higher mean MCV values than female cattle during the four seasons (Table 4.44iii). This again showed that there is distinct sexual dimorphism in cattle MCV response to the different management and seasonal variations in the study area. This highlights the need for some level of sexual distinction in the feeding and management of the animals, especially in line with identified physiological peculiarities such as estrus and lactation states (Harewood *et al*., 2000; Alavi-shoustari *et al*., 2006).

Table 4.44: Management and parameter interactions on MCV(fl) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Management ×	Sex		
Pastoral	Male	54.451 [a]	0.1194
Pastoral	Female	54.142 [b]	
Semi-sedentary	Male	54.453 [a]	
Semi-sedentary	Female	54.141 [b]	
(ii) Management ×	Season		
Pastoral	LRS	54.380	0.1689
Pastoral	EDS	54.248	
Pastoral	LDS	54.367	
Pastoral	ERS	54.192	
Semi-sedentary	LRS	54.380	
Semi-sedentary	EDS	54.249	
Semi-sedentary	LDS	54.367	
Semi-sedentary	ERS	54.192	
(iii) Sex ×	Season		
Male	LRS	54.532 [a]	0.1689
Male	EDS	54.344 [a]	
Male	LDS	54.432 [a]	
Male	ERS	54.500 [a]	
Female	LRS	54.228 [b]	
Female	EDS	54.153 [b]	
Female	LDS	54.303 [b]	
Female	ERS	53.884 [b]	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

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4.6.6 Effect of different parameter interactions on mean corpuscular hemoglobin (MCH pg) of cattle in Adamawa state

Table 4.45 shows breed and other parameters interactions on MCH of cattle in Adamawa State.

(a) Breed and other parameters interactions on MCH of cattle

i. Breed and management interaction: The results showed insignificant ($p > 0.05$) differences in the mean MCH of cattle under both pastoral and semi-sedentary systems (Table 4.45i). However, White Fulani had the highest values under the two systems, while Adamawa Gudali recorded the lowest values. The MCH recorded by the animals were again, within the normal recommended values for tropical cattle (Ajuogu *et al*., 2014).

ii. Breed and sex interaction: Table 4.45ii shows breed and sex interactions on MCH of cattle. The results indicated that all males across breeds recorded similar mean MCH which were significantly ($p < 0.05$) higher than value recorded in female Adamawa Gudali

iii. Breed and season interaction: White Fulani MCH values during ERS was significantly ($p < 0.05$) lower than other breed values across seasons (Table 4.45iii). Other breed and season interactions values were however, similar. These results agree with those of Aengwarich *et al*. (2009) that there is no seasonal effect on some hematological values of cattle. El-Nouty, Al-Haidary, and Salah. (1990) however, reported that mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) are of paramount value for the adaptation of animals to the environment.

Table 4.45: Breed and parameter interactions on MCH (pg) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Breed ×	Management		
White Fulani	Pastoral	22.614	0.1262
Red Bororo	Pastoral	22.536	
Sokoto Gudali	Pastoral	22.558	
Adamawa Gudali	Pastoral	22.492	
White Fulani	Semi-sedentary	22.614	
Red Bororo	Semi-sedentary	22.536	
Sokoto Gudali	Semi-sedentary	22.558	
Adamawa Gudali	Semi-sedentary	22.492	
(ii) Breed ×	Sex		
White Fulani	Male	22.676 [a]	0.1262
Red Bororo	Male	22.578 [a]	
Sokoto Gudali	Male	22.603 [a]	
Adamawa Gudali	Male	22.611 [a]	
White Fulani	Female	22.552 [a]	
Red Bororo	Female	22.493 [a]	
Sokoto Gudali	Female	22.513 [a]	
Adamawa Gudali	Female	22.373 [b]	
(iii) Breed ×	Season		
White Fulani	LRS	22.836 [a]	0.1785
Red Bororo	LRS	22.542 [a]	
Sokoto Gudali	LRS	22.586 [a]	
Adamawa Gudali	LRS	22.415 [a]	
White Fulani	EDS	22.614 [a]	
Red Bororo	EDS	22.477 [a]	
Sokoto Gudali	EDS	22.535 [a]	
Adamawa Gudali	EDS	22.511 [a]	
White Fulani	LDS	22.718 [a]	
Red Bororo	LDS	22.545 [a]	
Sokoto Gudali	LDS	22.512 [a]	
Adamawa Gudali	LDS	22.508 [a]	
White Fulani	ERS	22.288 [b]	
Red Bororo	ERS	22.578 [a]	
Sokoto Gudali	ERS	22.600 [a]	
Adamawa Gudali	ERS	22.534 [a]	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

(b) Management and other parameters interactions on MCH of cattle

Table 4.46 shows the management and other parameters interactions on MCH of cattle in Adamawa state. There were no significant ($p > 0.05$) differences in the mean MCH of cattle under the two management systems studied. However, male animals recorded higher values than female cattle under both pastoral and under semi-sedentary systems of production (Table 4.46i).The results of management and season relationships also showed no significant ($p > 0.05$) differences in mean MCH during the four seasons under pastoral and semi-sedentary management systems. However, animals recorded highest values during LRS under the pastoral and semi-sedentary systems, while the least values were recorded during ERS as shown in Table 4.46ii. The results of sex and season relationships again showed no significant ($p > 0.05$) differences in the mean MCH of cattle across the four seasons. Male animals had the highest values during LRS, while female animals recorded the lowest values during EDS as can be seen in table 4.46iii.

Table 4.46: Management and parameter interactions on MCH (pg) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Management ×	Sex		
Pastoral	Male	22.617	0.0892
Pastoral	Female	22.483	
Semi-sedentary	Male	22.617	
Semi-sedentary	Female	22.483	
(ii) Management ×	Season		
Pastoral	LRS	22.595	0.1262
Pastoral	EDS	22.534	
Pastoral	LDS	22.571	
Pastoral	ERS	22.500	
Semi-sedentary	LRS	22.595	
Semi-sedentary	EDS	22.534	
Semi-sedentary	LDS	22.571	
Semi-sedentary	ERS	22.500	
(iii) Sex ×	Season		
Male	LRS	22.692	0.1262
Male	EDS	22.678	
Male	LDS	22.619	
Male	ERS	22.479	
Female	LRS	22.498	
Female	EDS	22.390	
Female	LDS	22.522	
Female	ERS	22.479	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

4.6.7 Effect of different parameter interactions on mean corpuscular hemoglobin concentration (MCHC gm/dl) of cattle in Adamawa state

(a) Breed and other parameters interactions on MCHC of cattle

Table 4.47 shows breed and parameter interactions on MCHC of cattle in Adamawa State.

i. Breed and management interaction: The results showed insignificant ($p > 0.05$) differences in the mean MCHC of cattle under both pastoral and semi-sedentary management systems (Table 4.47i). However, White Fulani recoreded the highest values under the pastoral and semi-sedentary systems, while Adamawa Gudali recorded the lowest values. The MCHC recorded by the animals were however within the normal recommended values.

ii. Breed and sex interaction: Table 4.7ii shows breed and sex interactions on MCHC of cattle. Male and female Red Bororo recorded significantly ($p < 0.05$) lower mean MCHC than other groups. These differences may be due to the breed, sex, genetic and other environmental influences.

iii. Breed and season interaction: Table 4.47iii shows breed and season interactions on MCHC of cattle. The LDS and ERS values of Sokoto Gudali and ERS values of White Fulani and Adamawa Gudali were significantly ($p < 0.05$) lower than the values recorded by the other breeds during the other seasons. Koubkova *et al*. (2002) stated that changes in hematological parameters such as mean corpuscular hemoglobin concentration (MCHC) are of value in determining the adaptation of animals to the environment.

