DETERMINATION OF EPIDEMIOLOGICAL FACTORS ASSOCIATED WITH BOVINE TUBERCULOSIS IN SELECTED LOCAL GOVERNMENT AREAS OF KATSINA STATE, NIGERIA

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BY

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVETRSITY, ZARIAIN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF MASTER OF TROPICAL VETERINARY MEDICINE

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JUNE, 2017

DECLARATION

I declare that the work in this Dissertation titled "DETERMINATION OF EPIDEMIOLOGICAL FACTORS ASSOCIATED WITH BOVINE TUBERCULOSIS IN SELECTED LOCAL GOVERNMENT AREAS OF KATSINA STATE, NIGERIA" has been carried out by me in the Department of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other institution.

Muhammad Hashiim DAHIRU _____ Signature _____ Date

CERTIFICATION

This Dissertation titled "DETERMINATION OF EPIDEMIOLOGICAL FACTORS ASSOCIATED WITH BOVINE TUBERCULOSIS IN SELECTED LOCAL GOVERNMENT AREAS OF KATSINA STATE, NIGERIA" By Muhaammad Hashim DAHIRU meets the regulations governing the award of the degree of Master of Tropical Veterinary Medicine of the Ahmadu Bello University, Zaria, Nigeria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This research work is dedicated to my late father Mallam Muhammad Dahiru Ismail and my mother MalamaRahamat Muhammad Dahiru deepest thanks for laying foundation of my education. Dad, may your soul rest in perfect peace, amen.

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ABSTRACT

In a study to determine the knowledge, attitude and practices along with epidemiological factors of bovine tuberculosis from pastoralists and the communities around them in Katsina State, two Local Government Areas (LGAs) were randomly selected without replacement from each of the three Senatorial districts of the State. Furthermore, two wards from each of the selected LGAs were further randomly selected without replacement. Ten percent of the total estimated population of pastoralists in the State was used in the study. A closed-ended questionnaire was designed to capture the knowledge, attitude and practices of the respondents along with the epidemiological factors of thedisease. A total of 592 respondents participated in the study with one hundred each from five of the LGAs and 92 from the sixth LGA. From the study 510 (86.0%) respondents indicated knowing 5 animal diseases each while 49 (8.27%) and 24 (4.05%)of them knew 10 and 15 animals diseases respectively. Among the diseases they knew were CBPP (43.70%), fasciolosis (21.90%), helminthosis (19.90%), black leg (8.70%) and FMD (3.80%). They attributed their sources of knowledge of these diseases to veterinarians (28.50%), human hospitals (6.70%), friends (4.56%), fellow herdsmen (3.37%) and the media (31.25%). Furthermore, 76.01% of the respondents were aware of bovine Tb and ascribed signs of the disease in both cattle and humans as coughing (61.48%), weight loss (20.60%), and death (15.20%). They demonstrated knowledge of the means of transmission of the disease in animals as ingestion (16.80%), drinking contaminated water (36.60%) and closeness (35.90%) among infected and susceptible animals and humans while means of transmission of the disease in humans to be consumption of contaminated meat (33.10%), drinking contaminated milk or milk products (36.48%) and closeness between infected and susceptible individuals (30.40%). With regard to their attitude to tuberculosis, 87.80% of the respondents indicated eating roasted meat (‘Suya’) daily while others indicated drinking fermented milk (81.41%) and fresh milk from the udder (66.04%) of their cattle and that 64.80% of them considered that there was no adverse effect in taking milk directly from the udder of their animals. Among the respondents, 19.42% reported eating while milking their cattle as they (10.97%) regarded that there was no adverse effect in doing so. With regard to control of diseases in both animals and humans, they reported vaccinating their children against killer diseases like tuberculosis using BCG (44.08%), and they reported to the veterinary clinics (54.39%) when their animals were sick. With respect to their practices, 54.50% of the respondents reported keeping their animals under extensive

management system while 8.70% and 36.60% of them reported keeping their animals under intensive and semi-intensive management systems respectively. Some of the respondents (19.50%) grazed their animals within 1km from their 'Ruga' while 47.29% and 33.10% reported grazing their animals 2km and 3km away from their 'Ruga' respectively. Some (40.37%) of the respondents reported that the distance between their 'Buka' and the animals' kraalswere 1 metre away from the kraal while others (30.40% and 14.80%) said their 'Bukas' were 5metres and 10 metres away from thecattle kraals respectively.With respect to epidemiological factors to exposure to bTB, 72.97% of the respondents reported mixing their cattle with others from other herdsdaily and that 54.39% of the pastoralists reported all suspected diseases including bTB to veterinary clinics while 29.56% were sending such animals to markets for sale. From the study it was concluded that no less than 76.01% of the respondents were aware of tuberculosis in both animals and humans and that their attitude, practices along with the presence of epidemiological factors are capable of spreading tuberculosis within their areas and beyond.

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LIST OF ABBREVIATIONS

BCG = Bacillus Camette–Guetin

DNA = Deoxyribonucleic acid

FPA = Fluorescence Polarization

HIV/AIDs = Human immunodeficiency Virus/Acquired immunodeficiency

MAPIA = Multi-antigen Print Immunoassay

New World Camelids

ELISA = Enzyme -linked immunosorbent Assays

N-PCR = Nested Polymerase Chain Reaction

NTVM = Non-tuberculous mycobacteria

OWCs = Old World Camelids

REA = Restriction endomic lease analysis

RELP = Restriction Fragment Length polimorphism

SICCT = Single Intradermal Comparative cervical tuberculin test

TBH= Human Tuberculosis

UNG =Uracyl-in-glycerol

MAPIA = Multiantigen Print Immunoassay

WHO = World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1Background of the Study

The pastoralists, also known as Fulani herdsmen, are people who live mostly in remote areas and whose lives are primarily dependent on livestock (Saidu *et al.,* 1991). Their occupation is mostly in tendering their livestock which comprise mostly cattle, sheep, and goats and to a certain extent poultry (Saidu *et al.,* 1991; Kaltungo, 2013; Buhari, 2014). They may also have horses and/ordonkeys which they use for haulage of their goods and children during migration (Saidu *et al.,* 1991). They also participate in crop farming, providing the much needed manure for the crop farms while at the same time using their bulls to till the land (Saidu *et al.,* 1991).

Diseases have been variously reported to affect efficient livestock development in many African countries to the effect that, in many situations, the European Union and the United States of America and other donors had to come to the aid of these countries (PARC, 1999*).* Some of these diseases include rinderpest, contagious bovine pleuropneumonia (CBPP) and foot and mouth disease (FMD). Diseases of public health importance like tuberculosis and brucellosis have also been reported to be widely spread among the national cattle herd and other animals in the Nigerian livestock industry (Abubakar, 2007; Kaltungo, 2013; Buhari, 2014; Baba, 2016). These diseases have been shown to occur in humans. For example, the organism (*Brucella abortus*) has been shown to cause orchitis in man. Similarly tuberculosis, due to *Mycobacterium bovis*, a primarily cattle disease agent, has been demonstrated in pastoralists and other community members in Bauchi and Gombe states recently (Ibrahim, 2016). This may not be

unconnected with the cultural habits of most rural communities and even among some urban dwellers who take millet paste with unpasteurized milk in the form of 'Nono' (Ibrahim, 2016).

It is for these and other reasons that this study was designed to determine the knowledge, attitude and practices of pastoralists and communities where these pastoralists reside with regard to the epidemiology of tuberculosis in Katsina State.

1.2 Statement of Research Problem

Livestock production in Nigeria is largely in the hands of pastoralists who own greater than 80% of the national cattle herd (Saidu, *et al.,* 1991). These pastoralists are in a habit of moving with their livestock from one area to another, especially during the dry season as they go out searching for crop residues for their livestock. It is also during this period that water for them and their livestock is scarce and this adds to the reason for their migration. In the process, many herds meet and this is capable of spreading diseases, especially communicable ones like tuberculosis. The level of education by these pastoralists has been shown to be low and therefore they are not aware of how diseases are necessarily transmitted or spread among animals (Saidu *et al.,* 1991*;* Kaltungo, 2013;Buhari, 2014). The cultural activities of the pastoralists with regard to their eating and drinking habits has further added to the possibility for acquisition of infection and even the spread of such diseases like brucellosis and even tuberculosis, should the animals under their care be infected (Kaltungo *et al*,, 2013). Thus, today the prevalence of both tuberculosis and brucellosis seem to be on the increase (Alhaji, 1976; Abubakar, 2007; Bertu *et al.,* 2010; Kaltungo, 2013).

Hitherto, Nigerian Governments depended greatly on oil for executing most of their activities in running governance. The present national administration is diverting its interest in making agriculture to contribute significantly to the Nigerian economy. Therefore, the livestock sector of agriculture should be seen to make greater impact in supporting the economy. This cannot be possible with increasing occurrence of livestock diseases and even zoonotic ones. Thus, determining the status of bovine tuberculosis in Katsina State will go a long way in making cattle to meaningfully contribute economically to the state and even national economy by way of increased supply of livestock products and productivity.

1.3 Justification

Nigeria is one of the countries in Africa with the highest livestock populations (Jahnke *et al.,* 1986). However, other countries like Botswana and Kenya are able to tap from their livestock population more than Nigeria as they have substantially controlled livestock diseases (Jahnke *et al.,* 1986). The potentials for increased and improved livestock production in Nigeria were there as there were many grazing reserves and stock routes that could facilitate livestock development(Saidu and Alhaji, 1981). There are also many extension delivery outlets that can educate the livestock keepers (pastoralists) to improve their production system (Dafwang, *et al.,* 1987; Mijindadi and Saidu; 1990*).* However, diseases, especially zoonotic ones, are capable of not only reducing productivity of the national cattle herd but also adversely affecting the human population that will be expected to drive the economy of the nation around. This is at a time when many Nigerians have ventured into yoghurt production earning little income while Nigerians are able to receive dairy products as a means of improving the per caput animal protein intake, especially for the young and old members of the citizenry. The colonial administration along with the Regional Governments tried to introduce livestock development programmes like

Livestock Investigation and Breeding Centres (LIBC) and dairy farms with the sole aim of boosting livestock production. This has become a thing of the past as the livestock owners are left more to themselves. There is,therefore, the urgent need to look into the diseases that, not only affect livestock, but also influence public health and productivity of both animals and man. Thus, this study is set out to determine the epidemiological factors that will lead to the spread of tuberculosis in selected Local Government Areas (LGAs) of Katsina State.

1.4Aim and Objectives of the Study

1.4.1 Aim

The aim of the study was to determine the epidemiological factors associated with bovine tuberculosis in selected Local Government Areas of Katsina State, Nigeria

1.4.2 Objectives

1. To determine the knowledge, attitudes and practices of pastoralists and rural communities in Katsina State on tuberculosis.
2. To determine the epidemiological factors associated with bovine tuberculosis in selected Local Government Areas of Katsina State.
3. To determine the risk factors of bovine tuberculosis with regard to pastoralists' and communities' attitudes and practices in selected Local Government Areas of Katsina State.

1.4.3 Research Questions

1. What are the knowledge, attitudes and practices of pastoralists and rural communities with regard to bovine tuberculosis in Katsina State?
2. What are the epidemiological factors associated with bovine tuberculosis in selected Local Government Areas of Katsina State?
3. What are the risk factors of bovine tuberculosis with regard to pastoralists' and communities' attitudes and practices in selected Local Government Areas of Katsina State?

CHAPTER TWO

2.0LITERATURE REVIEW

2.1 Background

Tuberculosis is an infectious, contagious, granulomatous bacterial disease of domestic and wild animals and man caused by acid-fast bacilli of the genus *Mycobacterium (*Alhaji, 1989). It is also referred to as a chronic debilitating disease though it may assume acute and rapidly progressive course. The disease affects almost all domestic animals with cattle being the most affected *(*Alhaji, 1989).

Tuberculosis has been reported to be infecting both animals and humans from antiquity *(*Lawn and Zumlo, 2011).

2.2Global Livestock Production

Livestock as a word was first used between 1600 and 1650 as a merger between the word live and stock. Livestock is also defined as useful animals kept on a farm (RIIA, 2016). Livestock are domesticated animals raised in an agricultural setting to produce commodities such as food, fiber and Labour. They have been regarded as being useful financial gain *(*Ducan*et al.,* 2016*).* In recent years livestock are also raised to promote the survival of rare breeds (Ducan *et al.*, 2016). Raising animals through animal husbandry is a component of modern agriculture. It has been practiced in many countries since the transition to farming from the hunter gatherer lifestyle *(*Ducan *et al*., 2016).

Animals were domesticated when breeding and living conditions were controlled by human.Over time, the collective behavior,and lifestyleof livestock owners changed radically (R.I.I.A. 2016).

Historically, domestication and use of the conventional livestock breeding techniques developed through the desire to produce livestock products (Leakey *et al.*, 2009).

The global livestock sector is characterized by a dichotomy between developed and developing countries. The total meat production in the developing world tripled between 1980 and 2002 from 45 million to 134 milliondollars *(*World Bank, 2006*).*Most of this was concentrated in countries that experienced rapid economic growth, especially in East Asia where most of the increase was through poultry and pigs*(*World Bank, 2006*).*The increased demand for animal protein in the developing countries represented a greater opportunity for livestock keepers in countries, where most of the demand is met by local production. In developed countries, on the other hand, production and consumption of livestock products are now growing slowly to a stagnantlevel(World Bank, 2009*).*

It has been estimated that the human population wouldreach 9.15 billion with a range of 7.96 to 16.4 billion by the year 2050.Most of the increase in this population is projected to take place inthe developingcountries like Africa. It has also been projected that East Asia would have shifted to negative population growth by the late 2040s *(*FAO, 2010). In contrast, population in sub-Saharan Africa (SSA) will still be growing at 1.2% per year. Rapid population growth could continue to be an important impediment to achieving improvements in food security in some countries. Another important factor determining demand for food is urbanization.

The next few decades will see unprecedented urban growth, particularly in Africa and Asia. Urbanization has conservable impact on patterns of food consumption in general and on demand for livestock products in particular. Urbanization often stimulates improvements in infrastructure, including cold chains, and this allows perishable goods to be traded more widely (Delgado, 2005*).*A third factor leading to increased demand for livestock products is income

growth. There was an annual global per capital income growth of 2.1% *(*Maddison, 2003).As income grows, so does expenditure on livestock products *(*Steinfeld*et. al*., 2006*).* Economic growth is expected to continue into the future, typically at rates ranging from between 1.08 and 3.1 percent *(*van Vuuren *et al.,*2008). Growth in industrialized countries is projected to be slower than that in developing economics *(*Rosegrant *etal.,*2009).

The resultant trends in meat and milk consumption in developing and developed countries are increasing as estimated for 2015 – 2050 *(*FAO, 2006). Differences in the consumption of animal products are much greater than in total availability, particularly between regions. Demand for livestock products will nearly double in sub-Saharan Africa and South Asia from some 200 kcal per person per day in 2000 to around 400 kcal per person per day in 2050. More so in most organization of economy of developed countries (OECD) that already have high calories intake of animal product (1000 kcal per person per day or more) consumption levels will barely change while levels in South America and countries of the former Soviet Union will increase to OECD lives *(*van Vuuren *et al.,*2009*).*

Global livestock production has increased substantially since the 1960s.Beef cattle production has more than doubled over the same period.Beef production has also increased by a factor nearly 10, made up of increase in both number of animals and productivity (FAO, 2010*).* Furthermore, carcass weight increased by about 30% for both chicken and beef cattle from the early 1960s to the mid-2000s and by about 20% for pigs (FAO, 2010). Carcass weight for camels and sheep increased per head, by about 5% only over this period, while increase in milk production per animal amounted to about 30% for cow's milk, as well as for increase in egg production per chicken over the same time period (FAO, 2010).

It has also been projected that between 2000 and 2050, the global cattle population may be from 1.5billion to 2.6 billion while the global goat and sheep population would increase from 1.7 billion to 2.7 billion *(*Rosegrant *et al.*,2009*).*

Livestock system evolution in the coming decades is inevitably going to involve trade – offs between food security, poverty, equity, environment sustainability and economic development *(*Rosegrant e*t al.*,2009). The livestock sector is increasingly organized in long market chains that employ at least 1.3 billion people globally and directly support the livelihoods of 600m poor smallholder farmers in the developing world *(*Thomton *et al*, 2006). Keeping livestock is an important risk reduction strategy for vulnerable communities and livestock are important providers of nutrients and traction for growing crops in smallholder systems. Livestock products contribute 17% to kilocalorie consumption and 33 percent to protein consumption globally, but there are large differences between rich and poor countries *(*Rosegrant *et al.*,2009). Livestock systems have both positive and negative effects on the natural resources base, public health, social equity and economic growth *(*World Bank, 2009*).*

2.2.1 Livestock production in Africa

The main categories of domestic livestock in tropical Africa are large ruminants (cattle, sheep and goats), non-ruminant grazing animals (asses, mules and horses), pigs and chickens *(*Johnke,1982*).*The population of livestock in tropical Africa excluding South African Republic is said to consist of 160 million cattle, 264 million small ruminants where sheep represent 46% and goats represent 54% of the small ruminants populations. In addition to these are 12million camels, 12 million equines, 10 million pigs and some 460 million chickens *(*FAO, 1987*).* The use of livestock in tropical Africa is multiple, and that their economic and social importance is related to their production system *(*Fahunkes, 1982; Weber, 1986).Some of the areas of their

importance include animal traction, manure as fertilizer and organic materials as fuel, hides, skins and wool and they provide transport services(FAO, 1987).