Table 4.47: Breed and parameter interactions on MCHC (gm/dl) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Breed ×	Management		
White Fulani	Pastoral	33.231	0.1154
Red Bororo	Pastoral	33.192	
Sokoto Gudali	Pastoral	33.132	
Adamawa Gudali	Pastoral	33.128	
White Fulani	Semi-sedentary	33.231	
Red Bororo	Semi-sedentary	33.192	
Sokoto Gudali	Semi-sedentary	33.175	
Adamawa Gudali	Semi-sedentary	33.146	
(ii) Breed ×	Sex		
White Fulani	Male	33.283 ^{a}	0.1154
Red Bororo	Male	33.364 ^{a}	
Sokoto Gudali	Male	33.171 ^{a}	
Adamawa Gudali	Male	33.138 ^{a}	
White Fulani	Female	33.179 ^{a}	
Red Bororo	Female	33.020 ^{b}	
Sokoto Gudali	Female	33.136 ^{a}	
Adamawa Gudali	Female	33.137 ^{a}	
(iii) Breed ×	Season		
White Fulani	LRS	33.432 ^{a}	0.1632
Red Bororo	LRS	33.205 ^{a}	
Sokoto Gudali	LRS	33.279 ^{a}	
Adamawa Gudali	LRS	33.174 ^{a}	
White Fulani	EDS	33.315 ^{a}	
Red Bororo	EDS	33.215 ^{a}	
Sokoto Gudali	EDS	33.217 ^{a}	
Adamawa Gudali	EDS	33.137 ^{a}	
White Fulani	LDS	33.118 ^{a}	
Red Bororo	LDS	33.141 ^{a}	
Sokoto Gudali	LDS	33.071 ^{b}	
Adamawa Gudali	LDS	33.161 ^{a}	
White Fulani	ERS	33.060 ^{b}	
Red Bororo	ERS	33.206 ^{a}	
Sokoto Gudali	ERS	33.047 ^{b}	
Adamawa Gudali	ERS	33.077 ^{b}	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

(b) Management and other parameters interactions on MCHC of cattle

Table 4.48 shows management and parameter interactions on MCHC of cattle in Adamawa state. There were insignificant ($p > 0.05$) sex effects in the mean MCHC of cattle across the two management systems. However, male animals recorded higher values than female cattle under both systems of production as shown in table 4.48i. The results of management and seasonal relationship also showed that cattle managed under the two systems had insignificant ($p > 0.05$) MCHC means during the four seasons. However, animals recorded highest values during LRS, while the least values were recorded during ERS (Table 4.48ii). The results of sex and seasonal relationship showed that male cattle had significantly ($p < 0.05$) higher mean MCHC during LRS and EDS than female animals during other seasonal periods (Table 4.48iii).

Table 4.48: Management and parameter interactions on MCHC (gm/dl) of Cattle

Parameter Interactions		*Mean*	*SEM*
(i) Management ×	Sex		
Pastoral	Male	33.225	0.0816
Pastoral	Female	33.117	
Semi-sedentary	Male	33.253	
Semi-sedentary	Female	33.119	
(ii) Management ×	Season		
Pastoral	LRS	33.282	0.1154
Pastoral	EDS	33.209	
Pastoral	LDS	33.064	
Pastoral	ERS	33.127	
Semi-sedentary	LRS	33.263	
Semi-sedentary	EDS	33.233	
Semi-sedentary	LDS	33.181	
Semi-sedentary	ERS	33.067	
(iii) Sex ×	Season		
Male	LRS	33.394^{a}	0.1154
Male	EDS	33.323^{a}	
Male	LDS	33.098^{b}	
Male	ERS	33.141^{b}	
Female	LRS	33.152^{b}	
Female	EDS	33.120^{b}	
Female	LDS	33.147^{b}	
Female	ERS	33.054^{b}	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

4.7 Effect of Different Parameter Interactions on Serum Enzymes of Cattle in Adamawa State

4.7.1 Effect of different parameter interactions on aspartate aminotransferase (AST) of cattle in Adamawa state

(a) Breed and parameter interactions on AST of cattle

Table 4.49 shows breed and parameter interactions on AST of cattle in Adamawa State.

i. Breeds and management interaction: The results showed insignificant ($p > 0.05$) differences in the mean AST of cattle under both pastoral and semi-sedentary management systems (Table 4.49i). However, Sokoto Gudali had the highest values under both management systems, while White Fulani recorded the lowest values. In spite of this, the AST values were within the normal recommended values (Adedibu *et al*., 2013).

ii. Breed and sex interactions: Table 4.49ii shows breed and sex interactions on AST of cattle. The female White Fulani and Red Bororo recorded significantly ($p < 0.05$) lower values than the other males and females across breeds.

iii. Breed season interaction: Table 4.49iii shows breed and seasonal interactions on AST of cattle. There were no significant ($p > 0.05$) differences in the mean AST of animals across the seasons. However, Adamawa Gudali breeds recorded the highest values during EDS, while White Fulani had the least values during LRS. This may again, be attributed to breed, seasonal feed availability, environmental conditions and health status of the animals. The results agree with Muna (2009), who reported insignificant seasonal differences in the hematological and serum enzymes of local cattle in Basrah, Iraq**,** while it disagrees with Chandra (2012), who reported AST to significantly increased during summer over spring season.

(b) Management and other parameters interactions on AST of cattle

Table 4.50 shows management and parameter interactions on AST of cattle in Adamawa State. The results showed that there were insignificant ($p > 0.05$) differences in the mean AST of male and female cattle under pastoral and semi-sedentary systems. However, male animals recorded higher values than female cattle under both systems of production as shown in table 4.50i.

The results of management and seasonal relationship showed that there were also insignificant ($p > 0.05$) differences in the mean AST during the four seasons under pastoral and semi-sedentary management systems. However, animals recorded highest values during EDS under the pastoral and semi-sedentary systems while the least values were recorded during LDS under semi-sedentary system (Table 4.50ii). Again, the results of sex and seasonal relationship showed no significant ($p > 0.05$) differences in the mean AST of cattle across the seasons. Male animals had the higher values than female animals across all seasons as shown in table 4.50iii, reflecting the higher male values reported earlier.

Table 4.49: Breed and parameter interactions on AST (μl) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Breed ×	Management		
White Fulani	Pastoral	71.824	0.4004
Red Bororo	Pastoral	72.063	
Sokoto Gudali	Pastoral	72.544	
Adamawa Gudali	Pastoral	72.397	
White Fulani	Semi-sedentary	71.793	
Red Bororo	Semi-sedentary	72.025	
Sokoto Gudali	Semi-sedentary	72.544	
Adamawa Gudali	Semi-sedentary	72.424	
(ii) Breed ×	Sex		
White Fulani	Male	73.134 [a]	0.4004
Red Bororo	Male	72.849 [a]	
Sokoto Gudali	Male	72.487 [a]	
Adamawa Gudali	Male	72.529 [a]	
White Fulani	Female	70.483 [b]	
Red Bororo	Female	71.240 [b]	
Sokoto Gudali	Female	72.601 [a]	
Adamawa Gudali	Female	72.292 [a]	
(iii) Breed ×	Season		
White Fulani	LRS	71.709	0.5663
Red Bororo	LRS	71.717	
Sokoto Gudali	LRS	72.647	
Adamawa Gudali	LRS	72.444	
White Fulani	EDS	71.865	
Red Bororo	EDS	71.890	
Sokoto Gudali	EDS	72.611	
Adamawa Gudali	EDS	72.971	
White Fulani	LDS	71.770	
Red Bororo	LDS	72.031	
Sokoto Gudali	LDS	72.528	
Adamawa Gudali	LDS	72.035	
White Fulani	ERS	71.890	
Red Bororo	ERS	72.538	
Sokoto Gudali	ERS	72.391	
Adamawa Gudali	ERS	72.191	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

Table 4.50: Management and parameter interactions on AST (μl) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Management ×	Sex		
Pastoral	Male	72.682	0.2832
Pastoral	Female	71.732	
Semi-sedentary	Male	72.818	
Semi-sedentary	Female	71.576	
(ii) Management ×	Season		
Pastoral	LRS	72.136	0.4004
Pastoral	EDS	72.348	
Pastoral	LDS	72.105	
Pastoral	ERS	72.239	
Semi-sedentary	LRS	72.123	
Semi-sedentary	EDS	72.321	
Semi-sedentary	LDS	72.076	
Semi-sedentary	ERS	72.266	
(iii) Sex ×	Season		
Male	LRS	72.645	0.4004
Male	EDS	72.696	
Male	LDS	72.972	
Male	ERS	72.686	
Female	LRS	71.614	
Female	EDS	71.973	
Female	LDS	71.210	
Female	ERS	71.819	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

4.7.2 Effect of different parameter interactions on alanine amino-transferase (ALT) of cattle in Adamawa state

(a) Breed and other parameters interactions on ALT of cattle

Table 4.51 shows breed and parameter interactions on ALT of cattle in Adamawa State.

i. Breeds and management interaction: The results showed insignificant ($p > 0.05$) differences in the mean ALT of cattle under pastoral and semi-sedentary management systems (Table 4.51i). However, Adamawa Gudali had the highest values under the semi-sedentary systems, while Sokoto Gudali recorded the lowest value under the pastoral system. The ALT recorded by the animals were again, within the normal recommended values (Adedibu *et al*., 2013).

ii. Breed and sex interactions: Table 4.51ii shows breed and sex interactions on ALT of cattle. The female animals recorded significantly ($p < 0.05$) higher ALT than males animals across all breeds with the exception of Adamawa Gudali. These variations may again be due to the breed, sex, genetic and other environmental influences.

iii. Breed season interaction: Table 4.51iii shows breed and seasonal interactions on ALT of cattle. There were no significant ($p > 0.05$) differences in the mean ALT of animals across the seasons. However, Adamawa Gudali breeds recorded the highest values during EDS, while Sokoto Gudali had the least values during LRS. The results disagree with that of Chandra (2012), who reported significant increase in ALT during summer over spring season.

Table 4.51: Breed and parameter interactions on ALT (µl) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Breed ×	Management		
White Fulani	Pastoral	41.606	0.3956
Red Bororo	Pastoral	41.597	
Sokoto Gudali	Pastoral	41.524	
Adamawa Gudali	Pastoral	41.940	
White Fulani	Semi-sedentary	41.608	
Red Bororo	Semi-sedentary	41.599	
Sokoto Gudali	Semi-sedentary	41.555	
Adamawa Gudali	Semi-sedentary	42.029	
(ii) Breed ×	Sex		
White Fulani	Male	40.464 ^{b}	0.3956
Red Bororo	Male	40.489 ^{b}	
Sokoto Gudali	Male	40.633 ^{b}	
Adamawa Gudali	Male	42.114 ^{a}	
White Fulani	Female	42.750 ^{a}	
Red Bororo	Female	42.707 ^{a}	
Sokoto Gudali	Female	42.446 ^{a}	
Adamawa Gudali	Female	41.855 ^{a}	
(iii) Breed ×	Season		
White Fulani	LRS	41.308	0.5595
Red Bororo	LRS	41.608	
Sokoto Gudali	LRS	41.126	
Adamawa Gudali	LRS	42.065	
White Fulani	EDS	41.687	
Red Bororo	EDS	41.991	
Sokoto Gudali	EDS	41.868	
Adamawa Gudali	EDS	42.463	
White Fulani	LDS	41.857	
Red Bororo	LDS	41.622	
Sokoto Gudali	LDS	41.398	
Adamawa Gudali	LDS	41.431	
White Fulani	ERS	41.574	
Red Bororo	ERS	41.172	
Sokoto Gudali	ERS	41.766	
Adamawa Gudali	ERS	41.978	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

(b) Management and other parameters interactions on ALT of cattle

Table 4.52 shows management and parameter interactions on ALT of cattle in Adamawa state. There were insignificant ($p > 0.05$) differences in the mean ALT of male and female cattle under the pastoral and semi-sedentary systems. However, female animals recorded higher values than male cattle under both both systems of production (Table 4.52i). The results of management and season interactions also showed insignificant ($p > 0.05$) differences in the ALT mean during the four seasons under pastoral and semi-sedentary management systems. However, animals recorded highest values during EDS under the semi-sedentary systems, while the lowest values were recorded during LRS under pastoral system (Table 4.52ii). Again, sex and season interactions data showed no significant ($p > 0.05$) differences in the ALT means of cattle (Table 4.52iii).

Table 4.52: Management and parameter interactions on ALT (μl) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Mgt. ×	Sex		
Pastoral	Male	40.912	0.2797
Pastoral	Female	42.421	
Semi-sedentary	Male	40.937	
Semi-sedentary	Female	42.458	
(ii) Mgt. ×	Season		
Pastoral	LRS	41.504	0.3956
Pastoral	EDS	41.990	
Pastoral	LDS	41.555	
Pastoral	ERS	41.617	
Semi-sedentary	LRS	41.550	
Semi-sedentary	EDS	42.015	
Semi-sedentary	LDS	41.599	
Semi-sedentary	ERS	41.628	
(iii) Sex ×	Season		
Male	LRS	40.558	0.3956
Male	EDS	41.461	
Male	LDS	40.794	
Male	ERS	40.886	
Female	LRS	42.496	
Female	EDS	42.543	
Female	LDS	42.359	
Female	ERS	42.359	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

4.7.3 Effect of different parameter interactions on alkaline phosphatase (ALP µl) of cattle in Adamawa state

(a) Breed and other parameters interactions on ALP of cattle

Table 4.53 shows breed and parameter interactions on ALP of cattle in Adamawa State.

i. Breeds and management interaction: The results showed insignificant ($p > 0.05$) differences in the mean ALP of cattle under both pastoral and semi-sedentary systems (Table 4.53i). However, Adamawa Gudali had the highest values under the pastoral and semi-sedentary systems, while White Fulani recorded the lowest values under both systems. In spite of this, the ALP recorded by the animals was, again, within the normal recommended values (Adedibu *et al*., 2013).

ii. Breed and sex interaction: Table 4.53ii showed that breed and sex interactions on ALP of cattle were not significantly ($p > 0.05$) different in their mean ALP. However, Sokto Gudali males recorded the highest, while Red Bororo females recorded the lowest values.

iii. Breed and season interaction: Table 4.53iii also showed no significant ($p > 0.05$) breed and seasonal interactions of ALP in cattle across the seasons. Red Bororo however recorded the highest values during LRS, while Sokoto Gudali had the least values during EDS. These results disagree with Chandra (2012), who reported plasma enzymes such as ALP to significantly increase during summer over spring season. The ALP is important in diseases of the skeleton and is usually found in the intestine, liver, kidney and bones. In serum of young fast growing animals, isoenzyme from bones predominates, while in older animals that grow slower, the activity of ALP is reduced (Kaneko, 1997).