Pastoralism is a vital part of African economy with 66% of the Africa's land being used to graze animals. Animals are generally a family's most valuable asset, providing dairy products for sell and subsequent maintenance of the family(Mijindadi and Saidu, 1990; Saidu *et al.*, 1991). Work bulls for traction for farm ploughs and transport for the family have similarly gained ground (Dialogue, 2014). Ruminant livestock are raised across Eastern Africa where environmental conditions allow for substantial livestock production in the dry lands. Similarly such land is available in Djibouti, Eritrea, Kenya, Somalia, Sudan, with mixed farming and humid agro-ecology dominant in Ethiopia, South Sudan, Tanzania and Uganda. Furthermore, habitable land inBurkina Faso, Chad, Mali, Mauritania, Nigeria, and Senegal has greatly been used for mixed farming (Dialogue, 2014).

2.2.2 Livestock production in Nigeria

According to the Nigerian Livestock Census, the population of each of the various domestic animals in Nigeria was estimated as 82,400,000 chickens, 34,500,000 goats, 22,100,000 sheep, 13,900,000 cattle, 900,000 donkeys, 200,000 horses, and 90,000 camels (RIM, 1992). In monetary terms, the value of Nigerian livestock resources based on prevailing market prices in mid - 1991 was conservatively estimated to be in order of US $6000 million (RIM, 1992). More recently, other estimates for livestock in Nigeria include 15.24 million cattle, 96.67m goats, 15m sheep, 6.87m pigs and 14m poultry, (Kallah,1999). Livestock also contribute to 15. 20% of the agricultural Gross Domestic Product (GDP) and 5 to 6% of the country's total GDP and food security, food safety, economic growth and wealth creation in Nigeria (Kallah, 1999). Apart from providing food (meat, eggs and milk etc.) for the increasing human population, the

subsector has been providing raw materials for related industries and market for the product of the industrial sector, with over 60% of Nigerians depending on agriculture for livelihood *(*Kallah, 1999*).*

Livestock production contributes to the Nigerian economy through income generation, employment,food security among others *(*Saidu et a*l.,* 1991*).*Traditional livestock production in Nigeria is varied and complex, with ruminants being the most efficient users of uncultivated land and can contribute substantially to crop production(Hendy, 1977*).*

In Nigeria 80% of livestock production is in the hands of pastoralists *(*Saidu et a*l.,* 1991). The poor educational standard of the livestock owners, especially pastoralists has made modern livestock keeping as well as use of modern disease control and eradication strategies difficult leading to the livestock sector not making efficient contribution to the Nigerian GDP*(*Saidu *et. al.,* 1991; Enwezor *et al.*,1992).

The coming of the Agricultural Development Project (ADPs) in Nigeria in the early 1970s saw increased awareness by livestock and crop farmers on the use of crop residues for livestock production *(*Saidu *et al.,* 1991*).* Similarly, these livestock owners, especially pastoralists, employ mixed farming more than hitherto leading to increased livestock and crop production and productivity, especially in the northern parts of the country *(*Saidu *et al.*,1991*).*

With increasing urbanization and economic growth more land has been cultivated resulting in increased encroachment of cattle routesand grazing reserves *(*Jahnke *et al*, 1986*).*

Majority of the rural people in Nigeria earn their living through crop and livestock production. There are people who engage mainly in rearing and marketing of livestock such as cattle, sheep, goats, pigs, poultry and camels *(*Kallah, 1999).

The importance of livestock cannot be overemphasized as it was stated that more than 6 million pastoralists are completely dependent on their livestock as a means of employment and livelihood. Livestock has reached a situation whereby almost every household is involved in keeping them in one way or the other *(*Saidu*et al.,* 1991). They are also used for transportation and haulage of people and farm produce (RIM, 1992). The livestock subsector is a good source of foreign exchange earning with more than 600 million dollars earnings within 1978 – 1982 (.Kallah, 1999).

2.3Roleof Livestock in Agricultural Production in Nigeria

The pastoralists have been reported to hold greater than 60% of the national cattle herd in their hands (Saidu *et al.*,1991). They also have substantial part of the small ruminants while they also have few horses, donkeys and chickens (Saidu *et al.*,1991). These pastoralists are found in all the states of the Federation. They keep these animals mainly as a sign of wealth as well as their bank which they fall back to in times of cash needs (Saidu and Alhaji, 1981; Mijindadi and Saidu, 1990; Kaltungo, 2013*).* Thus, they sell their castrated male cattle when there is need for big cash while small ruminants and poultry are sold to take care of minor cash needs. At the village and semi-urban areas, dwellers have been reported to keep mainly small ruminants and poultry *(*RIM, 1992).

2.4 Geographical Distribution of Tuberculosis

Bovine TB is a chronic infectious disease which affects a broad range of mammalian hosts including humans, cattle, deer, domestic cats, wild carnivores (foxes, coyotes) and omnivores

(possums and rodents) andit rarely affects sheep and equidae *(*Karlson and Lessel, 1970; Phillps *et. al*., 2001*)*. The disease has been reported in almost all continents of the world *(*Alhaji, 1976; Radostits *et al.*, 2007). The disease has been substantially controlled in industrialized countries through pasteurazation of milk and improved zoo-sanitary measures, while in developing countries the disease can be said to be on the increase due to poor control measures (Ibrahim, 2016).

2.4.1 World distribution of tuberculosis

Tuberculosis, otherwise known as phthisis pulmonaris and consumption, is an infectious bacterial disease caused by various strains of mycobacteria usually referred to as *Mycobacterium tuberculosis(*Kumar *et. al.*, 2007*).* It generally affects the lungs of affected animals or humans though it can also spread to the body organs and tissues.

The disease is said to be foundin cattle throughout the world though some countries have been able to reduce or limit its incidence greatly*(*O'Reilly and Daborn, 1995).Thus most of Europe and several Caribbean countries including Cuba are said to be virtually free of *M. bovis*. Australia has been reported to be officially free of the infection with *M bovis* through the use of bovine tuberculosis eradication and control (BTEC)programmes. There is, however, the suspicion that residual infection in water buffalo may still be present in Australia. In Canada, the disease has been reported in wild elk and white-tailed deer (Paul, 2011*).*

In 1930, *M bovis* was reported in humans and possum in the United Kingdom (UK) and that the latter were presumed as the vectors of the disease (Paul, 2011).Similarly, in the UK, the disease has been reported to exist though the incidence has drastically reduced. Here again, badgers (*Meles meles*) were reported to make important contribution in maintaining the disease among

cattle herds (Davies,2006*)*. Davies(2006*)* report that *M bovis*infection in cattle in the USA was not common though the disease was endemic in white-tailed deer(*Odocoileus virginianus*). Furthermore, they reported that raccoons (*Procyon lotor*), opossums (*Didelphis virgiana*) and coyotes (*Canis latrans*) could serve as spill-over and-end hosts for *M bovis* in the USA.

The disease due to *M bovis* has also been reported in wild and farmed animals in NewZealand (Baker et. al., 2006). They showed that *M bovis* accounted for 2.7% of human infections. Furthermore, the disease was reported to account for 1.2% of the cases from 1986 to 1990 (Hardie and Watson, 1992).In Australia,*M bovis* caused about 1% human infection between 1970 and 1994 (Cousins and Dawson (1999).

2.4.2 Distribution of tuberculosis in Africa

The disease has been reported in many African countries like Nigeria, Ethiopia, Chad, Cameroun, Uganda, Tanzania, South Africa, Eritrea, and Zambia *(*Alhaji, 1976; Cook *et al.,* 1996*;* Weinhhaupl *et al.,* 2000; Omer *et al.,* 2001*)*Ayele *et al.,* 2004*;*; Kazwala *et al*., 2001;Teklu *et al.,* 2004*;* Cadmus *et al*., 2006; Swai *et al*., 2006). These reports confirmed the existence of the disease in cattle and other domestic animals. In a study to determine the prevalence of bovine tuberculosis and brucellosis in Ethiopia, Tschopp *et al*. (2015),using comparative intradermal skin test (CIDT)found 0.3% of the tested cattle to be positive for bTB while 1.7% of them were infected with brucellosis. Cross-breeds of the cattle were found to be far more prevalent (100%) for bTB.

Bovine tuberculosis infection affects animals' wellbeing, productivity and causes economic losses in many countries (Pollock and Neil, 2002*).*The economic losses due to bTB in livestock includereduced milk production, infertility, reduced meat production and condemnation of

carcasses *(*Oliveira *et al* 2007). In societies where animals and humans live together bTB was seeing to affect the farming communities *(*Neil *et al.,* 1994)*Mycobacterium bovis* has been shown to have no geographical borders *(*Kazwala *et al.,* 2001*)* and it is one of the FAO – OIE "List B" diseases due to its significant public health and socio-economic impacts (Benkirane, 1998; OIE, 2008). The epidemiology of bTB in developed and developing countries varies only in the implementation of preventive measures (WHO, 1999).

Cattle are believed to be the major hostsfor*M. bovis*. The disease has been reported in other species including humans, other domestic animals and wildlife *(*Delisle *et al.,* 2002*).* Some studies from Africa indicate that ingestion of *M. bovis* has an important role in the transmission of the disease in cattle, because mesenteric lymph nodes were shown to be more affected than mediastinal lymph nodes (Ameni *et al.,* 2007;Cleaveland*et. al.,* 2007). The crucial factors that promote bTB transmission within a herd, especially dairy ones and animals reared in feedlots or semi intensive systems are direct contact among animals.It has been shown that a carrier animal in a given environment can serve as constant source of *M. bovis*to other animals (Blood and Radostits, 1989).

Cattle and buffalo are the maintenance hosts for the bacteria. Infections have also been described in many other animals including sheep, goats, horses, pigs, dogs and cat *(*Ayele *et al,* 2004*).* However, the disease is a widespread in Africa, some parts of Asia and Middle East *(*Cosivi *et al., 1998;* Ayele *et al., 2004).* In Africa the actual trend of the disease has not been well evaluated due to economic predicament *(*Ayele *et al, 2004),* but there are substantial evidences to indicate that the disease is endemic and present in most African countries *(*Alhaji, 1976;WHO, 1994a; Cosivi *et al.,* 1998*).*

2.4.3 Distribution of tuberculosis in Nigeria

Bovine tuberculosis has been reported in almost all the states of Nigeria *(*Alhaji, 1976; Igbokwe *et al*., 2001; Danbirni, 2016; Ibrahim, 2016).Alhaji (1976) reported a prevalence of 4% in the North western States of Nigeria while Igbokwe*et. al*. (2001)reported isolating *M bovis* in 62.5% cases, *M. tuberculosis* in 14.0% cases and unclassified mycobacteria in9.5% cases from abattoir samples. This led Raufu and Ameh (2010) to observe that the disease, bTB, could have detrimental effect on animal production, especially considering the possible economic losses thatcould accompany the disease. Furthermore, in a study to determine the epidemiology of bovine tuberculosis in Borno and Yobe States, Danbirni (2016) reported isolating *M bovis* and*M tuberculosis*in cattle and humans and concluded that the disease is of economic importance in the Nigerian livestock industry.

Reports of bTB in Nigeria indicate that the disease is endemic with infection in cattle mostly, though infections have also been reported humans *(*Alhaji, 1976; Amanfu, 2006; Okaiyeto *et al*, 2008; Cadmus *et al*, 2010*).*

Ibrahim (2016) in a study of bovine TB (bTB) in Bauchi and Gombe States, Nigeria, examined 5,509 cattle using the single caudal fold intradermal tuberculin test (CFT) and found 232 (10.96%) of the 2116 cattle from Bauchi State positive for TB while 463 (13.73%) of the 3373 cattle from Gombe State were positive for TB. He also reported the herd based prevalence of bTB in Bauchi and Gombe States to be 56.04% and 55.29% respectively. In this study, he confirmed the existence of *M bovis*, and*M tuberculosis* in both cattle and humans using PCR. Similarly, Ahmad (2015) using abattoir samples from Gusau abattoir in Zamfara State, Nigeria,confirmed the existence of *M bovis* and other members of the MTC in cattle in Nigeria.

In this study, *M bovis* was found to have isolation rates of 88.2% while *M caprae* and *M tuberculosis* had 8.8% and 2.9% isolation rates respectively. He observed that the finding of *M tuberculosis* in the tissues of the cattle examined to account for a possible interaction of the pathogen from humans to cattle indicating a reverse zoonotic transmission. This could be due to a number of opportunities for close and repeated human-livestock interactions in the study area. Such opportunities, he indicated, included smallholder fattening schemes where the cattle were kept inside owners' houses and that such facilities allowed for sharing of water and food sources. The cattle that were found to harbour tubercle bacilli were mainly old and of the female sex (Ahmad, 2015). He also found that there were risk factors for the transmission and spread of zoonotic bovine TB amongst abattoir cleaners, animal health scientists, butchers, cattle handlers and traders in that these individuals were in the habit of handling meat and meat products using bare hands and that they had inadequate knowledge about bovine TB and its modes of transmission. Their eating habits and food preference through the consumption of unpasteurized milk and poorly cooked meat could also add to their exposure to infection with *M bovis* and its other members (Cadmus *et al.,* 2006; Danbirni, 2016*).*

Many of the studies in Nigeria were based on postmortem examination at abattoirs (Igbokwe *et al,* 2009; Kwagbe *et al,* 2009) as well as tuberculin skin testing in cattle herds (Danbirni *et al.,* 2012; Ibrahim *et al;* 2012*).* The public health and epidemiological significance of bTB have not been well established as a result of inadequate number of laboratories that are capable of differentiating *M. bovis* from *M. tuberculosis* and other members of the Mycobacterium Tuberculosis Complex (MTC) along with the problem of resistance of the organism to routine medication in humans (Cadmus *et al*., 2004). In addition, the poor to none reporting of bTB outbreaks and lack of tuberculosissurveillanceprogrammes in Nigeria have made it difficult to

know the actual status of bovine tuberculosis in cattle *(*Cadmus *et al*, 2004).It has been abundantly demonstrated that the bacteria are shed by infected animals in respiratory secretions,faeces, milk and less commonly other body fluids (Ibrahim, 2016).

2.5 Tuberculosis in Domestic Animals and Man

Internationally, TB is considered a threat to the whole world. A large number of cattle have been shown to have TB in the developing world where there are neither schemes for compensation nor government policies for eradication of the disease. Bovine TB is probably increasing in Africa as a result of farming policies allowing free movement of cattle (http://www.ncbi.nlm.nih.gov/poic/artieles/pmc15920581). The disease has been reported in a number of domestic animals that include cattle, small ruminants, camels and wild animals(Alhaji, 1976; Igbokwe e*t. al.*,2001; Ibrahim, 2016).

2.5.1 Tuberculosis in Cattle

Davies (2006) reported that as early as 1800s tuberculosis was reported to have been in cattle in slaughter houses. Hefurther noted that Villemin showed that infected tuberculous material could be injected from one species to another to cause disease while Koch in 1882 pointed out that there was a danger that tuberculosis could be transmitted from animals to humans. Bovine TB due to *M bovis* seems to be on the increase in England and Wales, especially where cattle are in close proximity with badgers *(*Davies, 2006).

The disease in cattle is a chronic, insidious and contagious caused by certain pathogenic organisms of the genus *Mycobacterium*. It is characterized by development of tubercles with

resultant cassation and calcification*(*Amalendu, 2012*).* The tubercles are frequently located in the lungs and lymph nodes, but may be formed in the liver, spleen, intestine, peritoneum, meninges and long bones. With exception of skeletal muscles, tubercles can be seen almost in all the tissues and organs of the body. As a zoonotic disease bTB has been found to cause human tuberculosis. Gland tuberculosis of children can be contacted from bovine tuberculosis while according to W.H.O, 5% of cattle are affected with tuberculosis and 30% of cattlelose their potency of productivity (Amalendu, 2012).

Tuberculosis has been declared as global emergency by the W.H.O and that one third of the world's human population is infected with tuberculosis (Joardar et al.,2006).In cattle bTB causes economic losses through condemnation (10%) during meat inspection, loss of milk production (22%), reduction in reproductive performance (6.5%), loss of meat production (7.1%) and loss of body weight (11.1%) (Joarda*ret. al.,* 2000).

The World Organization for Animal health (OIE, 2008) has listed tuberculosis as a list B disease. This is a disease which is regarded as a disease of socioeconomic and public health impotence. It is also of significance interms of international trade in animal and animal products (Cousins, 2001).

The initial confirmed report of *Mycobacterium bovis* infection in cattle was based on a report by Columella in the year 40A.D. in Germany when grape – like lesions (parlsucht) whichwere considered to be the clinical signs of syphilis led to strict measures for the disposal of affected animals(Schlisser, 1982*).* Later, the misdiagnosis was corrected leading to removal of the control measures placedearlier on. Then it was considered safe to eat meat from tuberculosis animals and there were no preventive measurestaken for the spread of the disease. Later,

*Mycobacteriumbovis*was identified by Robert Koch and the relationship between "Perlsucht" and lung tuberculosis in cattle was established.

The discovery of bovine tuberculosis infection in the wildwhite tailed deer population of North East Lower Michigan (USA) and subsequently in nearby cattle (Cotton, 1998) has increased awareness of cross infection of the agent between cattle and wildlife. By 1917, one out of 20 cattle slaughtered in theUnited States of America (USA) had bTB and this resulted in very extensive economic losses to farmers (Cotton, 1998).This led to the introduction of a control programme using reactors via tuberculin skin test. The disease in cattle was seen to spread to humans and that the effects of bovine tuberculosis on human health became a concern. It was thought that approximately 20% of humans with TB were infected with *Mycobacterium bovis*, the causative agent of bovine tuberculosis. Furthermore, most human cases werelinked to the consumption of unpasteurized milk *(*Collen, 1998).