Table 4.53: Breed and parameter interactions on ALP (µl) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Breed ×	Management		
White Fulani	Pastoral	46.165	0.2163
Red Bororo	Pastoral	46.363	
Sokoto Gudali	Pastoral	46.438	
Adamawa Gudali	Pastoral	46.573	
White Fulani	Semi-sedentary	46.180	
Red Bororo	Semi-sedentary	46.361	
Sokoto Gudali	Semi-sedentary	46.442	
Adamawa Gudali	Semi-sedentary	46.591	
(ii) Breed ×	Sex		
White Fulani	Male	46.501	0.2163
Red Bororo	Male	46.693	
Sokoto Gudali	Male	46.745	
Adamawa Gudali	Male	46.718	
White Fulani	Female	45.844	
Red Bororo	Female	46.031	
Sokoto Gudali	Female	46.134	
Adamawa Gudali	Female	46.446	
(iii) Breed ×	Season		
White Fulani	LRS	46.318	0.3059
Red Bororo	LRS	47.061	
Sokoto Gudali	LRS	46.579	
Adamawa Gudali	LRS	46.831	
White Fulani	EDS	46.363	
Red Bororo	EDS	46.393	
Sokoto Gudali	EDS	45.823	
Adamawa Gudali	EDS	45.968	
White Fulani	LDS	46.076	
Red Bororo	LDS	45.903	
Sokoto Gudali	LDS	46.661	
Adamawa Gudali	LDS	46.707	
White Fulani	ERS	45.933	
Red Bororo	ERS	46.091	
Sokoto Gudali	ERS	46.697	
Adamawa Gudali	ERS	46.822	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

(b) Management and other parameters interactions on ALP of cattle

Table 4.54 shows management and parameter interactions on ALP of cattle in Adamawa State. The results showed that there were insignificant ($p > 0.05$) differences in the mean ALP of male and female cattle under the pastoral and semi-sedentary systems. However, male animals recorded higher values than female cattle under both pastoral and under semi - sedentary systems of production as shown in Table 4.44b(i). The results of management and seasonal relationship also showed insignificant ($p > 0.05$) differences in the ALP means during the four seasons under pastoral and semi-sedentary management systems. However, animals recorded highest values during LRS under the pastoral and semi-sedentary systems while the least values were recorded during EDS under pastoral and semi- sedentary systems as shown in table 4.54ii).

The results of sex and seasonal relationship were also not significant ($p > 0.05$), however male animals had the highest values during LRS while female animals recorded the lowest values in the LDS (Table 4.54iii). The results disagree with Chandra (2012), who reported plasma enzymes such as ALP to significantly increase during summer over spring season.

Table 4.54: Management and parameter interactions on ALP (μl) of cattle

Parameter Interactions		*Mean*	*SEM*
(i) Management ×	Sex		
Pastoral	Male	46.656	0.1529
Pastoral	Female	46.113	
Semi-sedentary	Male	46.672	
Semi-sedentary	Female	46.115	
(ii) Management ×	Season		
Pastoral	LRS	46.695	0.2163
Pastoral	EDS	46.129	
Pastoral	LDS	46.337	
Pastoral	ERS	46.377	
Semi-sedentary	LRS	46.699	
Semi-sedentary	EDS	46.145	
Semi-sedentary	LDS	46.336	
Semi-sedentary	ERS	46.394	
(iii) Sex ×	Season		
Male	LRS	46.873	0.2163
Male	EDS	46.355	
Male	LDS	46.763	
Male	ERS	46.666	
Female	LRS	46.521	
Female	EDS	45.918	
Female	LDS	45.910	
Female	ERS	46.105	

Late Rainy Season (LRS), Early Dry Season (EDS), Late Dry Season (LDS) and Early Rainy Season (ERS)

4.8: Chemical Characteristics of the Most Preferred Crop Residues and Browses during Dry Season in Adamawa State

It has been observed from this study that adequate nutrient supply, as a factor of production is a major constraint to cattle productivity in the study area. It has also been observed that cereal residues such as cowpea and groundnut haulms, sorghum, maize and rice straws and browse plants are the most considered alternatives to forage grasses for sustenance of ruminant animals during the critical off season periods. Based on this, the proximate composition of the agro-residues and browse leaves commonly utilized by the farmers during the dry season were determined. This was done in order to evaluate the appropriateness of the farmers preferences of these feeding materials since data generated from such experiments could inform policy on materials to further develop for use by the farmers during those critical periods (Okoli *et al*., 2003).

4.8.1 Chemical characteristics of the most preferred crop residues

Crop residues which are post-harvest materials or roughages left after the removal of the primary feed (grain) from crop plants constitute important feed for ruminants during the long dry season. In northern Nigeria, cereal residues such as cowpea and groundnut haulms, sorghum, maize stovers and rice straws are the most important quantitatively regularly used for ruminant feeding.

(a) Proximate composition

Table 4.55a showed the proximate composition and fiber partition of the most preferred crop residues at the study locations. Mean DM was high at 94.90±0.92%, with a range of 93.7 - 96.2%, indicating that the materials are very dry and that animal consuming them will require high water supplementation. There may therefore be the need for pre-moistening/wetting or mixing of these crop residues with other high moisture materials such as molasses before offering them to the animals in order to improve their palatability and nutrient release (Okoli *et al*., 2009).

Table 4.55: Proximate composition (%) of the most preferred dry season crop residues in Adamawa state

Parameters	*Maize Stover*	*Sorghum Stover*	*Rice Straw*	*Cowpea Haulm*	*G/nut Haulm*	*Means/SD*	*Range*
(a) Proximate Composition							
DM (%)	95.30	94.60	93.70	94.70	96.20	94.90±0.92	93.70 - 96.20
CP (%)	7.50	5.20	4.50	9.10	9.80	7.22±2.33	4.50 - 9.80
CF (%)	45.50	41.20	42.80	34.30	26.10	37.98±7.82	26.10 - 45.50
EE (%)	1.30	2.10	1.80	1.50	1.80	1.70±0.30	1.30 - 2.10
ASH (%)	10.00	8.90	9.50	14.10	10.70	10.64±2.04	8.90 - 14.10
(b) Fiber Partition							
NFE (%)	49.20	56.50	47.90	35.40	51.50	48.10±7.82	35.40 - 56.50
NDF (%)	75.50	52.80	56.30	47.80	45.70	55.62±11.86	45.70 - 75.50
ADF (%)	57.70	36.70	45.00	36.50	34.80	42.14±9.55	34.80 - 57.70
ADL (%)	3.20	3.40	3.60	9.40	9.30	5.78±3.26	3.20 - 9.40
HEM (%)	17.80	16.10	11.30	11.30	10.90	13.48±3.22	10.90 - 17.80

Note: Dry matter (DM); Crude protein (CP); crude fiber (CF); Nitrogen Free Extract (NFE); Neutral Detergent Fiber (NDF); Acid Detergent Fiber (ADF); Acid Detergent Lignin (ADL); Ether extract (EE)

The findings fall within the reference values for tropical crop residues and corroborate that of Onaleye *et al*. (2012), who reported similar DM content of crop residues in neighboring Taraba State, Nigeria to range from 94.25 to 95.29%.

However, studies have shown some contradictory results such as Okah, Okeke, and Anya (2012), who reported lower dry matter content of some crop residues in Southern Nigeria to range from 89.85 to 90.73%. The mean crude protein (CP) value of crop residues at 7.2% was low, with the range of 4.5 - 9.8%. The CP of 7.5, 9.1 and 9.8% obtained in maize stover, cowpea husk and groundnut hump are however high enough to support rumen microbial activities and energy supply, while sorghum stover and rice straw are too poor to be used alone in animal feeding. The results corroborate that of Onaleye *et al*. (2012), who reported similar CP of crop residues in neighboring Taraba State, Nigeria to range from 7.64 to 14.43%. Again, the findings support report of Malau-Adulia, Eduvieb, Lakpinib, and Malau-Adulib (2004) on CP of some crop-residues in Zaria, Kaduan State, Nigeria. Nonetheless the results disagree with that of Bogoro, Lufadeju, Adeyinka, Butswat, and Kudi (1994), who reported CP of groundnut haulm to be 10.1%, while Aregheore (2000) reported lower CP of crop residues and agro-industrial by-products in four pacific island countries, indicating differences in nutrient content of crop residues across different geographical locations.

The mean crude fibre (CF) was 37.98±7.82%, with maize straw recording the highest value of 45.5%, while the range was between 26.1 to 45.3%. High CF in feed may be detrimental to animal digestion since it represents insoluble carbohydrate e.g. alkali insoluble lignin, as well as fibre bound nitrogen and cellulose. There is however the need to partition these into beneficial and non nutritionally beneficial fibers. The results corroborate the earlier study of Onaleye et *al*. (2012), who reported CF of crop residues in Jalingo, Taraba State, Nigeria to range from 13.40 to 34.23%. Alhassan *et al.* (1986) also reported similar CF of maize and sorghum straw to be 46.2 and 41.1% respectively.

The mean ether extract (EE) value stood at 1.70±0.30% with a range of 1.30 - 2.10%, indicating very low EE values of these crop residues. The results are again similar to the findings of Okah *et al*. (2012), who reported analogous ether extract of some crop residues in Southern Nigeria to range from 1.84 to 2.73, while Aregheore (2000) reported lower EE of crop residues and agro-industrial by-products in four pacific island countries. The mean ash value of 10.64±2.04 was high, with values ranging from 8.9 to 10.7%. Since the ash proximate composition represents the mineral content of the feed or forage this high ash could be of value in other agricultural applications such as straw treatment to improve their nutrient (Malau-Adulia *et al*., 2004). Adegbola (2002), Ngele (2008) and Bogoro *et al.* (1994), also reported similar ash content of rice straw and groundnut haulm respectively in Bauchi, northeastern Nigeria.

The results showed mean nitrogen free extract (NFE) of 48.10±7.82% with a range of 35.4 to 56.5%, indicating high carbohydrate content although most of it may not be available to the animals due to rapid lignifications that accompany maturation of the straws. Onaleye *et al.* (2012) reported similar NFE values (35.36 to 57.27%) in crop residues produced at Jalingo, Taraba State. Okah et *al*. (2012) also reported NFE of some crop residues from Southern Nigeria to range from 53.27 to 55.18%, indicating that higher carbohydrate values because of location of production.

(b) Fiber partition

Table 4.55b shows that the mean neutral detergent fibre (NDF) of the crop residues was 55.62±11.86% with a range of 45.7% recorded by groundnut haulm to 75.5% recorded by maize straw. NDF is the total cell wall which comprises the ADF fraction and hemicellulose. NDF fraction is therefore reflects the amount of forage the animal can consume and increases as dry matter intake decreases. The level of NDF in the animal ration also influences the time of rumination, although the concentration of NDF in feeds is negatively correlated with energy concentration (Ngele, 2008). The high NDF content of some crop residues in this study is probably due to longer time required for crop maturity in the study area that provides opportunity for fibre accumulation in plant tissues. The results agree with Onaleye et *al*. (2012), who reported NDF of crop residues in Jalingo, Taraba State, Nigeria to range from 27.61 to 70.91%.

The mean acid detergent fiber (ADF) was 42.14±9.55%, with values ranging from 34.8 to 57.7%. The ADF value refers to the cell wall portions of the forage made up of cellulose and lignin. ADF values relate to the ability of an animal to digest the forage. As ADF increases the digestibility of the forage decreases (Yitaye *et al*., 2001). The findings are again similar to that of Onaleye *et al*. (2012), who reported that ADF of crop residues at Jalingo, Taraba State, Nigeria ranged from 20.54 to 37.02%. Since the ADF values were high, strategic supplementation with protein from other sources is important to maintain optimum feed intake in animals grazing on crop stubbles in the study area.

The mean ADL was 5.78±3.26, with a range of 3.2 to 9.4%. Lignin is the prime factor influencing the digestibility of plant cell wall material. As it increases, the digestibility, intake and animal performance usually decreases. As the percent of lignin increases, the percentage of ADF and NDF also increases in forages (Mohammed, Kibon, Abbator, & Idris, 2001). The results agree with Onaleye *et al*. (2012), who reported ADL of crop residues in Jalingo, Taraba State, Nigeria to range from 3.16 to 9.33%. However, the values from this study are higher than those reported by Adebowale (1992).

The results showed the mean HEM of 13.48±3.22%, with a range of 10.90 to17.80%, indicating that maize and sorghum straws have much higher digestible carbohydrates than the other crop residues. Again, the findings fell within the reference values for tropical crop residues and corroborate that of Onaleye *et al*. (2012), who reported similar DM content of crop residues in neighboring Taraba State, Nigeria to range from 94.25 to 95.29%.

4.8.2 Proximate composition and fiber partition of (%) of the most preferred browses during dry season

(a) Proximate Composition

The results showed mean DM content of the most preferred browses during dry season was 89.78±3.99% with the range of 84.90 to 94.24% as presented in table 4.56a. The *Balanite aegyptica* with 84.90% DM and therefore 15.10% moisture content was not properly dried and grow mold if stored for extended period. The results however fell within the reference values for tropical browse crops and agree with Gidado *et al*. (2013), who reported similar mean dry matter (MDM) content of some browse species in Taraba State to be 86.97%. These values are much higher than the mean dry matter value of 65.1 % reported by Carew *et al.* (1980) for browse plants in the derived savannah area of Nigeria.

The mean crude protein of the preferred browse plants was 13.96±3.08% with a range of 9.35-16.73%. *Khaya senegalensis* had the highest CP of 16.73% followed by *Tamarinae indica* with 16.50%, while the least was recorded by *Panicum maximum* (9.35%) which is actually a grass but was selected by the farmers for unknown reasons. This could probablly because it is a perenial grass that is always found along river banks and fadama areas even during the critical periods of the dry seasons. Therefore, all browse plants have a reasonable quantity of crude protein which can be used in cattle production. The results agree with that of Njidda (2010), who reported similar CP content of semi-arid browse forages of North-Eastern Nigeria. Omoniyi *et al*. (2013) also reported *P. maximum* a tropical natural grass in humid and sub humid regions of Nigeria to have 9.27%, while *B. aegyptica* was reported to yield 19.63% CP. Norton (2003) also justifies the use of browse forages in small quantities in order to supplement poor quality pastures and crop residues.