The disease in cattle has been described as a chronic and wasting disease along with other nonspecific clinical signs that include anoraexia, drop in milk production, chronic intermittentcough, dyspnoea and enlarged lymph modes *(*Radostits *et al.*,2007).

2.5.2 Tuberculosis in Small Ruminants (sheep and goats)

The incidence of tuberculosis infection in sheep and goats is said to be associated with the frequency of the disease in other hosts like cattle because detection of the disease in small ruminants is unfeasible when the disease level in cattle is low. However, the prevalence of the disease is up to 5% in sheep flocks as reported in NewZealand (Davidson *et al.*, 1981).

2.5.3 Tuberculosis in Camels

Tuberculosis is a chronic debilitating disease in camels as in other domestic animals. The clinical signs in camelids include wasting, anorexia, and respiratory distress, enlargement of superficial lymph nodes, recumbency and eventual death *(*Abdurahman and Bornstein, 1991; Lyashchenko*et al.,* 2007; Twomey*et al.,* 2010*).* Clinical signs may also often be associated with extensive respiratory pathology, and it is surprising that overt respiratory distress is sometimes not observed in animals with severe lung lesions (Dinkla*et al.,* 1991*).* Animalsmayalso be occasionally found dead with no previous clinical observations *(*Barlow*et al.,* 1999; Farrant*et al.,* 2010*).* Also,Saxena and Kavita(2014) were able to associate camel milk with tuberculosis in humans following a questionnaire study.

Hitherto, camelids were not considered to be highly susceptible to tuberculosis. However, in recent years increased numbers of cases have been experienced in some countries. In most of the cases, transmission probably could have occurred through contact with infected cattle or wildlife. As in cattle, none of the ante-mortem tests currently available can consistently provide accurate diagnosis of the infection in live camelids. Recently developed serological assays have the potential for rapid and accurate diagnosis of tuberculosis though these still need to be validated. In a study to determine the pathology and aetiologic agent of tuberculosis in camels in Ethiopia,10.04% (91/906) of the camels were found to be infected and that upon molecular characterization using multiplex PCR, 68% (21/31) of the samples were positive for *Mycobacterium, bovis* (*M. bovis*) using RD4 deletion typing*(*Mamo *et al.*, 2011). Similarly, in a cross sectional study of tuberculosis in camels in Ethiopia, 14 out of 276 camels that were examined were found to be infected following slaughter out of which 4 were confirmed to have

M bovis (Anon, 2009). In this study, there was no difference in infection rate among age, sex and body condition with regard to prevalence of the disease.

2.5.4 Tuberculosis in Equidae

It was believed for a long time that the horse is refractory to infection with the tubercle bacillias it is extremely rare to see the disease in this species. They noted that recent enquiries, however, tend to prove that this view is erroneous as the improved methods of investigation which have lately been introduced have enabled the demonstration of the tubercle bacilli in various organs like the - lungs and liver in cases that were wrongly diagnosed as caseous degeneration, lymphadenoma, and induration, or scirrhus(Wortley and Hlokwe, 2016). In the horse, as in most animals, the lungs are more often more affected than other organs, and it may be assumed that the most frequent mode of infection is through the respiratory passages. It should be noted that the horse, like other animals, can be infected through other routes (Wortley and Hlokwe, 2016).

Similarly, Pavlik *et al. (*2008*)* reported tuberculosis in amare and attributed the infection to be due to *M avium* serotype 2. Clinically, the mare did not present any signs that could be suggestive of tuberculosis save increased breath sound over the entire lungs and that endoscopic examination of the airways revealed secretion in the trachea.

2.5.5 Tuberculosis in Dogs and Cats

It was reported that tuberculous lesions were found in 4 dogs and 24 cats after 61 contacts in a farm with bovine tuberculosis. Also, human to dogs transmission was suggested because in Tennessce in the United State of America (USA).a woman diagnosed with tuberculosis had

a$3^{1}/_{2}$year old male Yorkshire terrier which later was diagnosed to be infected with tuberculosis (http://www.nccdc.gov).

2.5.6 Tuberculosis in Pigs

In 1921 in the USA, 12% of pigs slaughtered under federal inspection were found to have tuberculosis lesions and transmission between pigs was considered epidemiologically less important in that lesions were localized and hogs were slaughtered at an early age and high disease levels in cattle might lead to a prevalence of up to 25% in local pigs (Blood and Radostits, 1989). Muwonge et al. (2010) reported cases of tuberculosis in pigs in Uganda where they confirmed the infection to be due to *M bovis*and noted that the infections were increasingly becoming important and of concern.

2.5.7 Tuberculosis in Wildlife

Tuberculosis is widely distributed in wild mammal populations in the USA where outbreaks due to *M. bovis* infection were reported from zoos, game parks and primate colonies (Schlisser, 1985). Epidemics of TB have been reported in the USA, with the one reported in Los Angeles Zoo being the most reported *(* Holtp, 2015*).*During this incidence, no less than 55 animal handlers tested positive to TB. Since then there has been more with 60 out of 446 elephants confirmed cases of TB in elephants in the USA *(* Holtp, 2015*).*Before the eradication of cattle TB was attained in the developed world, intermittent occurrence of *M. bovis* in wild mammals was reported in European countries and significant levels of tuberculosis infection could be found in wild species like buffalo, hogs, deer, badgers, and brush – tailed possums *(*Lepper *et al.*, 1983).

2.5.8 Tuberculosis in Man

The disease is a major cause of human infection in underdeveloped countries. However, it is not considered a significant public health hazard in the developed world *(*Joardar *et. al.,* 2000*).* It constitutes a major economic problem for agricultural trade and industries of the developing and underdeveloped world *(*Amalendu, 2012).About 5% of the affected individuals may develop active disease during the first few years of exposure. It has been reported that about 8 million new cases do occur each year of which 3 million could die. In 1990 alone, about 2.5 million people died of *tuberculosis (*Harth *et al.,*1996*).*Davies (2006*)* reported Ravenel as having demonstrated *Mycobacterium bovis* in a child having tuberculous meningitis. He further reported that the incidence of TB in humans seemed to be on the increase in England and Wales in the 1980s. There,the disease was seen more in older age groups indicating that the tubercle bacilli could have been circulating in humans for decades and that aerosol transmission could have played significant role in such cases. The fact that the diseaseis transmitted from wildlife to cattle, infection can by extension also move from wildlife to humans *(*Davies, 2006).

Mycobacterium bovis has been regarded as having persisted in humans causing pulmonary and extrapulmonary disease.There is the need to conduct more studies as to the persistence of *M bovis* infection in humans even though Danbirni (2016) and Ibrahim (2016) havereported cases of *M bovis* infections in humans in some States in Nigeria. They further attributed this to the consumption of fresh milk and the use of unpasteurized dairy products (‘Nono’) as a possible means of transmission of *M bovis* in their study areas.

The disease due to *M tuberculosis*in humans generally affects the lungs though other parts of the body can also be affected *(*Kumar *et. al.,* 2007).One-third of the world's population has been thought to have been infected with *M tuberculosis*and that about 1% of the population is said to come down with the disease each year ((WHO, 2010). By 2013, 13.7% million chronic cases were reported globally while in 2013 an estimated 9 million new cases occurred (WHO, 2010).

Although *M. tuberculosis* is responsible for most human cases, bovine Tb, caused by *M. bovis*, is an important zoonosis that can spread to people through ingestion of raw milk and sometimes by inhalation of infectious droplets *(*Thoen *et al.,* 2006a).Outbreaks of bovine Tb are therefore of considerable concern to public health officials and personnel responsible for the health of animals in zoos, animal parks and private herds *(*.van der Schaaf, 1962; Bush*et al.*,1990*).*Dekker and Dinkla*et al.,* 1991; Moser*et al*., 2008).

2.6 Aetiology

Mycobacterium species is in the family *Mycobacterineae* in the Order Actinomycetales, Phylum Actinobacteria and Kingdom Bacteria (PHE,2014).The Mycobacterium Tuberculosis Complex (MTBC) includes four other TB-causing mycobacteria that include *M bovis*, *M africanum*, *M canetti* and *M microti(*van Soolingen *et. al.,* 1997). *Mycobacterium africanum* is not widespread but has been reported in many parts of Africa (Niemann *et. al.,* 2002*;* Niobe-Eyangoh *et al.,* 2003*).*The genus *Mycobacterium* is associated with chronic infections by its characteristics and*M. bovis* is the most highly pathogenic for all mammals including humans and that the zoonotic effects of *M. bovis* was well established *(*Cousins, 1999*).*

Members of the MTBC can be cultured on selective laboratory mediaand are resistant to acid decolorizing stains.Under the microscope, they appear as slender rods which are 1.3 to 0.6nm in diameter and 1.5 – 3.0nm in length. They are slow growing and do not grow outside the host *(*Thoen *et. al.,* 2009). They can be killed by being exposed to prolonged heat, sunlight, dry conditions and other harsh environmental conditions, but can survive cold, and darkconditions*(*Phillips *et. al.,*2003).

The organisms are slender, slightly bent or straight rods (0.2 – 0.6, u x 15 – 4 u). They are nonsporulating and non- motile in nature and occur singly or in groups either irregularly or like bundle of faggots *(*Amalendu, 2012). The bacilli are enveloped in waxy substance or fatty capsules that provide them the property of taking up certain aniline dyes with difficulty. The characteristic feature of mycobacteria is their acid fast staining characteristic which is due tothe waxy substance (mycolic acid) embedded in the bacterial cell wall. This mycolic acid is softened on heating and permits the stain to penetrate into the bacteria and as such the stain is retained and is not decolorized by acid alcohol. On the basis of this property Ziehl Nelsen staining technique was evolved *(*Amalendu, 2012).

Mycobacteria are differentiated from gram positive bacteria because the molecules attached to their cell walls are lipids not proteins or polysaccharides. Thus, they do not retain crystal violet and appear as "ghost" after Gram staining *((*Madison, 2001). Mycobacterial resistance to decolonization with acid alcoholsolutions when stained with aryl methane dyes like carbolfuchsin is described as "acid – fastness" *(*Madison, 2001*).* For epidemiological purposes the tubercle bacilli were classified as follows:

1. The classical human variety *M. tuberculosis*
2. *M.africanum*mainly isolated from patients from East Africa

3. The Asianvariety which originated from Southern India as *M. tuberculosis*
4. The classical bovine variety *M. bovis* synonym*M. tuberculosis* var*bovis;* the infection by this organism is not only of bovine variety (Collins et al., 1984).

"Acid Fastness" is the most significant practical feature for the identification of tubercle bacilli, especially pathological specimens *(*Abe, 2003*).* The characterization of MTBC members is done with regard to the sequence of the nucleotide level and identical 16SRNA which is upto 99.9% similar in all members *(*Taylor *et. al.,* 2003*).* The combination of discrete acquired single–nucleotide polymorphism is the feature responsible for the evolution and adaptation of the different members of MTBC (Gutacker *et. al.,* 2002*)* and the region of difference (RD) loci which is also described as gross gene alteration like duplication, deletions, insertion and invasion *(*Brisch *et. al.,* 2002; Huard *et. al.,* 2006*).* Some regions of the genome which are present in MTBC but absent in *M. bovis*, BCG sub-strains and various non-tuberculous mycobacteria (NTM) are the regions of difference (RDS) (Parkash *et. al.,* 2009*).* These RDS enclose 80kb genomic DNA of *M tuberculosis* which are predicted to posses 89 open reading frames (ORFS) that can be enabled to encode an equal number of *proteins (*Behir *et al*, 1999*;* Mustafa, 2002*).* The RDS possesses genes which encode potential virulence factors that include prophage (RD3, RD11), invasion (RD7) expolysaccharidebio-system (RD4) and phospholipases C (RD5) while the only missing RD is RD1, from the vaccine strains BCG and *M. microti* but found in all MTC members *(*Cole, 2002). These RDS can be used as diagnostic tools for identification of MTBC members *(*Brisch *et al*, 2002*).*

Mycobacteria are resistant to disinfectants containing chlorine and remain viable in 6% NaOH after an hour of exposure.The organisms are readily killed by solution of creosote and sodium or the phenolphenateand disinfectant if used should be given in higher concentration than necessary

for other organisms.Thus, for mycobacterial classification, biochemical tests such asniacin, catalase, arylsulfatase and growth inhibition test have been suggested (Amalendu, 2012).

Cultures that showed evidence of growth are subjected to a number of tests with a view to characterizing the organisms.The method routinely used in differentiation of *Nocardia* from *Mycobacterium* spp includenitrophenol test of vestal; growth on yeast-glucose agar medium at 28^{o}C, hydrolysis of casein, and decomposition of tyrosine (Gordonand Mihm, 1962) while others include Z – N staining characteristics, growth rate, pigmentation, Tween 80 hydrolysis, and catalaseproduction *(*Alhaji, 1976*).*

The bacillus (*M tuberculosis*) causing tuberculosis was identified and described in 1882 by Roberts Koch and this led him to earn a Nobel Prize in 1905.

Mycobacterium bovis that once became a major programme has been greatly reduced in Europe through pasteuralization (O'Reilly and Daborn (1995a). However, in Africa the organism has been abundantly reported *(*Alhaji, 1976; Ibrahim, 2016*).Mycobacterium canetti* has been reported mainly in the horn of Africa and afew cases have been reported in African emigrants (Pfyffer et al., 1998; Acton and Ashton, 2011). They further reported that *M microti* was rare and mainly seen in immunodeficient people.

Other pathogenic mycobactetria include *M laprae*, *M avium* and *M kansasii* of which *M avium* and *M kansasii* are regarded as non-tuberculous mycoobacteria (NTM) (ATS, 1997).

Mycobacterium tuberculosis is a small aerobic nonmotile bacillus *(*Dolin *et. al.*, 2010). It has a high lipid content that makes itto produce unique clinical characteristics (Southwick, 2007*).* It has been reported to be capable of dividing every 16 to 20 hours which is extremely slow compared with other bacteria (Jindal*,* 2011*).* They have an outer membrane made of lipid bilayer

(Niederweis et. al., 2010).It does not stain well with Gram stain. Where it does, it stains weakly positive (Madison, 2001). The organisms are very clearly stained when acid fast s tain (AFB) is used *(Madison, 2001; Kumar et. al., 2007).* The most common acid-fast staining techniques in use, however, are the Zielhl-Nelsen stain and auramine-rhodamine stain and they are followed by fluorescence microscopy (Piot *et. al*., 2008).

The organisms can withstand weak disinfectants and survive in a dry state for weeks. In nature, the bacterium can grow only within the cells of a host organism, but *M tuberculosis* can be cultured in the laboratory (Paarish and Stoker, 1999).

The tuberculous bacilli are enveloped in a lipoidal covering which protect and make them resistant to external influences. The bacilli in the pus and morbid discharges can remain viable for several weeks, but if subjected to drying they become ineffective for years.. The organisms are killed by direct sunlight in few hours; however when they remain in organic matter like faeces they may live longer. The tubercle bacilli are very much sensitive to heat and one of the easiest methods of destroying them in milk and cream is pasteurization (Amalendu,2012).

The main causative agent of many cases of bovine tuberculosis in cattle is *Mycobacterium bovis* as well as cases in domesticated and wild mammals resulting to a chronic progressive respiratory disease (Francis, 1947, Cousins, 2001). Variable studies pointed out that the physiology and host range of *M. bovis* and *M. tuberculosis* are different but genome sequence variation is slight. However, M. bovis is closely related to *M. tuberculosis* and they share genetic identity of over 99% at the genome level (Garner *et al*., 2003).

*Mycobacterium bovis*was further subdivided into *M. bovis*subsp.bovisand *M. bovis* subsp. caprae, but *M. bovis* and *M. caprae* are the accepted taxonomy of these members of the

Mycobacterium tuberculosis complex (Aranaz *et al*., 2003).According to antimycobacterial sensitivity,*M. bovis* subsp. bovis is resistant to pyrazinamide (PZA) whereas *M. bovis* subsp. Caprae is sensitive to pyrazinamide (PZA) *(*Wayne and Kubica, 1986*).*

2.7Transmission

2.7.1 Transmission in Animals

The main means of transmission of bovine tuberculosis (bTB) seems to be as a result of translocation of infected cattle to areas where there are fully susceptible ones (Davies, 2006). There is also the likelihood of spread between domestic and wild animals through the moving of animals into interspaces *(*Davies, 2006*).*In New Zealand, the brush tail possum was considered as a vector of *M bovis* and legislation was put in place in 1993 for its control and this substantially reduced the infection rates in cattle and deer herds. Similarly, in the United Kingdom, transmission of *M tuberculosis* from humans to animals seemed to be first described by Matjaz *et al*., 2000) using molecular typing of the isolates involved in the transmission of the infection.

Cattle are infected by inhalation of droplets (aerosols) that contain the bacteria.Infections also occurs by ingestion (oral) if an animal swallows the bacteria (Kaneene and Pfeiffer, 2006*).*More so, infection can occur through the gastro- intestinal tract and become systemic and affect other organs *(*Cousins*et et.al,* 2004). Bovine tuberculosis is usually a slowly progressive and debilitating disease, but can occasionally have a quick onset and progress radically *(*Shitaye *et al.,* 2006*),* As the disease progresses, there is weight loss, lack of appetite, weakness and low grade fever are common. When the disease involves the lungs, animals will have a cough that is worse in the morning during cold weather or activity and they may have difficulty in breathing.

If the digestive tract is also involved, animals may develop diarrhoea that comes and goes, or become constipated (Artoise *et al;* 2000; Naima *et al;* 2008).