Table 4.56 Proximate composition (%) of the most preferred browses during dry season in Adamawa State

Parameters	*B. egypt*	*K. senegalensis*	*T. indica*	*P. maxim*	*M. indica*	Means/SD	Range
(a) Proximate Composition							
DM (%)	84.90	88.60	87.64	93.54	94.24	89.78±3.99	84.90 - 94.24
CP (%)	14.71	16.73	16.50	9.35	12.54	13.96±3.08	9.35 - 16.73
CF (%)	26.37	23.53	24.80	32.50	27.46	26.93±3.45	23.53 - 32.50
EE (%)	6.71	6.72	5.62	2.89	5.67	5.52±1.56	2.89 - 6.72
ASH (%)	10.53	10.70	7.74	9.87	13.25	10.41±1.97	7.74 - 13.25
NFE (%)	50.23	49.70	47.67	52.45	48.27	49.66±1.87	47.67 - 52.45
(b) Fiber Partition							
NDF (%)	48.50	40.20	43.26	64.50	47.00	48.69±9.41	40.20 - 64.50
ADF(%)	22.64	19.60	23.25	39.40	34.53	27.88±8.57	39.40 - 19.60
ADL (%)	5.62	5.61	5.44	9.61	13.45	7.94±3.54	5.44 - 13.45
HEM(%)	25.90	20.60	20.00	25.90	12.50	20.98±5.50	12.50 - 25.90

Note: Dry matter (DM); Crude protein (CP); crude fiber (CF); Nitrogen Free Extract (NFE); Neutral Detergent Fiber (NDF); Acid Detergent Fiber (ADF); Acid Detergent Lignin (ADL); Ether extract (EE);

The mean crude fiber content of the browses was 26.93±3.45%. *Panicum maximum* recorded the highest crude fibre (CF) content of 32.50% followed by *Mangifera indica* with 27.46%, while *Khaya senegalensis* had the lowest CF of 23.53%. The crude fiber content of the various browse plants is within the range of 15 - 20% CF recommended for improved intake and production in finishing ruminants since it represents insoluble carbohydrate such as alkali insoluble lignin, fibre bound Nitrogen and cellulose (Buxton, 1996).

The results of mean ether extract (EE) was 5.52±1.56%, with *Khaya senegalensis* having the highest value of 6.72%, followed by *Balanite aegyptica* with 6.71%, while the lowest value of 2.89% was recorded by *Panicum maximum*. Ether extracts content of browses in this study fell within the range of 4 – 10% EE recommendation (Preston, 1995 and Campbel *et al.,* 2006). The results agree with that of Njidda (2010), who reported a range of 2.00 to 5.00% for EE of Northeastern Nigerian browse forages. The value for all the browse species in this study are higher than the 3.0% reported by Dibal (1991) and Ifut (1982) in semi-arid Northeastern Nigeria and for browse plants in Western Nigeria.

The mean ash value of the browse plants was 10.41±1.97%, with a range of 7.74 - 13.25%. *Mangifera indica* had the highest value of 13.25% followed by *Khaya senegalensis* with 10.70% and the least value of 7.74% was recorded by *Tamarinae indica*. The results agree to that of Njidda (2010), who reported a range of 8.00 to 18.00% for ash of northeastern Nigerian browse forages. Omoniyi *et al*. (2013) also reported that ash content in *M. indica* was higher (13.66%) than other plants. In Southern part of Nigeria, Ahamefule *et al*. (2006), reported ash content of heavily browsed plants to be comparatively higher than values obtained in this present study. Le Houerou (1980a) and Gohl (1981) stated that the different figures obtained in the ash content of browse plants in many regions may be due to differences in soil, species and season.

The mean nitrogen free extract (NFE) was 49.66±1.87%, with a range of 47.67 - 52.45%. *Panicum maximum* recorded the highest value of 52.45% followed by *Balanite aegyptica* with 50.23%, with *Tamarinae indica* having the least value of 47.67%. These results fell within the recommended values a feed would have for livestock feeding as NFE represents the soluble carbohydrate of the feed, such as starch, sugars, pectin, organic acids, hemicelluloses and alkali-soluble lignin.

(b) Fiber Partition

The browse forages in the study area had low to moderate content of fibre. This is a positive attribute of the browse forages since the voluntary DM intake and digestibility are dependent on the cell wall constituents (fibre), especially the NDF and lignin (Bakshi & Wadhwa 2004). The availability of a variety of browses and the selection process enable cattle to extend as well as meet their feed preferences. Traditional farmers in the semi-arid region of Nigeria allow their cattle to browse on tree forages in the range lands and they cut and feed these tree foliages as supplements based on experience and convenience.

Neutral Detergent Fiber (NDF) mean value obtained from the present study (Table 4.56b) was 48.69±9.41%, with a range of 40.20 - 64.50%. The results therefore showed that *Panicum maximum* had the highest value of 64.50% followed by *Balanite aegyptica* with 48.50%, whereas *Khaya senegalensis* had the lowest with 40.20%. The results agree with Gidado *et al*. (2013), who reported similar mean NDF values for the browse plants analyzed to be 48.97%, higher than the as 25 - 45% and 20 - 35% reported by Le Houerou (1980b) and Norton (1994) respectively. The results, again, corroborate that of Njidda (2010), who reported fibre contents of 37.3 to 51.2% for NDF for browse forages in northeastern Nigeria.

The results *Panicum maximum* recorded the highest value of 39.40% followed by *Mangifera indica* with 34.53%, while the lowest value of 19.60% was recorded by *Khaya senegalensis*. Mean value stood at 27.88±8.57% and agrees with Gidado *et al*. (2013), who reported similar ADF in 30 browse species to be 23.30%. The results again corroborates that of Njidda (2010), who reported ADF contents of 16.2 to 41.2% for browse forages in northeastern Nigeria.

The results show that *Mangifera indica* recorded the highest ADL of 13.45% followed by *Panicum maximum* with 9.61%, while the least was recorded by *Tamarinae indica* with 5.44%. The results corroborate that of Njidda (2010), who reported 4.9 to 12.7% ADL for browse forages in northeastern Nigeria. Omoniyi, Isah, Taiwo, Afolabi, and Fernandez (2013) also reported variations in the ADL from 6.46% - 34.53% for some browses.

The mean hemicellulose value was 20.98±5.50%, with a range of12.50 - 25.90%, indicating that *B. egyptica* and *P. maxim* had the highest level of digestible carbohydrates. The results again, corroborate that of Njidda (2010), who reported 4.9 to 12.7% ADL for browse forages in northeastern Nigeria.

4.8.3 Comparison of chemical characteristics of crop residues and browses

Table 4.57 showed that crop residue had significantly ($p<0.05$) higher DM, CF and NDF compared to browses. While, browses had significantly ($p<0.05$) higher CP, EE, ADL and HEM than crop residues, indicating that browses may be the best stable feed that could be used for nutritional intervention during the critical periods of dry season when forage grasses have been grazed to defund and crop residues have lost most of their nutrients. The findings fall within the reference values for tropical crop residues and browses (Onaleye et *al*., 2012). The results corroborate earlier studies that characterization of forage fibre, lignin, protein and other chemical components are used increasingly to predict animal performance. Forage chemical analyses could be used to identify factors in forages that may be limiting animal performance (Minson, 1981).

Table 4.57: Comparison of chemical composition of the crop residues and browses

Parameter	*Crop residues*	*Browses*	*P value (<0.05)*
DM	94.76[a]	89.76[b]	0.04
CP	7.22 [b]	13.96 [a]	0.05
CF	32.40 [a]	26.94 [b]	0.00
EE	1.70 [b]	5.52 [a]	0.00
ASH	10.64	10.42	0.87
NFE	48.10	49.68	0.72
NDF	42.14 [a]	27.88 [b]	0.11
ADF	55.62	48.70	0.40
ADL	5.76 [b]	7.94 [a]	0.03
HEM	13.48 [b]	21.06 [a]	0.02

Note: Dry matter (DM); Crude protein (CP); crude fiber (CF); Nitrogen Free Extract (NFE); Neutral Detergent Fiber (NDF); Acid Detergent Fiber (ADF); Acid Detergent Lignin (ADL); Ether extract (EE);

4.9 Chemical Characteristics of Available Water Resources for Cattle in Adamawa State

Amongst all the numerous natural resources on earth, water is one of the most essential for life support especially in tropical Africa. Water is required for domestic, industrial and animal agricultural purposes in both rural and urban areas. The sources of water include: rivers, streams, ponds and wells (Akintoye *et al*., 2014). In most most rural communities in Nigeria, valuable man-hours are spent on seeking and fetching water which is often of doubtful quality (Efe, Ogban, Horsfall, & Akporhonor, 2005; Kubkomawa & Williams, 2010b).

The chemical parameters useful for water quality assessment are determined by the presence of both organic and inorganic compounds that are either suspended or dissolved in it, while some of these compounds are toxic to the ecosystem (Boukori, Bawa, & Djaneye, 1999). Water quality is made up of physical, chemical and biological factors which influence the use of water for human and livestock purposes (Kubkomawa & Williams, 2010b). Hence, it is necessary to obtain physicochemical characteristics of water so as to monitor water quality and determine the type of treatment that may be required before use (Odigure & Adeniyi, 2001).

The results of mean chemical characteristics of water resources for cattle in three LGAs of Adamawa state are presented in table 4.58. The results show the concentrations of Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), Copper (Cu), Lead (Pb) and pH of water from hand operated boreholes, hand dug wells and streams in the study area and the water quality standard values as documented by WHO (1993). The concentration of chemicals in the water from the hand dug wells were higher followed by that of streams and the least was hand operated borehole water. This could be linked to the soil type which is ferruginous tropical soils of Nigeria based on genetic classification of soils (FAO, 1996). It could also be because of the seasonality of rainfall and the nature of the wood-land vegetation of the zone and perhaps the mineral resources found in the state which include iron, lead, zinc and limestone (Adebayo & Tukur, 1997). However, the results were within the World Health Organization's (WHO) permissible values. Therefore, it was deduced that the water sources in the study area are of good quality, safe and recommended for livestock and human consumption. The findings revealed that ground water such as wells and boreholes are limited, while surface water such as streams, ponds, rivers runs dry, especially during the critical periods of the dry season leaving livestock owners to continue shifting camps in search of water resources.

Table 4.58: Mean Chemical Characteristics of Water Resources for Cattle in Adamawa State

Parameters	*Borehole*	*Well*	*Stream*	*WHO 1993*
Calcium (mg/1)	72.144	85.156	82.144	250
Magnesium(mg/1)	19.444	20.474	20.844	80
Potassium (mg/1)	3.000	4.000	3.520	-
Sodium (mg/1)	0.0545	0.0745	0.0845	200
Cupper (ug/1)	0.061	0.081	0.071	2
Lead (ug/1)	0.010	0.020	0.020	0.01
pH	7.3	6.0	6.3	<8.0

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Pastoral cattle production in Adamawa state is predominated by experienced, married, male Fulani Muslims aged mostly 31 – 40 years and having limited western education, indicating limited change in the socio-cultural status of actors in the face of a rapidly changing production environment exemplified specifically by shrinking land and vegetal resources. The common cattle breeds encountered in the state were the indigenous Zebu cattle, with the White Fulani (Bunaji), predominating at Gombi LGA, the Red Bororo (Rahaji) at Mubi north, Adamawa Gudali at Jada LGA and Sokoto Gudali (Bokoloji) being sparingly distributed across Adamawa State. Most predominant herd size was 40 to 50 cattle reared for multi-purposes, indicating shrinking herd size probably in response to shrinking pastoral land and vegetal recourses.

Uncontrolled breeding, high levels of reproductive wastages and ethno-veterinary patronage against conventional veterinary services was evidenced, indicating limited adoption of modern animal production approaches by the pastoralists. Calving rates were particularly highly influenced by prevailing seasons with lowest rates during the early rainy season period. Morpho-physiological results, seemed to suggest that Adamawa Gudali out-performed the other breeds followed by Red Bororo in many instances, especially on the bases of body condition scores, normal rectal temperature, respiratory rate and pulse rates, which might have been influenced by coat color and other genetic characteristics of the breeds that enabled their earlier adaptation to the study area. The semi-sedentary system of production generated better cattle performance results than the pastoral system as shown by the superior body condition scores, rectal temperature and seasonal responses of the animals under this production system. Interactions of breed or management effects with morpho-physiological parameters were also significant for pulse rate, RBC count, PCV, MCV, MCH, MCHC, AST and ALT, with these interactions being more significant in Adamawa Gudali and Red Bororo in many cases, indicating again, the better adaptation of these breeds to both seasonal and management vagaries of the production environment.

Feed resources availability was also heavily influenced by the different seasons, with pasture and range land resources being more abundant during the late rainy and early dry seasons and crop residues/browse resources predominating during the remaining two seasons, indicating that feed availability is controlled by natural cyclic seasons. Movement of animals, splitting of herds and offering of browse plants and crop residues were the most observed pastoralist practices geared towards reducing the morphometric effects of lean feed resources during the hash seasons. All the browse plants offered to the animals, especially *B. aegyptica, K. senegalensis and T. indica* yielded higher leaf crude proteins and lower crude fibers than the crop residues, indicating that the browse plants could form better dry season feed resources if found in enough quantities. The results also led to the conclusion that the major constraints to pastoralist cattle production in Adamawa state were seasonal feed and water shortages, shrinking pasture lands and desertification which could be linked to changes in the production environment, with resultant conflicts/ insecurity and poor animal performance.

5.2 Recommendations

i. The study therefore recommends that appropriate government agencies should formulate policies to address the static socio-cultural conditions of pastoralists in Nigeria that resists adoption of agricultural technologies adapted to the realities of a modern world.

ii. Governments should also address the major challenges of a changing pastoral environment characterized by shrinking land and vegetal resources due to expanding arable farm lands, construction, industrial and mining activities.

iii. The Adamawa Gudali and to some extent the Red Bororo are recommended for further investigation as candidate cattle breeds that could be adopted for semi-sedentary production in the study area.

iv. Since browse plants were shown to yield better nutrient compositions than crop residues/by-products produced in the study area, there is the need to encourage extensive planting of these browse plants in semi-sedentary farms in order to generated enough quantities that could be used along side crop residues during the critical dry season periods.

v. Further research to develop appropriate blends of crop residues and browse plants of high nutrient values is also recommended.

vi. Again, future studies need to capture the interactions between the pastoral and broader sectors in order to generate holistic reliable data that would advice effective interventions.