Mycobacterium bovis infection can be via aerosols when the organism is deposited in the environment. The environment can also be an important medium for transmission to cattle during grazing or feeding in troughs contaminatedwith urine or faeces from infected animals *(*Goodchild and Hadley, 2001; Phillips *et. al.*,2003). Natural transmission of *M. bovis* between domestic and wild animals of the same or different species may occur and uncommonly from animals to humans, or from humans to animals and human to human *(*Collins, 2000*).* All terrestrial mammals can be infected with *M. bovis* depending on the magnitude of exposure, innate resistance, and immunity system, kind of husbandry practice, ecology and characteristic pathology (Morris *et al.,* 1994). In contrast with regard to host range,*M. bovis* has a wide range of hosts than *M. tuberculosis(*de la Rua- Domenech, 2006). In naturally infected cattle, bovine tuberculosis appears as a respiratory tract infection (Francis, 1947; Neill et al; 1994). As such the most common source of transmission of bTB infection is the aerosols form, when the bacilli are excreted, especially from the lungs (Pritchard, 1988; Phillips et al; 2003).

Cattle infection from humanshas been seen to be more from farmers that have been infected with pulmonary or urino-genital tuberculosis (Pritchard, 1988; Danker et al; 1993; Grange and Yates, 1994). Human to cattle transmission of *M. bovis* has been reported, but medical literature has few case reports (Sjogren and Hillerdal, 1978; O' Reilly and Darborn, 1995; Ayele et al., 2004).*Mycobacteriumtuberculosis* is said to cause mild, no progression bTB in cattle which may lead to a temporary sensitization of bovine tuberculin, providing the antigen for routine diagnosis of TB in cattleand other animalsatante *mortem* (Pavlik *et al.,*2003).

Vertical transmission of *M. bovis* from an infected dam to her calf through congenital infection in-utero has been described (Mathews*et al*.,2006). Ingestion of contaminated colostrum/milk is another way of bTB transmission from cow to calf, as suggested by Zanini *et al.*(1998). The risk for pseudo-vertical transmission through close contact between a cow and its calf (grooming) has been considered, especially in developing countries as a possible means of transmission of *M bovis* (Phillips *et al.,*2003). In developed countries, however, where regular testing programmes are implemented and where outbreaks are rare, this risk may be considered negligible.

2.7.2 Transmission in Man

Bovine tuberculosis can infect humans and the most common routes of infections are from drinking (oral) raw (unpasteurized) milk or eating dairy products made from raw milk and less commonly the bacteria can enter the body via breathing (aerosols) or through breaks in the skin (direct contact). Infected humans may show no signs, but may develop infection in the chest and lungs or have infections in other parts of the body such as the kidney, spine and brain. The symptoms of chest and lungs infections can include fever, chest pain and cough. Infected individuals often cough up blood (Cadmus *et al,* 2010).

Transmission of *M bovis* from infected animals to humans can occur by inhalation or ingesting the bacteria shed by animals or through contamination of unprotected cuts in the skin while handling infected animals or their carcasses (Blood and Radostits, 1989)).

Mycobacterium bovis transmission from human to human was demonstrated in the UK during an outbreak of the disease in Birmingham (Blood and Radostits, 1989).The bacteria can be transmitted by close contact or by droplets containing the bacteria that float through the air after a sneeze or cough (Holt, 2015).It is spread through the air when people who have an active TB

infection cough, sneeze or otherwise transmit respiratory fluids through the air (Kumar *et. al*., 2007).

People with active pulmonary TB can spread the infection through coughing, sneezing, speaking closely with others, singing or spitting(Nicas *et al*., 2005).In this regard, Cole and Cook (1998) reported that a single sneeze could release up to 40,000 droplets and that each one of these droplets could transmit the disease since the infectious dose is very small (Nicas *et. al*., 2005).

The site of tuberculosis infection in humans seems to be associated with the route of transmission as majority (56.7%) of *M bovis* infections were shown to be pulmonary as is recorded for *M tuberculosis* infection. This would indicate possible transmission via inhalation in contrast with that via ingestion when unpasteurized milk was the main source of transmission (Maclean, 1964; Baker *et. al*., 2006).

The disease can be transmitted in humans via exhaled air,sputum, urine, faeces, and pus depending on the species involved.In a study to determine the prevalence of bTB and brucellosis in the Oromia region of Ethiopia,Tschopp *et al.* (2015*)* found that 55.4% of the livestock owners under their study were in the habit of drinking fresh milk only while 77.0% of them drank raw milk occasionally during the week. Furthermore, 22.3% of the farmers drank milk on daily basis. Yet another 0.7% reported never drinking fresh milk. Furthermore, all the respondents reported consuming raw milk products like butter and cheese on regular basis. Some of the respondents also indicated drinking milk from small ruminants (Tschopp *et al*., 2015).As of their perception on the route of transmission of BTB in humans, they mentioned coughing/sputum, as bad air through confinement in poorly ventilated houses, contaminated milk and materials, consumption

of raw meat, contact with infected animals, consumption of contaminated drinks and food as the main sources for coming down with bTB.

Health challenges like immunodeficiency virus and acquired immunodeficiency syndrome (HIV/AIDS) and scientific technology coupled with the incapability of tools for the specific identification of bovine TB bacillus and its strains had affected research on zoonotic TB in the last 50 decades. For instance, the discovery of polymerase chain reaction (PCR) and other molecular tools to identify*M. bovis* and differentiate it from other members of the *Mycobacterium tuberculosis* complex have allowed the discovery of cases in retrospective studies and have indicated various new routes of transmission (Cousins, 1999). The potential sources of infection and the routes of spread of the disease are not well established in Africa (Cleaveland *et al,* 2007).

Transmission of the disease has also been reported from human to canine (Erwin *et al*., 2004).The first documented cat to human transmission of *Mycobacterium bovis* in England was in two people who had contact with an infected cat confirmed to be infected with *M bovis* (Phleahvla, 2014) Molecular analysis of the *M bovis* in the cat and infected humans were indistinguishable. Further investigation revealed that two other persons had evidence of exposure to the organism through cats though the risk potential of transmission of *M bovis* from cats to humans has beenregarded to be low.

2.8 Epidemiology

2.8.1 Livestock Husbandry and Management Practices with regard to Tuberculosis

The epidemiology of bTB remains largely unknown in Africa due to politico-economic reasons as not much work has been done (Alhaji, 1976; Blood and Radostits, 1989). However, the

husbandry and management practices being practiced by pastoralists who own more than 60% of the national herds in most African countries could facilitate national herds to come down with the disease as long as there are infected animals amidst them (Saidu *et al*., 1991; Ibrahim, 2016). Sharing grazing and watering points along with borrowing of breeding bulls for mating with cows on heat as reported by Kaltungo (2013) and Buhari (2014) can also increase the chances of spreading the disease among herds.

2.8.2 Interaction of Man with Animals

By 1930s, about 40% of the cattle in the UK were infected with *M bovis* and that 50,000 new cases of human *M bovis* infections were recorded every year (Pheavla, 2014). Strategic badger control reduced the incidence significantly. The interaction of man with wild animals in zoos as workers has greatly facilitated their acquiring of the disease.

2.8.3 Aetiological Agents' Factors

The cultural habit of humans in Nigeria whereby they take soured milk and millet paste as a daily meal has been incriminated to facilitate zoonotic TB in some States of Nigeria (Danbirni, 2016; Ibrahim, 2016). Similarly, man's living closely with cattle in rural areas and even by pastoralists has been incriminated in increasing the prevalence of zoonotic TB among those that practiced such livestock management system as they demonstrated *M bovis* in the sputum of the livestock keepers (Shehu, 1988; Danbirni, 2016; Ibrahim, 2016).

2.8.4Environmental, Seasonal and Climatic Factors

Information on survival of *M. bovis* outside living animals has not been fully documented. For example, Menzies and Neill (2000) stated that *M. bovis* is able to survive in the environment for

only a few weeks under natural conditions, considering that environmental contamination is a less effective means of disease transmission in cattle. Furthermore, Morris *et al.* (1994)concluded that contaminated feed and pasture play a negligible role in the transmission of the disease to cattle because *M. bovis* does not survive long enough on formites to be infective, but also because animals are not commonly exposed to a high enough dose to become infected orally. However, the importance of environmental contamination in the transmission of bTB to healthy cattle might differ between developed and developing countries as in developing countries livestock are grazed week-in-week out in the same grazing fields and that herds of no complete history could mix during grazing (Cleaveland *et al.*,2007; Kaltungo*, 2013;* Buhari*,* 2014; Baba, 2016).

As of climate, the colder the weather the greater chances for the survival of M bovis outside the host. For example, water points like streams where pastoralists' herds take their water daily could be said to provide avenues for the survival of the organisms (Phillips *et al*., 2003).In Africa, flooding has also been suggested as a propagating factor of *M. bovis* in the environment (Cleaveland *et al*., 2007).

2.8.5 Risk Factors for Tuberculosis

A number of factors have been advanced for making people to be more susceptible to TB infection. These factors include HIV, especially in sub-Saharan Africa where the rates of HIV are high (WHO, 2006; Chaisson and Martinson, 2008). Overcrowding and malnutrition have also been closely associated with Tb in humans making it one of the principal diseases associated with poverty (Lawn and Zumlo, 2011). Others that have been regarded to also be at risk of contracting TB include people who inject themselves illicit drugs, inhabitants and employees of

locales where vulnerable people gather, medically under- privileged and resource-poor communities (Griffith and Kerr, 1996). People with chronic lung disease (silicosis),especiallythose working in quarries have been reported to have increased chances to come down with the infection with TB (van Zyl Smit *et al.,* 2010). Alcoholism and diabetes mellitus have also been reported to increase chances of such people by three-fold *(*Dolin *et al., 2010;* Lawn and Zumlo, 2011). Certain medications such as corticosteroids and infliximab have similarly been incriminated in increasing patients receiving them to come down with TB infection, especially in the developed world (Lawn and Zumlo, 2011).

2.8.6 Species,Breed, Age and Sex

Numerous studies have shown that age, sex and even animal species and breed are potential factors for an animal to come down with tuberculosis (Cleaveland *et al.,* 2007; Inangolet *et al.,* 2008). They showed that the longer an animal remains in a herd the more the possibility for it to be exposed to infected animals in such herds. Griffin *et al*. (1996) observed that an animal might be infected at a young age but may only express the disease clinically when it reaches adults stage, especially that Pollock and Neill (2002) indicated that mycobacteria have the ability to remain in a latent state for a long period before reactivation at which time the host would have been older.

With regard to sex, Kazwala *et al.* (2001) reported that male cattle that were used as work oxen were more affected with bTB than female cattle as they were mostly used as oxen and that they had more possibility of contact with infected cattle from other affected herds. However, Ibrahim (2016) in a study in Nigeria reported female cattle to be more affected since they too were more retained in herds for producing younger and milk that was used to provide daily needs for the

pastoralists. Whatever could account for the gender related risk for bTB, management practices could be said to influence the occurrence of the disease in these animals. For example, Marie-France *et al*. (2009) observed that gender-linked factors are probably related to management practices or behavioural habits as males and females are managed differently, both in developed and developing countries. For example, in developed countries, dairy cows usually reach older age than males because of their role in calving and milk production just like as it obtains in most African countries.

As for breed predisposition to bTB, studies in some African countries have shown that exotic cattle were more prone to infection with bTB than indigenous ones (Omeret *al.,* 2001*;* Elias *et al.,* 2008; Danbirni, 2016; Ibrahim, 2016). The difference of susceptibility between breeds is likely to be related to differences in management as imported dairy animals are generally kept under intensive conditions.

2.8.7 Interaction of various Animal species

Tuberculosis has been reported in many animal species. Thus, anything that would cause the various animal species to meet one another could trigger infection, should any one species be infected. For example, infection with *M. bovis* has been described in dogs and cats (Wilesmith and Clifton-Hadley,1994; Gay *et al.,* 2000), but no transmission to cattle has been reported so far. Furthermore, there are many reports of *M bovis* infection in slaughter pigs and no any incrimination of the spread of the disease from pigs to cattle or even humans (Thoen et al., 2006a). In Africa, goats are kept in mixed production with cattle and sheep by pastoralists and infection in these animal species could occur (Gutiérrez *et al*., 1999*;* Seva *et al.,* 2002).

The risk of contaminating bTB-free cattle herds by introducing infected goats should not be dismissed. Individual cases of *M. bovis* tuberculosis in sheep have been reported, but ovine disease is rare and usually associated with cattle cases *(*Lugton *et al*., 1998*).* Similarly, pastoralists keep horses and donkeys and there is every chance that such equidae could acquire infection with *M bovis* should the cattle under their hands care have the disease.

2. 9. Pathogenesis

Once in the susceptible host, the cells of innate and adaptive immune response in the lymph nodes and respiratory tissues react with *M. bovis* leading to the colonization and infection resulting to development of lesions and formationof granuloma in the infected tissues/organs (Palmer *et al*., 2007). The capacity of mycobacteria to elicit a disease depends on certain complex lipids present in their cell wall (trehalose-5,6dimycorate,sulphur containing glycolipids) or strongly acidic lipids(Thoen, 1979). The combination of toxic lipids and factors released by virulent tubercle bacilli initiates disruption of phagosome, interference with phagosomalformation, hindering of the release of hydrolytic enzymes from attached lysosomes or inactivation of the lysosomal enzymes released into the cytoplasmic vacuoles (Thoen and Himes, 1985). On entry, through either inhalation or ingestion, the bacilli localize in the point of entry and produce a typical tubercle in associated lymph nodes. This type of reaction is termed a primary tuberculosis complex. Pharyngeal and mesenteric lymph nodes are most frequently involved through ingestion of the bacilli. The infection may extend across the body cavities, blood vessels and lymph nodes and cause primary dissemination.Then, at a later stage, extensive lesions occur to undermine host resistance and this stage is known as the stage of late generalization (Amalendu, 2012).

There is some degree of host susceptibility to the various *Mycobacterium*species, although cross infectionsare known to occur, with animal species being more susceptible to bovine tubercle bacilli, whereas man and dogs on the other hand appearto be more susceptible to the human species of the organism (Alhaji, 1976; Collins and Grange, 1983). Both $CD4^+$ T-cells and $CD8^+$ T-cells have a significant role in controlling infected cells (Pallock *et al.*,2005) while $CD8^+$ may play a deleterious role in the immunopathology of bovine tuberculosis(Villareal– Ramos *et al;* 2003). However, there exists a balance between mycobacterial killing and *survival* (Sannders and Britton, 2007).

2.10Clinical Signs

2.10.1 Clinical Signs in Animals

Bovine tuberculosis is a chronicand infectious disease which is manifested by emaciation, anoraexia, reduction in milk yield, loss of production,cough, dyspnoea and enlargedregional lymph nodes thatrupture as the disease progresses (Abdurahman and Bornstein, 1991; Blood *et al.,* 2000; OIE, 2009). Signs are mostly noticed when the disease has reached an advanced stage (Corner, 2006; Shitaye *et al;* 2006).Bovine TB is sometimes subclinical and that clinical signs are not distinctive (OIE, 2009) and is difficult to diagnose using clinical signs only because it has similar clinical manifestation with other diseases like contagious bovine pleuropneumonia (CBPP), traumatic pericarditis, chronic aberrant fasciolosis, pasteurellosiss and *Corynebacterium pyogenes*pneumonia (Blood and Radostits, 1989; Grist, 2008).Infected animals (livestock) may look apparently healthy but lesions are found during meatinspection at slaughter houses (Murray *et al.*,1991; Shitaye *et al.,* 2006).

Clinical signs of the disease in camelids include wasting, anorexia, respiratorydistress, enlargement of superficial lymph nodes, recumbency and eventual death (Abdurahman and Bornstein, 1991).

2.10.2Clinical Signs in Man

Most infections do not have symptoms and affected patients are said to have latent tuberculosis (Kumar *et. al.,* 2007). It has been reported that about 10% of latent infections could progress to active disease which, if untreated, could kill up to 50% of such patients (Kontaninos, 2010).The classic symptoms of active TB in humans include chronic cough that could be blood-tinged sputum, fever, night sweats and weight loss. Infection in other organs could result in a variety of symptoms (Kumar *et. al.,* 2007).

Extra-pulmonary TB has been reported to include in the pleura (tuberculous pleurisy),central nervous system (tuberculous meningitis), and in bones and joints (Pott disease of the spines), among others. When it spreads to the bones, it is also called osseous tuberculosis ((Kumar*et al*., 2007). Such ulcers, if they are originating from a nearby lymph node, are painless but enlarge slowly and take wash leather appearance (Burkitt, 2007).

A potentially more serious widespread form of TB referred to as disseminated TB or military tuberculosis has been reported to be about 10% of extrapulmonary cases of TB (Ghash,*et. al*, 2008).

2.11Pathology

Lesions are usually associated with the route of infection(Biet *et al.,* 2005).For example, lesions in the respiratory tract are commonly associated with the transmission of the disease through aerosols. These lesions are typically granulomatous or tubercles in affected tissue organs (Blood

and Radostits, 1989; Leibana *et al.,* 2008).In miliary TB, lesions can be seen in regional lymph nodes, gastrointestinal tract, lungs, brain and such other lesions (Francis, 1977; Blood and Radostits, 1989; McAdams *et l.,* 1995). There may also be caseous necrosis of the affected organs especially the lungs (Blood and Radostits, 1989). Lesions due to TB in camels have been reported to be spread in the lungs, mesenteric, mediastenal and retropharyngeal lymph nodes (Kinne *et al.,*2006; Anon., 2009).

In most cases of TB in camelids, tubercles are characterized histologically by granuloma formation, with infiltration by epithelioid macrophages, lymphocytes, plasma cells and neutrophils, central caseous necrosis and variable calcification and fibroblastic reaction (Bush *et al.,* 1990; García-Bocanegra*et al.,* 2010;Oevermann *et al*., 2004).Giant cells have rarely been described, except by Zanolari*et al*.,2009) who found them in eight of eleven*M. microti*-infectedNew World Camelids (NWCs). Results ofZiehl–Neelsenstaining of sections have been variable, with most sections revealing few acid-fast bacilli although abundant numbers have been noted in some reports on NWCs (García-Bocanegra*et al.,*2010).

2.12 Diagnosis

The diagnosis of bovine tuberculosis in Africa is more often made mostly on the basis of post mortem examination when conducting meat inspection at abattoirs, or by the use of tuberculin skin test and by scarcely bacteriological methods (Ameni *et al*.,2000; Asseged *et al*.,2004;Shitaye *et al*; 2007).This is because the isolation of the infectious mycobacterium is very difficult. The bacterial species identification is necessary for the study of the transmission of mycobacteria as well as in the study of the epidemiology and surveillance and control of the

disease (Michel *et al.*,2010). For the diagnosis of the disease, a number of tests/methods that include history taking along with physical examination of clinical cases, post mortem inspection, direct smear examination, culture and isolation of the causative agents and intradermal skin test among others are routinely applied. Of recent, the use of molecular techniques are progressively gaining grounds and even faster and cheaper, while at the same time being more reliable.

A definitive diagnosis can be made only at post-mortem examination by demonstration of typical gross lesions,followed by histopathology and confirmatory bacterial culture. Mycobacteria are slow-growing organisms thatmay require incubation on selective media, such as Lowenstein-Jensen media or Ogawa, for up to eight weeks (Quinn *et al*., 1994).More rapid diagnosis can be made using polymerase chain reaction (PCR) assays (Taylor*et al*., 2007).Initial identification of MTC bacteria can be made by targeting insertion sequences such as IS1081 or IS6110(Thomson, 2006; Taylor*et al*., 2007).Confirmation of mycobacterial species can then be made using primers for specific targets,for example, region of difference 4 (RD4) in *M.bovis*(Thomson, 2006). In addition to providing a faster diagnosis than with traditional culture, PCR methods can also be used on formalin-fixed tissues when fresh samples are not available for culture.This approach was used to confirm TB in an alpaca during investigation of a zoonotic incident (Twomey *et al*., 2010). Nevertheless, there are currently some disadvantages associated with PCR. Firstly, it does not allow further discrimination of the isolate by molecular typing, which can be done using cultured isolates and is important for epidemiological studies. Secondly, poor sensitivity of PCR has been reported, possibly associated with low numbers and uneven distribution of the bacteria in tissues. Resilience ofthe mycobacterial cell wall inhibiting extraction of DNA may also affect the sensitivity of the assay, and, for fixedtissues, degradation of DNA associated with prolonged formalin fixation and the processing technique may be afactor (Thomson, 2006; Taylor*et al*.,

2007). In live animals, clinical diagnosis is often difficult because of the lack of specific signs. Ancillary ante-mortem tests would therefore be useful to confirm the diagnosis. None of the tests currently available, including the classic tuberculin skin test (TST) and various blood assays, can diagnose TB in camelids with certainty, and none has been properly validated in these animal species. Although estimates of sensitivity and specificity are provided in some reports, these calculations are usually of limited value because of the small number of animals studied.

Bovine tuberculosis is a World Organization for Animal Health (OIE) listed disease and testing of camelids should follow the OIE guidelines (Bush *et al*;. 1990; Wernery*et al*., 2007). The method for camelids traded internationally is the single intradermal comparative tuberculin test (TST) and the site of inoculation is the axilla (De la Rua-Domenech*et al*., 2006).The maxillary site was found to be superior to cervical and tail-fold sites in studies using small numbers of llamas and dromedaries (Johnson *et al*., 1989). For statutory testing, purified protein derivatives of bovineand avian tuberculin (each 0.1 ml) are injected into a shaved area of the axilla, and the thickness of the skin ismeasured immediately before and 72 h after the injections. A positive result is indicated by an increase in skin thickness at the bovine site that is greater than the increase at the avian site. Some reports indicate that the TST has reasonable sensitivity and specificity, whereas others indicate a low predictive value (Dean *et al.,* 2009).The reason for this variation between reports is not clear, but many causes of falsenegative and false-positive reactions have been proposed in cattle, and it is possible that these could also apply to camelids (De la Rua-Domenech*et al*., 2006). The statutory 72 hour interval between injection of tuberculin and measuring the response to injection is based on the protocol for cattle, which have a swelling of greatest intensity 48 h to 72 h post injection. In dromedaries, however, the most potent response totuberculin was detected when skin thickness was recorded five days after tuberculin

injection (Wernery*et al*., 2007).It might thereforebe the case in camelids that the optimal testing regime has yet to be identified. A negative impact of this lack ofreliability in the interpretation of the TST results is that testing for TB in camelids has been discontinued in some zoologicalcollections, resulting in reduced disease surveillance. From these observations, it becomes obvious that any programme to control camelid TB based only on the TST faces severe limitations. These findings have stimulated research into blood-based assays. Serological tests for the diagnosis of TB have been developed since the 1980s and potentially offer a convenient and cost-effective means of TB surveillance. Early attempts at developing enzyme-linked immunosorbent assays (ELISAs) did not convincingly discriminate between naturally infected and vaccinated animals and issues of cross-reactivity with other mycobacteria were not addressed (Dean *et al*., 2009). More recent serological tests include the multi-antigen print immunoassay (MAPIA) and the Vet TB Stat-Pak or 'rapid test' (Lyashchenko*et al*.,2000). The MAPIA utilizes a range of antigensprinted onto nitrocellulose strips that are incubated with serum samples; the rapid test is a portable lateral-flowchromatographic assay that uses three MTC-specific antigens. These antigens have shown some promise fordetecting MTC-infected camelids, but further validation is still required before they can be used reliably for fielddiagnosis (Lyashchenko *et al*., 2007).They first used these tests in NWCs infected with *M. microti*and foundthat four of the five culture-confirmed cases were seropositive in the MAPIA; and two were positive in the rapid test. Dean*et al.* (2009)showed that both these tests were more sensitivethan the TST in a herd of llamas infected with *M. bovis*. Theherd included 14 tuberculous llamas; 12 of whichwere confirmed by culture. Only two of the 14 were detected in the TST, but 11 were positive in the rapid testand all the 14 were positive in the MAPIA. Nevertheless, the specificity of the rapid test was low in this herd (MAPIA specificity

notdetermined (ATS/CDC, 2000): 44 of 54 (81%) animals that werepositive in the rapid test had no detectable evidence ofinfection at necropsy. Werner*yet al*. (2007) reported positiveresults in both the MAPIA and rapid test in threedromedaries infected with bovine TB, confirmed atnecropsy and by culture, indicating a possible diagnosticbenefit in OWCs. To date, MPB83 hasbeen the most dominant antigen in sera from camelids infected with *M. bovis*and *M. microti*(Dean *et al*., 1994).The gamma interferon test (IFN-γ) and lymphocytetransformation assay are *in vitro* methods for measuringimmune responses of circulating lymphocytes. The IFN-γtest is acknowledged by the OIE as an alternative to theTST for internationally traded cattle (Werner*yet al*., 2007)but the currentlyused bovine IFN-γ assay (Bovigam, Prionics, Switzerland)is unsuitable for camelids. The lymphocyte transformationassay is not used for routine diagnosis because it is timeconsuming and complicated to perform. Scientists in NewZealand have developed a blood test for the diagnosis of TBin deer, which combines the lymphocyte transformation assay with ELISA and haptoglobin tests. This method hasalso been used in alpacas but its diagnostic benefit has notyet been demonstrated (Hesketh *etal*., 1994). These various methods will be examined briefly below.

2.12.1 History and Clinical Signs in Animals

Bovine tuberculosis is mostly subclinical, but if clinical signs are manifested they are not particularly distinctive. Such clinical signsinclude enlargement of the regional lymph nodes, anoraexia, weakness, and progressive coughing in advanced stages of the disease (OIE, 2009). It is not easyto diagnose bTB using only clinical manifestation because other disease conditions like CBPP, pasteurellosiss or *Corynebacterium pyogenes* pneumonia, and traumatic pericarditis have similar clinical manifestations with bTB in cattle (Blood and Radostits, 1989; Grist, 2008).

2.12.2 History, Clinical Signs and Symptoms in Man

Diagnosing active TB based merely on signs and symptoms is difficult, especially if the patient isimmunosuppressed (Huouben *et. al.,* 2006; Bento *et. al*., 2011).A chest X-ray and multiple sputum cultures for acid-fast bacilli are typically part of the initial evaluation of an infection (Escalante, 2009). Interferon-α release assay and tuberculin skin test are also used but have little value in developing countries.

2.12.3 Tuberculin Tests

Tuberculin test for the identification of cattle with tuberculosis was introduced in the 1930s (Davies, 2006). The Mantoux tuberculin skin test could be used to screen people at high risk for TB (Escalante, 2009). However, those that have been previously immunized may react false-positively to this test as those with sarcoidosis will have false-negative (WHO, 2014).

Tuberculin skin test is the initial and widely used diagnostic technique for tuberculosis which is applied for testing in both animals and humans. However, the tuberculin test has deficiency due to its inability to differentiate between specific species of MTC as well as failure to distinguish between latent stages of infection and disease and between vaccinated and infected individuals (De la-Rua-Domenech *et al., 2006).*Nonetheless, the tuberculin skin test is still not replaced by any other more accurate or satisfactory technique.Other test techniques such as the caudal fold test (CFT) and single intradermal comparative cervical tuberculin test (SICCT) are the mostly routinely used (Monaghan et al; 1994). Skin indurationreaction is read 3 days after tuberculin injection for all types of the tests. The cell mediated delayed-type hypersensitivity (DTH)

response in cattle is characterized by a classical manifestation of the predominant infiltration of CD4 and $CD8^+$ T-cells and macrophages (Doherty *et al*., 1996). The SICCT is the more specific test method since the comparative use of PPDA allows for the measurement of non-specific sensitization to environmental mycobacteria that are present in PPD-B.

The recently evolved Bovigan® test for cattle, the quantiferon®-TB-test, detects the production of interferon-gamma in stimulated blood samples. This technique has contributed most importantly to the improved determination of early *M. bovis* infection in bovine and more wildlife species as applied in both test formats (Grobler *et al*; 2002; Denis *et al*., 2007; Morar *et al*., 2007; Kirm *et al*., 2008; Waters *et al*., 2008). Other current improvements of the test are the use of two MTC specific antigens that is ESAT-6 and CFP-10, which have given increased test specificity (Buddle *et al*., 2009). Both the tuberculin skin test and the interferon--gamma test could be used to differentiate between infected and vaccinated individuals. However, the use of these techniques in developing countries for diagnosis in animals is almost impossible because sophisticated laboratory equipment and the need to rapidly process the blood samples following collection are required (de la Rau-Domenech, 2006).

2.12.4Sample Collection

In humans, samples include sputum, pus, and tissue biopsy from affected organs (WHO, 2006; NIHCE, 2011).

2.12.5 Laboratory Investigations

A definitive diagnosis of TB is done by identifying *M tuberculosis* in clinical samples that include sputum, pus and tissue*biopsy* (WHO, 2006; NIHCE, 2011).

Similarly, nucleic acid amplification tests and adenosine deaminase testing may be used to allow rapid diagnosis of TB (Bento *et. al*., 2011). They observed that these tests are not routinely done.

2. 12.5.1 *Direct smear examination, culture and isolation and biochemical tests*

Diagnosis of bovine TB has traditionally been based on clear cut differentiation of the phenotypic and biochemical tests (Quin and Karkey, 2003; Kubica *et al*., 2006).Not only that the rapid diagnosis of the disease is central to minimizing the risk of the disease transmission, particularly in humans. This is, especially in the wake of the emergence of drug-resistant TB and its severe implications for human immunodeficiency virus-infected patients *(*Chaissoand Martinson, 2008).Furthermore, even though culturing of the aetiologic agent remains the accepted "gold standard" for diagnosing TB, direct smear microscopy is by far the most popular among all the methods currently employed worldwide for TB diagnosis. This is more directly important with regard to diagnosing the disease in developing countries where the logistics and ability to adopt the technology can be met with challenges. In view of the enormous utility of smear microscopy, numerous efforts have been made to improve its sensitivity (Eisenach *et al*., 1990; Forbes and Hicks, 1996)with varying success rates.Chakravorty and Tyagi (2005) reported on the development of a novel, robust, reproducible, and multipurpose universal sample processing (USP) methodology for highly sensitive smear microscopy, culturing on solid and liquid media, and inhibition-free PCR which is suitable for the laboratory diagnosis of both pulmonary and extrapulmonary tuberculosis (TB). They reported that the direct smear microscopy lacks the sensitivity and versatility in terms of application to extrapulmonary specimens. The use of direct smear microscopy is an inexpensive and rapid test for diagnosis of tuberculosis (Kesarwani *et al*., 2004). However, it does not permit differentiation between species of *Mycobacteriumtuberculosis* complex. Also, *M.bovis* grows poorly in standard Lowenstein-Jensen medium which is one of the most widely used culture media (Grange *et al*.,

1996). It has been abundantly shown that culture is the gold standard for the confirmation of an infection in both animals and humans. However, it requires a lot of time, whereas clinical urgency necessitates immediate laboratory back up. In situations when an urgent confirmation is required, the PCR amplification of the *Mycobacterium tuberculosis* DNA may be needed as it is a rapid and reliable method for the diagnosis of the disease(Mc Adam *et al*., 2007).

Culture media for the growth and isolation of *mycobacterium* species in Veterinary bacteriology include Lowenstein Jensen medium that requires egg for fast growth of the colonies, agar-based medium such as Middlebrook $7H_{10}$ and $7H_{11}$ or blood based agar medium (OIE, 2009). Fentalum and Luke (2012) reported that validation of malachite green dye at 0.25g per 100ml of the medium enhances growth and serves as a selective agent for the organisms. Furthermore, glycerol may be added, though it inhibits *M bovis* while *M tuberculosis* and *M avium* are enhanced. In this regard, they recommended the addition of sodium pyruvate for *M bovis* in the medium. They also reported that the media can be made moreselective by the addition of cyclohexamide at 400µg per millilitre along with lincomycin (2µg/ml) and nalidixic acid (35µg/ml). All cultures of the suspected organisms should be incubated at 37^0C for up to 8 weeks (though 10 to 12 weeks are more preferable) before a negative result would be decided (Scanlar, 1988; Quin, 1994).

Culture of suspected samples for the purpose of mycobacterial organisms (bovine and even human Tb)identificationhas been used for long, especially in developing countries (Danbirni, 2016). The features used in these techniques include classical tests based on microbiological features such as growth rate and phenotypic and biochemical characteristicsthat have conventionally been utilized to distinguish members of the MTC. However, these tests are slow, cumbersome, unreliable, and time-consuming. The high degree of variability among these tests

resulted in the development of molecular biological tools for identification of MTC members. In this regard, multiple gene targets have been used to date to detect and differentiate genetically identical species, such as *M. tuberculosis* and *M. bovis*.

Kubica *et al*. (2006) observed that M.bovis shows a dysgenic colony shape on Lowenstein Jensen medium and that it has microaerophilic growth. On its part *M tuberculosis* has eugenic colony shape and aerophilic growth.

The production of pigments by mycobacteria is used for the characterization of the various organisms. For example, Quin (1994) demonstrated the use of niacin production test as a means for the confirmation of *M tuberculosis*. Similarly, Bisping andAmtsberg (1988) and Quin (1994)used nitrate reduction test to identify mycobacteria in culture colonies. Urease test has also been used in the identification of mycobacteria (Quin, 1994).

2.12. 5.2 Molecular techniques

Baker *et al*.(2006) used restriction endonuclease analysis (REA) to confirm human infections with *M bovis* in New Zealand and regarded these infectionsto be from animals to humans. Molecular methods like restriction fragment length polymorphism (RELP) have also been used in Argentina and Netherlands to diagnose TB in animals and humans (van Soolingen *et. al*., 1994). The use of various genetic markers in differentiation of *Mycobacterium bovis* strains from animals and humans and for studying epidemiology of bovine tuberculosis has been reported.

Collins *et al.* (1994)have reported that the conventional methods for the diagnosis and epidemiological studies of bovine tuberculosis and other mycobacterial diseases were far from beingideal and as such molecular biology has been shown to enable researchers to make substantial headway in arriving at definite diagnosis of mycobacterial infections.

A number of amplification-based techniques have been evolved to speed up and enhance the sensitivity of TB detection (Huggest *et al.*,2003). Thus,PCR can be used for any sample material in theory.However, it has some defects in that certain samples may contain PCR inhibitors, which may result in false negative amplicons that can quickly give rise to false positive.The PCR is also described as a method of diagnosis for making many copies of a specific DNA fragment (Saiki *et al*., 1988). Furthermore, PCR based – techniques are necessary for the accurate differentiation of mycobacterial species and molecular investigation of tuberculosis transmission (Warren *et al*., 2006). It is one of the most widely applied techniques in modern molecular biology that can be used in a wide variety of species(Innis *et al*., 1999).The MTC is characterized by 99.9% or greater similarity at the nucleotide level and by identical 165 RNA sequences (Sreavatsan *et al*., 1997; Broseh *et al*., 2002; Huard *et al*., 2006).