Contribution to Knowledge

The results and recommendations of this study when properly communicated and diseminated via conferences, seminars and articles published in reputable journals would add to the existing information on pastoral cattle production characteristics in the guinea savannah zones of northern Nigeira. It would help to fill the gab on problems related to pastoralists feeding practices during different seasons of the year, especially during the lean feed resource periods. It would relate breed and physiological adaptations of different cattle breeds to performance across different seasons. It could also contribute to science and the actual decision frame works of immediate local authorities on the management of pastoral animal feeding resources. These may include cattle breeding scheme to provide better breeding stock to cattle farmers, intervention strategies for feed resources provision such as fodder banking and grazing reserve development, improved marketing of cattle and cattle products to better the living standard of farmers.

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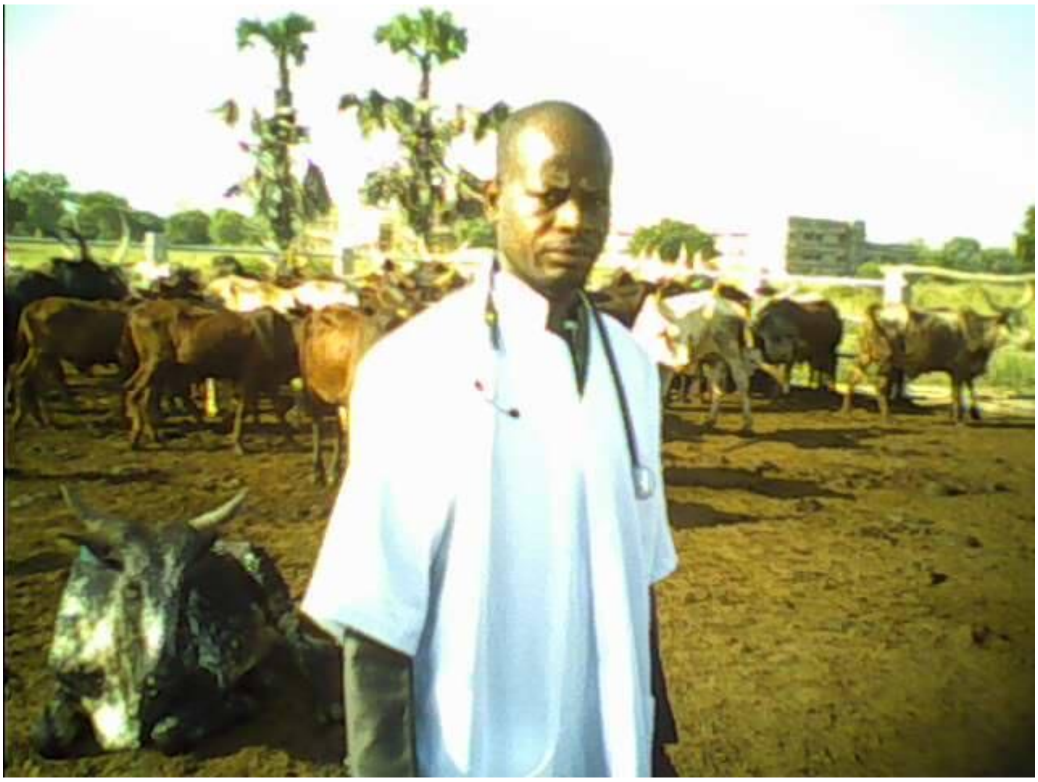

Figure II One of the herds surveyed during the study

Figure III Student taking respiratory and pulse rates during the survey

Figure IV Student collecting blood sample during the study

Figure V Showing a White Fulani cow with a BCS of 3 in pastoral herd during early rainy season

Figure VI: Showing a Red Bororo cow with BCS of 2 in pastoral herd during late dry season

Figure VII Showing Sokoto Gudali (Bokoloji) bull with a BCS of 4 in semi-sedentary herd during early dry season

Figure VIII Showing Adamawa Gudali cow with a BCS of 3 in semi-sedentary herd during late rainy season

APPENDIX I

RESEARCH QUESTIONNAIRE

Department of Animal Science and Technology,
Federal University of Technology,
P. M. B. 1526, Owerri, Imo State, Nigeria.

Dear Sir / Madam,

I am a Ph.D student of the above named University undertaking my final project (Thesis) titled: "**Studies On Characteristics of Pastoral Cattle Production in Adamawa State, Guinea Savannah Zone of Nigeria''**

Please kindly assist me in answering the below questions to enable me complete my research work. Any information given will be strictly used for this project work.

Socio-Economic Status of Cattle Producers

1. Age Distribution ---
2. Sex Distribution---
3. Tribe Distribution---
4. Marital status---
5. Religion---
6. Educational qualification--
7. Years of experience---

General Information on the Herd Structure

1. What type of breeds do you keep?

a. White Fulani (Bunaji)---
b. Red Bororo (Rahaji)---
c. Sokoto Gudali (Bokoloji)--
d. Adamawa Gudali---
e. Others specify---

2. What is the Herd composition?--- --------- 3. What is the Herd size?

a. 20 - 30
b. 31 - 40
c. 41 - 50
d. 51 and above

4. What is the purpose of rearing?

a. Meat
b. Milk
c. Breeding
d. Traction
e. Multi-Purpose

5. What is the Breeding system used?

a. Cross Breeding
b. In-breeding
c. Up-grading
d. Uncontrolled

6. What is the mating method used?

a. Hand mating
b. Pasture mating
c. Artificial insemination
7. What is the bull to cow ratio?
a. 1: 10
b. 1 : 50
c. 1 : 100
8. What is the age at first service?
Bulls
a. 2 - 3
b. 4 - 5
Heifers
a. 2 - 3
b. 4 - 5
9. What is the age at first calving?
a. 2 - 3
b. 4 - 5
10. What is the calving rate per cow before culling?
a. 1 - 5
b. 5 - 10
11. What are the seasonal cattle reproductive variations?--------------------------------------
12. What are the reproductive enhancements practiced? -------------------------------------
13. What are the seasonal feed resources available?
a. LRS = Late Rainy Season ---
b. EDS = Early Dry Season--
c. LDS = Late Dry Season--
d. ERS = Early Rainy Season--
14. What are their additional uses apart from being livestock feeds?-------------------------
a. Shelter for example, tached roofs, tents, beding materials and zana mats-----------------
b. Herbal medicines for animals and humans--
c. Food for humans--
d. Others specify--
15. What are the seasonal water sources available?---
16. What are the major constraints faced by cattle producers? For example, feed shortages and poor quality, parasites infestation, diseases incidences, pastoral land situation, lack of government support, lack of loans and incentives, lack of grazing reserves, lack of grazing routes, poor range land biomass, conflicts with arable crop producers, insecurity situation, lack of good markets, functions of middle men, lack of improve breeds, bad environmental conditions ---
17. What are the Forage resources common during wet period (April-September)? --
18. What are the Legumes and browses resources common during wet period (April-September)? ---
19. What are the Crop residues and by - products available during dry period (October-March)? --
20. What are the Browse resources available during dry period (October-March)? ---
21. What are the most cherished forage, browse, crop residues across the dry season?--
22. Specify feed use for specific purposes for example fattening, dairy, reproductive enhancement etc?---

23. What are the ethno-veterinary practices used? For example, ethno-veterinary plants and plant parts used? How they are prepared and used? Who use them to cure which diseases and parasitic conditions? Others like movement of herds away from disease epidemic? bush burning, branding of skins? use of stones? incantations, spit, salts etc?---