Deletions in *M.bovis* by comparison with the sequenced chromosome of *M. tuberculosis* wereidentified and that *M. bovis* would definitely be the terminal group in the lineage (Broseh *et al;* 2002).

The specificity and sensitivity values of PCR based assays vary with regard to the method, type of specimen and smear positivity or negativity (Woods*et al*;1990; Singh *et al*; 2002). But the nucleic acid based tests depend on amplification of specific nucleic acid sequences of mycobacteria which give quick diagnosis (Kiraz *et al*; 2010). Most of the techniques used for molecular TB detection are on the PCR basis because it is quick and easy to use. However, sensitivity can be affected by the presence of inhibitors that can lead to false negative results. This is prevented by improvement of extraction protocol,and controlled by using positive samples to determine assay accuracy. Laboratory practice is equally important because the various assays have been shown to be less variable than the laboratories performing them

(Noordhock *et al*; 1996). The molecular amplification methods are very powerful and enable for the detection of numbers of DNA targets and any slight contamination can lead to false positive, but when a strict four wom strategy with one direction work flow contamination is minimized (McHugh., 2000).

A nested PCR (N-PCR) assay was developed by Mishra *et al.*(2005) that replaced the PCR-RFLP assay for direct detection of *M. tuberculosis* and *M. bovis* in bovine samples. The N-PCR products of *M. tuberculosis* and *M. bovis* corresponded to 116 and 89 bp, respectively. The detection limit of mycobacterial DNA by N-PCR was 50 fg, equivalent to five tubercle bacilliand that *M. tuberculosis* and/or *M. bovis* were detected in 55.5% (105/189) of the samples by N-PCR, compared to 9.4% (18/189) by culture. The sensitivities of N-PCR and culture were 97.3% and 29.7%, respectively, and their specificities were 22.2 and 77.7%, respectively

2.12.5.3 *Serological Tests*

Nash and Donglass (1980) have reported the participation of humoral immunity in tuberculosis as they found a rise in the levels of immunoglobulin IgG and to a lesser extent IgA in tuberculous individuals.Similarly, some scholars have explored the use of serological methods in the diagnosis of tuberculous infection *(Daniel et al*., 1985).Therefore, in developing countries, serological tests, which are based on the detection of humeral immune response may be of importance use.However, there does not seem to be any serological test that is accurate for use in the diagnosis of TB today due to high variable antibody response between individuals to mycobacterial antigens and antigenic variation between mycobacterial strains (Pheiffer *et al.*, 2005).However, a lateral flow test which was recently developed and that can detect more than one antigen has given satisfactory results for tuberculosis diagnosis in certain animal species such as elephants(Iyaschckenk *et al*; 2008). *It*has also been associated that the change from

cellular to antibody response with advanced disease stage (Welsh *et al*., 2005). After an infection, the animal would elicit a cell mediated response which can progressively be replaced with antibody response (Pallock and Neill, 2002; Welsh *et al*., 2005; de la Rau-Domenech *et al.*,2006). Recently, the serological tests in use involve immunochromatography,lateral flow test (Lyashcenko *et al*., 2008). Fluorescence polarization assays (FPA) (Jollye *et al*., 2007),single antigen chemiluminescence (Green *et al*., 2009), multiplex chemilunescence immunoassays (Whelan *et al*; 2008) and multiantigen print immunoassay (MAPIA) (Waters *et al*., 2008).

2.12.6 Diagnostic Imaging

This is mostly useful in the diagnosis of human TB. However, Pavlik et al. *(2008)* used latero-lateral radiogram of the chest of a mare suspected with tuberculosis and found nodular interstial and alveolar pattern in the chest which they later diagnosed as tuberculosis due to *M avium* following further laboratory investigations.

2.13 Treatment and Control

2.13.1 Treatment in Animals

Tuberculosis is a reportable disease in many countries and,where this is the case, control is the subject of statutoryregulation, with culling of infected animals. Treatment ofinfected animals is therefore not usually attempted,although there are some reports of anti-Tb drugs beingused in captive wild animals (Thoen *et al*., 2009).After the diagnosis of TBin two bactrian camels kept in a zoo, prophylactictreatment of the remaining 17 camels was attempted usingisoniazid

incorporated into pelleted feed at a dose of2.4 mg/kg, fed *ad libitum* (Bush*et al*., 1990).However, possibly due toisoniazid toxicity, 7 camels died, exhibiting signs ofbone marrow suppression.

2.13.2 Treatment in Man

Treatment in humans has been said to take six to nine months. Drug resistance development has also been reported as the waxy coat of the bacteria has been reported to support the organism in resisting the medication (Holt, 2015).

Both *M.bovis* and *M. tuberculosis* have similarity in their sensitivity to antibiotics, but the standard treatment for *M. tuberculosis* for antibiotic sensitive isolates is a period of 2 months treatment with isoniazid (H), rifampicin®, ethambutol (E), and pyrazinamide(Z) followed with isoniazid and rifampicin for 4 months while*M. bovis* is sensitive to all the drugs except pyrazinamide (Daly *et al*., 2006).However, wild type of *M. bovis* is sensitive to all antibiotics including others such as streptomycin, ofloxacin, ethionamide and ethambutol, if antibiotic resistance has not been developed (Parreiras *et al*., 2004; Romero *et al*., 2007).

2.13.3 Control in Animals

Introduction of pasturalization of milk in the 1930s for the sole purpose of prolonging the shelf life of milk resulted in the full control of the transmission of bovine disease in humans (Davies, 2006). He further reported that between 1931 and 1937 human deaths reduced from 6.1% to 5.6% of the total deaths due to the disease, bovine TB in humans.The issue of control is between cost of eradication and the safety of populations at risk (Davies, 2006). The problem is more in the developing world where thereis neither scheme for compensation nor Government policies

for eradication. This poses a threat as it is feared that bTBis on the increase in Africa (http:/www.who.int/tb/en, Accessed April, 2006).

National control programmes are often based on intradermal tuberculin testing, but because of the limitations of this test in camelids, these programmes are unlikely to be successful.However, a combination of antemortem assays could improve the sensitivity of herd testing. Control depends on the removal of infected animals and prevention of further introduction of infection into the herd, but the disease will not be eradicated until infection is controlled in reservoir hosts, such as in wildlife (Thoen *et al*., 2006). Vaccines are not yet available for camelids*(Bush et al., 1990).*Treatment has been done in certain animal species in captivity, but it may be difficult for a herd or free ranging livestock(Michel; *et al*; 2010).

Control of bovine TB in developing countries can be said to be near impossible as there are many factors that have to be met (Cosivi *et. al*., 1998*;* Ayele *et al*., 2004). Control of bTB in developing countries is challenging particularly due to the financial burden and other logistics. For example, Tsechopp *et al.* (2012) showed that though bTB caused substantial financial losses to the Ethiopian economy, it remained not cost-effective to run a nation-wide test and slaughter programme due to the high number of cattle in the country, particularly if one considered the amount required for compensation that would have to be borne by the Government. They therefore suggested that an integrated approach where by inter-sectoral collaboration between the human and animal health sectors with government and non-governmental institutions as well as farmers/farmers cooperatives should be used in the control of the disease (Tsochopp *et al*., 2015).

Other methods of control and prevention of bTB include movement control/restriction, test and slaughter, pre-movement testing, abattoir surveillance, promotion of milk pasturalization by dairy cooperatives and they should be pursued (Tsochopp *et al*., 2015). There should also be a good knowledge of the disease in any given area before any meaningful development ofpreventive and/or control measures of the disease bTB in that area can be pursued(Prillutski, 2010).Control of TB in humans should be directed at proper meat inspection and strategies to prevent the consumption of contaminated meat and milk products *(Ibrahim, 2016).*

Denmark was the first to use tuberculin test in 1892 in the disease control programme. In Germany, the tuberculin test programme was considered to be economically non- feasible and by 1912 it introduced a programme called Ostertag's Eradication Scheme by using the method of detecting animals with open lesions on voluntary basis. The scheme was stopped in 1939 as it was discovered that reactor rates were greater in herds which participated in the programme. Tuberculin test to identify infected cattle was introduced in 1952 in West Germany as a compulsory tuberculosis control programme. The population of tuberculosis free herds moved from 9.9% in 1952 to 99.7% in 1961 (Grange,1988).

Schlisser (1982) pointed out that the main factors for persistent reactor rates in cattle at a lower level was a result of international trade of animals, their products and transmission from mycobacterium infected humans and the epidemiological variations between tuberculosis in humans and domestic animals.

Despite the actual eradication of bovine tuberculosis, infection in cattle in the South East England region was proven to be about 10% bacteriologically and the infection was caused by the bovine tubercle bacilli. In Germany, between 1954 and 1957 in areas with high cattle reactors, up to 2.7% tuberculosis infections in humans were caused by bTB whereas in areas

with low cattle tuberculosis, cases were linked to infection with *Mycobacteriumbovis* (Schlisser, 1982).

The complete eradication of bTB has not been achieved in any country of the world, but a virtual eradication with minor recrudescence can be said to be attained (Blood and Radostits, 1989) *Mycobacterium bovis* has the a widest range of hosts of all mycobacteria that makes it to have complex epidemiology which is complicating control methods (Collins and Grange, 1987).

The test and slaughter policy is the basis for international bovine tuberculosis control and eradication programmes using tuberculin skin test (TST) to detect affected herds periodically and remove reacting cattle that may disseminate the infective organism (Ladbert *et al*., 2005; Abernetty *et al*.,2006; Good, 2006;Awah-Ndukum, 2012).

As TB eradication progressed it became apparent that area testing was becoming inefficient as a method to locate diseased animals. In 1959, the emphasis was therefore switched from testing to the tracing of animals with lesions found by meat inspectors at slaughter. An epidemiological investigation team would locate the herd of origin for the animal with the lesion(s)and any other herds that might have been exposed to this animal. The epidemiological investigation of animals found infected at slaughter is still the main method that is used to locate tuberculosis (www.michigan.gov).Substantial progress has been made in the efforts to eradicate bovine tuberculosis in the USA.However, in December, 1990, Canada banned the importation of cervid speciesfrom the U.S A following the discovery of tuberculosis in an elk exported from the U.S A to Canada (Collen, 1998).

However, some factors such as the ubiquitous nature of mycobacteria, could hinder total eradication of the disease (Horsburgh *et al*., 1985). The mode of transmission of the disease

between man and animals along with the wide range of reservoir hosts and progressive nature in some animals may also make eradication difficult (Alhaji, 1976; Collins and Grange, 1983).

Bovine tuberculosis is shown to be potentially important mostly in developing countries all over the Globe. But, only relatively few countries in Africa have introduced effective control or eradication programmes (Chilland, 1992).This can be due to other factors such as politico-economic reasons that militate against suitable testingprogrammes coupled with social unrest due to political instability and ethnic wars (Chilland, 1992).Other factors include the relative ability of the organisms to withstand the action of phagocytic cells of the infected host, and their resistance to changes in pH (Draper, 1981; Brook *et al*., 1984). There is also often lack of veterinary expertise and communication networks and insufficient collaborative operations with neighboring countries. This translates to lack of effective quarantine, and associated smuggling of live animals across state boundaries (Ayele *et al*., 2004). Control and eradication programmes for bovine tuberculosis caused by *M. bovis*are based on early accurate detection and removal of infected animals (Pavlik, 2006). Despite the fact that animal test and slaughter schemes have succeeded in reducing the prevalence of bovine tuberculosis in majority of developed countries, such expensive control programmes have been increasingly questioned due to their economic burden and increasing resistance by farmers (Benneth, 2009; Torgerson and Togerson, 2007). In many developed nations there is effective mandatory reporting of *M. bovis* infection of all animals, quarantine of infected herds, tracing and retesting of contact animals with bovine tuberculin skin test positive reactors, restrictions of movement of cattle herds not yet tested for bovine tuberculosis and control of movement of animals out of the known TB infected herds and endemic areas (Citron, 1988; Gilbert *et al*., 2005; Abernethy *et al*., 2006; Good, 2006; Pavlik, 2006; OIE, 2009).

In underdeveloped countries such as Algeria, Burkina Faso, Cameroon, Namibia and South Africa among other 48countries in Africa that have applied a test and slaughter policy as a control strategy considered bovine tuberculosis as a reportable disease (Cosivi *et al*., 1998).This policy has successfully reduced the prevalence of bTB in these countries (Michel *et al*., 2009).The control strategy of bTB in Nigeria is regulated by the Federal Ministry of Agriculture with the control policy as stated in the Animal Disease (Control) Decree of 1988 being inadequately implemented in recent years. This could not be unconnected to politico-economic reasons and expensive costs of sustaining testing and slaughter, and the subsequent compensation to the farmers (Abubakar *et al*., 2011).In recent, the test and segregation control strategy, a modified form of the test and slaughter policy, has been advocated and may be more useful for developing countries, where the test and slaughter policy cannot be practicable for the cattle population (WHO, 1994).Therefore, interim measures to segregate herds and phase slaughter of reactors are done (Awah-Nduleum, 2012).

The development of TB vaccines for wildlife reservoirs and use in conditions where the test-and-slaughter policy is totally impracticable may be the way out for many underdeveloped countries (WHO, 1994). This may be in addition to the pasteurization of milk and milk products as components of bTB eradication schemes (WHO, 1994;Ayele*et al*., 2004). The combination of vaccination and culling of infected animals is a more attractive management option, However, vaccination against bTB or improvement in tuberculosis testing techniques will have no effect on wildlife tuberculosis prevalence (Kao *et al*., 1997) while BCG and recent TB vaccines give little or no protection against pulmonary tuberculosis in cattle and humans (Collins and Grange, 1983;Hogartha *et al*., 2005).However, vaccination could potentially control bovine tuberculosis (Cross and Gartz, 2006).

2.13.4 Control in Man

Control of TB in humans rests solely in the prevention of the disease in infants through vaccination (Lawn and Zumlo, 2011). The current vaccine in use in humans is the Bacillus Chalmette-Guerin (BCG) and has been shown to reduce the risk of children coming down with infection with the disease by 60% (McShare, 2011;Roy *et. al*., 2014). The immunity BCG induces has been shown to reduce the incidence of the disease over a ten year period (Lawn and Zumlo, 2011).

Control of the disease in adults is directed at ensuring consumption of only pasteurized milk and properly cooked meat.

2.14 Economic and Public Health Importance

2.14.1 Economic Importance

The costs of bTB in cattle have been rising steeply as more cattle herds were seen to come down with the disease (Ibrahim, 2016). Not only that, tuberculosis is the second most important cause of death in humans next to HIV/AIDs (Dolin *et al*., 2010).Mycobacterial infections are diseases of significant concern to the human population more importantly based on the direct and indirect devastating effects on livestock population and health hazard to human population directly (Alhaji, 1989).Economically,colossalamounts of money have been and are still being spent for the purchase of medicines for treating human cases and for compensation of slaughtered tuberculous animals (WHO,2002).There are losses due to condemnation of carcasses and milk,

neonatal deaths, decrease in milk production, infertility, poor condition resulting in low market value and effects on herd improvement programmes(Alhaji 1976; Eid, 1976).

Mycobacteriahave been associated with mastitis in cattle resulting in low milk yield and it servesas a possible source of infection to human, particularly children (Collins and Grange, 1983). The relative high frequency with which mycobacteria are isolated from market milk samples thereby rendering such productsunfit for human consumption is of economic importance(Shehu, 1988). Bovine tuberculosis as an important disease of cattle and humans has been controlled in many developed countries.However, for developing countries it is not yet controlled simply because of the amount of funds required which these countries can just not afford (Amanfu, 2006). The disease is significant not only because of its devastating economic effects on livestock production, but also for its public health and production implications (Radostits et al., 2007).

2.14.2 Public Health Importance

The WHO declared human TB (TBH) to be a global health remergency in 1993 and in 2006 the Stop TB Partnership developed a Global Plan to stop Tuberculosis with the sole aim of saving 14 million lives between its launch and 2015 (WHO, 2011).

Mycobacterium bovis infection in humans (zoonosis)cannot be differentiated from tuberculosis caused by *M. tuberculosis* in humans clinically and pathologically (Wedlock *et al*., 2002). The location of the lesions in animals depends on the route of infection and also on subsequent spread of *M. bovis* to other organs, whereas transmission of tuberculosis from cattle to humanstakes place via the consumption of unpasteurized milk, milk products and close contact with infected animals (Michel *et al*., 2010).In the first half of the 20th century, bovine tuberculosis was

considered to be one of the largest veterinary public health problems in central Europe (Michel et al, 2010). About 90% of cattle in Germany were infected with bTB before introduction of eradication scheme (Meissner,1974). The easy detection of "TB grapes" in slaughter lesions on pleura or mesentery were considered to be harmful to human and later linked to a living infectious agent, "ContagiumVivum", transmitted from humans to cattle *(Orland, 2003).* Majority of human tuberculosis cases were believed to be caused by *M. bovis* particularly in children and cattle herdsmen in rural areas (Schmiede, 1968). The eradication of bTB and its zoonotic effects in developed countries was achieved by the use of mandated tuberculin test of livestock and subsequent removal of positive reactors and compulsory pasteurization of milk (Michel *et al*., 2010).

Similarly, it has been reported that up to 700 new human cases in Latin Americaoccurred every year (Dekantor and Ritacco, 2006).Most cases in the UK were considered to be reactivation of latent infections contracted before 1960 or infections contacted outside the UK (Jalava*et al*., 2007) whereas the Centre for Disease Control (CDC) in the U.S.A reported 165 cases of human bTB out of 11860 case studies that were mostly linked to consumption of unpasteurized or unregulated dairy products in foreign born persons(Moonan *et al*., 2009).

In developing countries, the transmission of *M. bovis* to humans is still unchanged due topovertyand HIV/AIDS among others. Not only that, there are scarce health care programmes which exposed human populationstogreater and increasing risk (Ayele *et al*., 2004; WHO, 2009). According to the WHO report in 1998, 31% of human TB cases worldwide were attributed to *M. bovis* and that 0.4 – 10% of sputum isolates from patients in African countries could be due to *M. bovis*. This is because of the fact that *M. bovis* is mostly associated with extra pulmonary disease in humans (Cosivi *et al*., 1998). However, the exact percentage of *M. bovis* in human TB cases is

mostly difficult to confirm, because the general "TB" diagnosis is done based on sputum smears only (Thoen*et al*., 2006).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

Katsina State, with its capital at Katsina, is one of the states in the North West geopolitical zone of Nigeria and has 34 Local Government Areas (Katsina, 2007).The State is divided into three Senatorial districts (Fig 1). It is located between latitudes $11^{o}8$ and $13^{o}22$ North and longitudes $6^{o}22$ East and $9^{o}2$ East. The State is bordered by Niger Republic to the North, Sokoto and Zamfara States to the West, Kano State to the South West, Jigawa State to the North East and Kaduna State to the South (NPC, 2006).The human population in Katsina State is 5,801,584 while the cattle population is 1,109,729 and this accounts for 6.94% of the total population of the cattle in Nigeria (PACE, 2003; NPC, 2006). The pastoralists' population in the state is 50,000 (NPC, 2006). Majority of the people in the State depend on Agriculture producing subsistence and cash crops like sorghum, millet, cowpea and groundnuts. The State provides hides and skins among other livestock products and by-products. The people of the State are predominantly Hausa and Fulani ethnic groups. It is common to find all types of livestock in every LGA of the State with cattle holdings being mainly in the hands of the pastoralists while small ruminants, even though also found in pastoralists herds, being mainly in communities at the rural and peri-urban areas of the State (It is also common to find work-bulls in homes, especially in rural areas of the State.The people in the State have delicacy for "Fura da Nono" which is formed by mixing millet powder with sour unpasteurized milk as their afternoon meals.

The State has two seasons with the dry season being from September to May while the rainy season comes between May and August each year. The State enjoys an average annual rain fall of 32 inches and enjoys a temperature range of $15^{o}C$ to $40^{o}C$ from January to May and relative

humidity of between 10% around February and 80% by September each year (Katsina,2007).The State has Department of Veterinary Services in the Katsina State Ministry of Agriculture and Natural Resources, seven Zonal Veterinary Offices at Katsina,Daura,Funtua, Kankia,Mani, Malumfashi and Dutsamma. There is aVeterinary Clinic in each of these Zonal Offices. There is also aVeterinary Diagnostic Laboratory at each of Katsina,Dauraand Funtua Zonal Veterinary Offices. There is similarly aVeterinary Border Control Post at each of Jibia, Dankama, Maiadua and Kwangwalan.

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A B

Fig 1: Map of Nigeria showing Katsina State (A) and Map of Katsina State showing the three Senatorial Districts with the study areas (B)

Source: Google Map/http:/www.bing.com/images/search dated 24th February, 2016

3.2 Study Design

The study was a cross–sectional survey carried out among pastoralists and community members in the 3 Senatorial zones of Katsina State between January and September 2016. An inclusion criterion was used to involve only pastoral cattle herd owners and communities domiciled in the areas where these pastoral cattle were found in the State during the survey period while exclusion criterion was pastoral cattle herders less than 15years of age.

The study was designed to collect data using a questionnaire that was served to the respondents.

For the purpose of the study two Local Government Areas (LGAs) were randomly selected without replacement from each of the three Senatorial districts of the State.Similarly, two wards were randomly selected from each LGA selected for the study. The respondentswere selected from the wards based on convenience and agreement by the respondents to participate in the study. As much as possible, respondents were sourced through Fulani Ardoen and village heads so that maximum cooperation and results were obtained.

3.3 Sample Size Determination

Sample size was determined by taking 1% of the total population of the pastoralists in the State. From the Population Census figures (NPC, 2006) the population of pastoralists was 50,000. Thus, the sample size would be 500.However,the sample size was increased to 600 to increase precision.

The sample size was divided into the three Senatorial districts such that each ward would have 50 respondents (Questionnaires). The respondents were divided intoa ratio of 3:2 such that 30 respondents in each ward were pastoralists while the remaining 20 were community members.

3.4 Sample Collection

Data for the determination of the knowledge, attitudes and practices along with epidemiological factors of pastoralists and rural communities with regard to bovine tuberculosis were generated through the preparation and administration of questionnaires. Aspects of the questionnaires consisted of the respondents'biodata, their husbandry and livestock management practices with regard to tuberculosis. The epidemiological factors for the transmission and spread of tuberculosis among livestock and humans were determined through their responses on their attitude and practices. The questionnaire was prepared as close ended questions so that categorical answers were generated to allow easy presentation and analysis of the data. Since majority of the respondents did not understand English language, Hausa which is the local language that is well understood by all was used during the interview but responses were translated to English before recording.

3.5 Data Analysis

All data collected during the study were presented into tables. Similarly, they were statistically analyzed using multivariate analysis to determine the level of significance and association of age, sex, and respondent roles in the families as well as in the communities where the samples were collected. The results were transferred onto Microsoft spread sheet. They were analyzed using SPSS version 20, (IBM, USA 2011) statistical package using descriptive statistics. Chi-square was used to test for significance between categorical variables. A P–value of (≤ 0.05) was considered statistical significant for all the data where applicable.

CHAPTER FOUR

`4.0 RESULTS

4.1 Respondents' Location and Educational Levels

One hundred respondents each from Kankara, Bindawa, Mashi, Kaita and Batagarawa LGAs and 92 from Kafur LGA participated in the study. Similarly, 414 (69.93%) of them were in 'Ruga' settlements while 178 (30.06%) were in village settings (Table 4.1).The number of respondents in'Ruga' was statistically significantlyhigher than those in village setting ($\square^2$= 68.887; df = 5; p = 0.0001). Of the 592 respondents, 32 (5.40%) were of the age group of 15 to 30 years old while 227 (38.34%), 286 (48.31%) and 52 (8.78%) were of the age groups of 31 to 46, 47 to 60 and above 60 years of age respectively(Table 4.2)..Based on age, respondents in the age group 47 to 60 years old were highest and this is significant ($\square^2$= 1.224 df 10, P value = 0.000). Furthermore, 404 (68.24%) of the respondents had primary education while 162 (27.36%) and 24 (4.05%) had secondary and post-secondary education respectively (Table 4.2). The respondents with Primary education were significantly greater than those with other qualifications and this is statistically significant ($\square^2$ = 14.432, df 6, P value = 0.032).

Table 4.1 Respondents' locations in selected Local Gover5nment Areas of Katina State, Nigeria

LGA	Number of Respondents	Location	
		'Ruga'	Village
Kankara	100	87	13
Bindawa	100	50	50
Kafur	92	81	11
Mashi	100	64	36
Kaita	100	80	20
Batagarawa	100	52	48
Total	**592**	**414 (69.93%)**	**178 (30.06%)**

$\square^2 = 68.887$; df = 5; p = 0.0001

Table 4.2: Respondents' age and educational levels in selected Local Government Areas of Katina State, Nigeria

LGA	Number of respondents	Age				Educational Level		
		15-30 years old	31-46 years old	47 – 60 years old	>60 years old	Primary	Secondary	Post Secondary
Kankara	100	8	47	33	12	87	12	1
Bindawa	100	1	26	68	5	67	29	4
Kafur	92	0	30	50	12	66	23	3
Mashi	100	12	35	50	3	70	24	6
Kaita	100	5	25	55	15	49	42	9
Batagarawa	100	6	64	30	0	65	32	3
Total	**592**	**32 (5.40%)**	**227 (38.34%)**	**286 (48.31%)**	**47 (7.93%)**	**404 (68.24%)**	**162 (27.36%)**	**26 (4.39%)**
Chi-square	**51.224**					**14.060**		
df	**10**					**6**		
P-value	**0.000**					**0.029**		

4.2 Respondents' Knowledgeon Tuberculosis

4.2.1. Respondents' Knowledge on Animal Diseases

Of the592 respondents 510 (96.76%) reported that they knew five animal diseases while 9 (8.27%) and 24 (4.05%) of the respondents indicated knowing 10 and 15 animal diseases respectively. Also nine of them said they did not any animal disease specifically (Table 4.3). There is statistically significant difference in the number of diseases known by the respondents with those knowing only five diseases being greatest (X^2 =78.629; df = 10; P = 0.001).

Among the animal diseases, 259 (43.70%) respondents knew contagious bovine pleuropneumonia while 130 (21, 90%), 118 (19.90%), 52 (8.70%), 23 (3.80%) and 10 others knew fasciolosis, helminthosis, black leg,foot and mouth disease and no specific disease respectively (Table 4.3). There was statistical significant difference in the specific diseases the respondents could identify in favour of CBPP (X^2 = 92.348; df = 20; P =0.001). As to their sources of knowledge of these diseases, particularly bovine tuberculosis, 169 (28.50%) of the respondents indicated veterinarians while 40 (6.70%), 27 (4.56%), 20 (3.37%) and 185 (31.25%) others indicated hospitals, friends, fellow herdsmen and media respectivelyas their sources of knowledge on tuberculosis and other diseases (Table 4.4). their sources of knowledge on diseases are highly significant with the veterinary services and media taking significant roles (X^2 = 64.450; df 20; P = 0.0001). With regard to their knowledge of Tb, 423 (71.45%) of the respondents knew about Tb while the remaining 169 (28.50%) respondents did not indicate knowing about the disease andthis is highly significant (X^2 = 258.117; df =5; P = 0,0002). Furthermore, 442 (74.60%) respondents reported knowing about Tb treatment Centres while the remaining 150 (23.30%) of them did not know any Tb Treatment Centre and this is statistically

significant (X^2 = 2223.103; df = 5; P = 0.000). As of the duration of knowledge of Tb, 99 (18.41%) of the respondents indicated knowing the disease for the last 2 years while 203 (34.29%) of them reported knowing the disease for the last 5 years and this is highly significant (X^2 = 70.190; df 5; P = 0.000) (Table 4.4)

4.2.2 Respondents' Knowledge of Tuberculosis in Animals

Four hundred and fifty (76.01%) of the respondents indicated knowing cattle to come down with tuberculosis while 122 (20.60%) of them were not aware whether cattle could come down with the disease while the remaining 20 (3.34%) did not respond. The respondents' knowledge of the disease was statistically highly significant (X^2 = 103.882; df = 5; P = 0.0001) (Table 4.5). As to the signs of TB in cattle, 364 (61.48%), 112 (18.90%), 90 (16.80%) and 26 (4.39%) others reported signs of TB in cattle to be coughing, weight loss, death and others to be the signs of the disease in cattle respectively and this is highly statically significant (X^2 = 100.182; df = 15; P =0.001). On enquiring on the means of acquiring the disease by cattle, 90 (15.20%) of the respondents indicated ingestion as a means of acquiring the disease while 217 (36.60%), 213 (35.90%) and 62 (10.49%) others indicated drinking contaminated water, closeness to infected animals and infected humans respectively to be other means of acquiring infection by cattle and this is highly statistically significant (X^2 = 77.874; df = 15; P = 0.0001) (Table 4.5).

4.2.3 Respondents' Knowledge on Tuberculosis in Humans

With regard to their knowledge of how humans acquire infection with TB, 484 (81.70%) of the respondents agreed that humans could acquire Tb infection and that signs of the disease in man included coughing {281 (47.46%)}, weight loss {132 (22.29%)}, fever {102 (17.06%)}, and death {50 (8.45%)} (Table 4.6).The respondents' knowledge on the signs of the disease in man

is highly statistically significant (X^2 = 72.382; df = 15; P = 0.001) When asked of the means of acquiring Tb by man, 196 (33.10%) of the respondents indicated contaminated meat while 216 (36.48%) and 180 (30.40%) others respectively indicated contaminated milk and closeness with infected humans and their level of knowledge on these is statistically highly significant (X^2= 43.805; df = 10; P = 0.0001) (Table 4.6).

As to the disease being zoonotic, 472 (79.70%) of the respondents reported knowing that cattle could acquire the disease from man while 439 (74.15%) others reported man acquiring the disease from cattle and this knowledge is statistically highly significant (X^2 = 137.078; df = 5; P = 0.000) (Table 4.7). When asked if the respondents knew anybody with Tb, 91 (15.37%) of them said they knew while the remaining 501 (84.60%) respondents said they did not know anybody with Tb and this is statistically significant (X^2 = 14.947; df = 5; P =0.011) (Table 4.7). With regard to if they knew how the people acquired Tb, 43 (7.29%) of them said they knew while the remaining 549 (92.70%) said they did not know how the people acquired infection with Tb and this is also highly statistically significant (X^2 = 25.957; df = 5; P = 0.001). The responses as to whether their family members had Tb indicated that 5 (0.80%) had Tb in the family while the remaining 587 (99.15%) reported not having Tb in their families and this is not statistically significant (X^2 = 10.481; df = 5; P = 0.063) (Table 4.7).

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Table 4.3: Respondents' Knowledge on Animal Diseases in Selected Local Government Areas of Katina State, Nigeria

LGA	Number of respondents	No. animals diseases known				Names of diseases known					
		5	10	15	None	CBPP	Fasciolosis	Helminthosis	Black leg	Foot & Mouth Disease	None
Kankara	100	81	7	3	9	45	30	17	5	3	0
Bindawa	100	57	22	21	0	30	28	18	19	5	0
Kafur	92	92	0	0	0	40	10	14	15	3	10
Mashi	100	90	10	0	0	24	30	35	5	6	0
Kaita	100	90	10	0	0	58	10	20	8	4	0
Batagarawa	100	100	0	0	0	62	22	14	0	2	0
Total	**592**	**510 (86.14%)**	**49 (8.27%)**	**24 (4.05%)**	**9 (1.52%)9**	**259 (43.70%)**	**130 (21.90%)**	**118 (19.90%)**	**52 (8.70)**	**23 (3.80%)**	**10 (1.69%)**
Chi-square	**78.829**					**92.348**					
df	**10**					**20**					
p-value	**0.0001**					**0.001**					

Table 4.4: Respondents' awareness and sources of knowledge on tuberculosis and other diseases in selected Local Government Areas of Katsina State Nigeria

LGA	Number respondents	Knowledge of TB Treatment Centres		Knowledge of Tuberculosis		Source of Knowledge of TB					Duration of knowledge	
		Yes	No	Yes	No	Vet	Hospital friends	Friends	Fellow Herdsmen	Media	2 years	5 years
Kankara	100	14	86	59	41	10	8	2	5	34	34	12
Bindawa	100	54	46	78	22	35	5	8	2	28	15	35
Kafur	92	92	0	81	11	50	11	7	4	20	13	38
Mashi	100	100	0	93	7	46	2	5	7	40	1	66
Kaita	100	82	18	100	0	26	14	5	2	53	30	47
Batagarawa	100	100	0	12	88	2	0	0	0	10	6	5
Total	592	442 (74.60%)	150 (23.30%)	423 (71.45%)	169 (28.50%)	169 (28.50%)	40 (6.70%)	27 (4.56%)	20 (3.37%)	185 (31.25%)	99(18.41 %)	203 (34.29%)
Chi-square		223.103		258.117		64.450					70.190	
df		5		5		20					5	
p-value		0.000		0.0002		0.0001					0.000	

Table 4.5 respondents' knowledge of tuberculosis in animals in selected local government Areas of Katsina state Nigeria

LGA	Number respondents	Cattle acquire TB			Signs of tuberculosis in animals				Means of acquiring TB by cattle			
		Yes	No	No response	Coughing	Weight loss	Death	Others	Ingestion	drinking contaminated water	Closeness to other animals	From infected human
Kankara	100	34	46	20	46	23	18	13	4	45	50	1
Bindawa	100	86	14	0	50	35	12	3	16	40	38	6
Kafur	92	83	9	0	66	20	6	0	20	34	19	19
Mashi	100	64	36	0	67	20	13	10	8	36	46	10
Kaita	100	93	7	0	80	9	11	0	31	38	20	11
Batagarawa	100	90	10	0	55	15	30	0	21	24	40	15
Total	**592**	**450 (76.01%)**	**122 (20.60%)**	**20 (3.40%)**	**364 (61.48%)**	**122 (20.60%)**	**90 (15.20%)**	**26 (4.39%)**	**90 (16.80%)**	**217 (36.60%)**	**213 (35.90%)**	**62 (10.49%)**
Chi-square		**103.882**			**100.182**				**78.774**			
df		**5**			**15**				**15**			
p-value		**0.0001**			**0.001**				**0.0001**			

Table 4.6: Respondents' knowledge of tuberculosis in man in selected Local Government Areas of Katsina State Nigeria

LGA	No. of Respondents	Disease in Humans			Signs of Tuberculosis in man					Method of acquiring tuberculosis by man		
		Yes	No	No response	Coughing	Weight loss	Fever	Death	No response	Contaminated meat	Contaminated milk	Closeness with infected humans
Kankara	100	52	48	0	41	23	21	5	10	15	46	39
Bindawa	100	75	20	5	35	40	21	4	0	45	20	35
Kafur	92	68	24	0	44	29	20	9	0	33	26	33
Mashi	100	100	0	0	73	12	5	10	0	25	42	33
Kaita	100	96	4	0	38	15	15	12	20	40	42	18
Batagarawa	100	93	7	0	50	13	20	10	7	38	40	22
Total	**592**	**484 (81.70%)**	**108 (18.24%)**	**5 (0.86%)**	**281(47.46%)**	**132 (22.295%)**	**102 (17.06%)**	**50(8.45%)**	**37 (6.25%)**	**196 (33.10%)**	**216 (36.48%)**	**180 (30.40%)**
Chi-square		**112.282**			**72.382**					**43.805**		
df		**5**			**15**					**10**		
p-value		**0.000**			**0.001**					**0.0001**		

Table 4.7: Respondents' knowledge on tuberculosis being zoonotic in selected Local Government Areas of Katsina State,Nigeria

LGA	No. Respondents	Cattle acquiring TB from man		Humans acquiring TB from cattle		Knowledge of anybody with TB		Knowledge how he acquired TB		Member of Family with TB	
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Kankara	100	14	86	52	48	14	86	2	98	0	100
Bindawa	100	75	25	44	56	7	93	0	100	3	97
Kafur	92	76	16	90	2	16	76	5	87	0	92
Mashi	100	100	0	68	32	26	74	16	84	0	100
Kaita	100	84	16	92	8	13	87	10	90	2	98
Batagarawa	100	73	27	93	7	15	85	10	90	0	100
Total	**592**	**422 (71.45%)**	**170 (28.71%)**	**439 (74.15%)**	**153 (25.37%)**	**91 (15.37%)**	**501 (84.60%)**	**43 (7.29%)**	**549 (92.70%)**	**5 (0.80%)**	**587 (99.15%)**
Chi-square		**105.602**		**137.078**		**14.947**		**25.957**		**10.481**	
df		**5**		**5**		**5**		**5**		**5**	
p-value		**0.000**		**0.000**		**0.011**		**0.001**		**0.063**	

4.3. Respondents' AttitudeTowards Tuberculosis

4.3.1 Respondents' Eating and Drinking Habits

From the study, 482 (81.41%) of the respondents indicated eating roasted meat ('Suya') daily while 75 (12.66%) and 35(5.91%) of them indicated eating 'Suya' once a week and once a month respectively. Here, eating 'Suya' daily has the highest risk for people with that habit in possibly coming down with Tb should the animals be tuberculous (X^2 = 30.586; df = 4; P = 0.0001) (Table 4.8). Similarly, enquiry in the study showed that 25 (4.22%) of the respondents indicated staying with Tb patients while the remaining 567 (98.70%) said they were not staying with Tb patients and staying with Tb patients has slight statistical significance in acquiring Tb(X^2 = 11.317; df =- 5; P = 0.045).

With regard to drinking fermented milk ('Nono'), 520 (87.80%) respondents indicated they drank it daily while 50 (8.44%) and 22 (3.70%) reported taking 'Nono' only once a week andonce a month respectively (Table 4.9). Drinking 'Nono' daily was shown to be highly statistically significant for respondents coming down with Tb, should the 'Nono' be contaminated with tubercle bacilli (X^2 = 36.854; df = 8; P = 0.000). As for drinking milk directly from the udder of their cattle, 391 (66.04%) indicated doing so while the remaining 201 (33.70%) reported not doing so and drinking milk directly from the udder has high statistical significance in coming down with Tb should the animal be sheddingtubercle bacilli in the milk (X^2 = 42.335; df = 5; P = 0.001). When enquired on the effect of taking milk directly from the udder of their cattle, 208 (35.10%) reported that there was adverse effect in taking milk from the udder while 384 (64.80%) said there was no adverse effect at all and those that regarded no adverse effect had very high risk of coming down (X^2 = 168.564; df = 5; P = 0.0001) (Table

4.9).With regard to taking sheep and goats milk 180 (30.40%) respondents reported doing so while 412 (69.50%) others did not and that taking small ruminants milk is shown here to have significantly high risk (X^2 = 51.258; df = 5; P = 0.0001).

On further enquiry on milking and eating simultaneously, 115 (19.43 %) respondents reported they were in the habit of milking and eating simultaneously while 477 (80.57%) of them indicated not milking and eating simultaneously.The attitude of milking and eating simultaneously has significant possibility of leading to Tb (X^2 =45.358; df = 5; P = 0.2). When asked why they milked and ate simultaneously, those that were in this habit{62 (10.97%)} indicated that there was no adverse effect in doing so and that 59 (9.96%) of them said the milk was safe. The remaining 471 (80.91%) did not give any response on this. There is very high significant difference among the two groups (X^2= 45.528; df = 5; P = 0.0001) (Table 4.10). For those that were not in a habit of milking and eating simultaneously {240 (40.50%)}, they observed that this could result in diseases transmission while 263 (43.50%) of them observed that they would want to milk first before eating.The remaining 89 (15.03%) did not gie any response on this(Table 4.10). There is a very high statistically significant difference between them (X2 = 130.884; df = 5; P = 0.0001).

4.3.2 Respondents' Attitude towards Disease Control and Transmission

Four hundred and sixty eight (79.05%) of the respondents reported accepting childhood vaccination while 77(13.00%) of them indicated not vaccinating their children. The remaining 47 (7.95%) did not indicate their response on acceptance of childhood vaccination. There is a very high significant difference with regard to Tb from those that vaccinated and those that did not(X^2 =274.871; df = 5; P = 0.0001). Furthermore, 261 (44.08%) of the respondents reported

vaccinating their children against tuberculosis while 149 (25.16%), 96 (16.21%) and 56 (0.45%) of them reported vaccinating their children against polio, measles and small pox respectively. There is statistically significant in the acceptance of vaccination against routine diseases by the respondents (X^2 = 38.225; df = 15; P = 0.000)(Table 4.11).

With regard to control of tuberculosis in their herds, 322 (54.39%) said they reported such casesto Government Veterinarians while 138 (23.31%), 54 (9.12%), and 41 (6.92%) of the respondents reported either selling such infected animals, leaving them in the herd or doing nothing. The remaining 37 6.25%) of the respondents did not indicate doing anything.There is very high statistical difference among them (X^2= 332.025; df = 15; P = 0.0000) (Table 4.12).

Table 4.8 Eating habits of respondents in selected Local Government Areas of Katsina State

LGA	Number of Respondents	Frequency of eating 'Suya'			Staying with TB Patient	
		Daily	Once a week	Once a Month	Yes	No
Kankara	100	83	11	6	7	93
Bindawa	100	89	10	1	5	95
95Kafur	92	88	4	0	2	90
Mashi	100	16	10	3	8	92
Kaita	100	5	15	10	3	97
Batagarawa	100	60	25	15	0	100
Total	**592**	**482 (81.41%)**	**75 (12.66%)**	**35 (5.91%)**	**25 (4.22%)**	**567 (98.70%)**
Chi-square		**30.586**			**11.317**	
Df		**4**			**5**	
p-value		**0.0001**			**0.045**	

Table 4.9: Drinking habits of respondents in selected Local Government Areas of Katsina State

LGA	Number of Respondents	Frequency of drinking Nono			Drinking milk directly from cattle Udder		Effects of taking milk from animals		Drinking milk from Sheep and Goats	
		Daily	Once a week	Once a Month	Yes	No	Yes	No	Yes	No
Kankara	100	83	11	6	81	19	36	64	25	75
Bindawa	100	89	10	1	75	25	16	84	10	90
Kafur	92	88	4	0	50	42	83	9	30	62
Mashi	100	93	4	3	83	17	43	57	56	44
Kaita	100	74	16	10	52	48	20	80	28	72
Batagarawa	100	93	5	2	50	50	10	90	31	69
Total	**592**	**520 (87.83%)**	**50 (8.44%)**	**22 (3.72%)**	**391 (66.04%)**	**201 (33.70%)**	**208 (35.10%)**	**384 (64.80%)**	**180 (30.4%)**	**412 (69.50%)**
Chi-square		**36.854**			**42.335**		**179.064**		**51.258**	
df		**8**			**5**		**5**		**5**	
p-value		**0.000**			**0.001**		**0.0001**		**0.0001**	

Table 4.10: Respondents' eating and drinking Practices in relation to Tuberculosisin selected Local Government Areas of Katina State, Nigeria

LGA	Number Respondents	Milking and eating simultaneously		Reason for drinking while milking			Why no drinking while milking		
		Yes	No	No adverse effect	Milk is safe	No response	Fear disease transmission	Milking of cattle first	Milking of cattle first
Kankara	100	12	88	10	6	84	15	69	69
Bindawa	100	10	90	0	10	90	14	76	76
Kafur	92	20	72	11	9	72	51	21	21
Mashi	100	42	58	28	10	10	40	22	22
Kaita	100	20	80	10	10	10	30	50	50
Batagarawa	100	11	89	3	8	8	69	20	20
Total	**592**	**115 (19.42%)**	**477(80.50%)**	**62(10.97%)**	**53 (8.95%)**	**53 (8.95%)**	**219 (36.99%)**	**258 (43.58%)**	**258 (43.58%)**
Chi-square	**45.358**			**45.528**			**130.884**		
Df	**5**			**5**			**5**		
p-value	**0.0002**			**0.0001**			**0.0001**		

Table 4.11: Acceptance of childhood vaccination programmes in selected Local Government Areas of Katsina State, Nigeria

LGA	Number Respondents	Acceptance of Childhood vaccination			Vaccines Routinely taken			
		Yes	No	No response	BCG	Polio	Measles	Small pox
Kankara	100	95	5	0	43	27	18	12
Bindawa	100	87	13	0	30	20	40	10
Kafur	92	2	43	47	43	29	10	10
Mashi	100	100	0	0	45	38	10	7
Kaita	100	91	9	0	50	30	16	4
Batagarawa	100	93	7	0	50	15	22	13
Total	**592**	**515 (86.99%)**	**77 (13.00%)**	**47 (7.95%) (13.00%)**	**261 (44.08%)**	**159 (26.85%)**	**101 (17.06%)**	**56 (9.45%)**
Chi-square		**274.871**			**38.225**			
Df		**5**			**15**			
p-value		**0.0001**			**0.000**			

Table 4.12: Respondents' actions with regard to bovine tuberculosis in settled selected Local Government Areas of Katsina State, Nigeria

LGA	Number of Respondents	Action with cattle with TB				
Kankara	100	Report to Vet	Sell	Leave in herd	Do nothing	No response
Kankara	100	18	12	43	27	0
Bindawa	100	35	50	10	5	0
Kafur	92	48	4	1	0	37
Mashi	100	70	30	0	0	0
Kaita	100	61	32	0	7	0
Batagarawa	100	90	10	0	0	0
Total	**592**	**322 (54.39%)**	**175 (29.56%)**	**54 (9.12%)**	**41 (6.92%)**	**37 (6.25)**
Chi-square		**332.025**				
Df		**15**				
p-value		**0.0000**				

4.4. Respondents' Practices towards Tuberculosis

4.4.1 Respondents' Herding Practices

Three hundred and twenty three (54.56%) of the respondents reported managing their cattle under extensive system while 52 (8.70%) and 217 (36.60%) of them reported keeping their animals under intensive and semi-intensive management system respectively (Table 4.13).There is a very high statistically significant difference in the method of keeping these livestock by the respondents (X^2 =182.068; df = 10; P = 0.0000). Among the respondents, 116 (19.59%) grazed their herds within one kilometre of their 'Ruga' while 280 (47.29%) and 196 (33.10%) of them grazed their herds two kilometres and three kilometres away from their 'Ruga' respectively and there is a very high statistical significant difference in the distances they covered for grazing their livestock (X^2 = 78.533; df = 10; P = 0.0000) (Table 4. 14.). Similarly, 185 (31.25%) of them used community pond to water their animals while 59 (9.90%) and 347 (58.61%) of them used earth dams where other people also used to fetch water for their household use and where other cattle herds also used for watering respectively. There is a very high significant difference in the mode of watering their animals (X2= 149.853; df = 10; P = 0.0000).

4.4.2 Respondents' Housing Practices

Of the 592 respondents, 239 (40.37%) of the respondents reported that their rooms ('Buka') were 1 metre from the cattle kraal while 180 (30.40%) and 84 (14.18 and 89 (15.03%) of them indicated that theirrooms were 5 metres, and 10 metres away from their rooms (Table 4.15).

Table 4.13: Livestock management systems by respondents in selected Local Government Areas of Katsina State, Nigeria

LGA	Number of Respondents	Animal Management Practices		
		Extensive	Intensive	Semi-intensive
Kankara	100	78	3	19
Bindawa	100	66	9	25
Kafur	92	28	28	36
Mashi	100	22	6	72
Kaita	100	82	3	15
Batagarawa	100	47	3	50
Total	**592**	**323 (54.56%)**	**52 (8.70%)**	**217 (36.60%)**
Chi-square		**182.068**		
Df		**10**		
p-value		**0.0000**		

Table 4.14: Respondents' herding and grazing practices in selected Local Government Areas of Katsina State, Nigeria

LGA	No of respondents	Grazing distance from homestead ('Ruga')			Watering of Animals		
		1Km	2Km	3Km	Community pond	Earth dam where people fetch water	Facility where other cattle use
Kankara	100	18	36	46	44	9	47
Bindawa	100	4	20	76	38	34	28
Kafur	92	36	40	16	20	6	66
Mashi	100	9	83	8	28	0	72
Kaita	100	28	50	22	45	10	45
Batagarawa	100	21	51	28	11	0	89
Total	**592**	**116 (19.50%)**	**280 (47.29%)**	**196 (33.10%)**	**186 (31.59%)**	**59 (9.90%)**	**347(58.61%)**
Chi-square		**178.533**			**149.853**		
df		**10**			**10**		
p-value		**0.0000**			**0.0000**		

Table 4.15: Housing Management Practices by respondents in selected Local Government Areas of Katsina State, Nigeria

LGA	Number of Respondents	Distance of 'Buka' from Cattle Kraal			
		1 Metre	5 metre	10 Metre	>10 Metre
Kankara	100	40	30	12	18
Bindawa	100	15	50	25	10
Kafur	92	45	35	12	0
Mashi	100	29	30	15	26
Kaita	100	40	15	10	35
Batagarawa	100	70	20	10	0
Total	**592**	**239 (40.37%)**	**180 (30.40%)**	**84 (14.19%)**	**89 (15.03%)**

4.5 Epidemiological FactorstowardsTuberculosis

4.5.1 Respondents' Relations with other Herds

From the study, 432 (72.97%) of the respondents reported mixing their herds with others and that such mixing could be daily (44.50%), regularly (22.46%), and once a while (7.20%) while others (7.09%) reported not mixing their animals with other animals (Table 4.16). The remaining 12 (2.03%) respondents did not indicated mixing their herds or not with other herds. There is very high significant difference in the way they were mixing their herds with those mixing daily being greatest (X^2= 90.825; df = 15; P = 0.0000). Furthermore, mixing herds has very high risk of animals contracting diseases (X^2 =46.194; df =5; P = 0.0001). On further enquiry on their knowledge of the health status of the herds they were mixing with, 309 (52.19%) of the respondents indicated knowing the health status of such herds while 271 (45.70%) respondents indicated not knowing the health status of such herds they were mixing with. The remaining 12 (2.03%) respondents did not indicate anything of this enquiry.. There is a very high statistical difference in the knowledge exhibited by the respondents (X^2 = 98.228; df = 5; P = 0.0000). (Table 4.16). Furthermore, when asked if the animals in such herds were coughing, 171 (28.80%) of them said some of the animals in the herds they were mixing with were coughing while 409 (69.08%) said such herds they were mixing with were not coughing. The remaining respondents did not indicate their opinions on this enquiry. There is a very high statistically significant difference among them (X^2 = 57.628; df = 5; P =0.0001) (Table 4.16).

4.5.2 Respondents' Socialization Activities

Of the 592 respondents that participated in the study, 250 (42.22%) reported spending the evening with friends while 75 (12.66%), 31 (5.23%), and 235 (39.70%**)** reported spending the

evening with brothers, sisters and wives/husbands respectively (Table 4.17). There is a very high statistical significant difference in the ways the respondents spent the evening with people(X^2 = 149.405; df = 15; P = 0.0000). On enquiring further if any of the people they socialized with were coughing, 33 (5.50%) of the respondents indicated positively while the remaining 559 (94.46%) said noand this is highly significant (X^2= 33.586; df = 5; P = 0.0001).

Table 4.16: Respondents' herding practices in some selected Local Government Areas of Katsina State, Nigeria

LGA	Number Respondents	Mixing with other herds		Frequency of mixing with other herds					History of neighbouring herds No			Coughing animals in neighbouring herds		
	Number of respondents	Yes	No	Daily	Regularly	Once a while	Never	No response	Yes	No	No response	Yes	No	No response
Kankara	100	91	9	68	20	3	0	9	64	36	0	33	67	67
Bindawa	100	66	34	30	20	10	6	34	51	49	0	56	44	44
95Kafur	92	50	42	44	32	2	2	12	50	30	12	16	64	12
Mashi	100	84	16	43	20	16	5	16	84	16	0	30	70	0
Kaita	100	64	36	40	10	8	6	36	20	80	0	26	74	0
Batagarawa	100	77	23	39	31	7	23	0	40	60	0	10	90	0
Total	**592**	**432 (72.97%)**	**160 (27.02%)**	**264 (44.50%)**	**133 (22.46%)**	**46 (7.77%)**	**42 (7.09%)**	**107 (.18.07 %)**	**309 (52.19 %)**	**271 (45.20 %)**	**12 (.203%)**	**171 (28.80%)**	**409 (69.08%)**	**12 (2.03%)**
Chi-square		**46.194**		**90.825**					**98.228**			**57.628**		
df		**5**		**15**					**5**			**5**		
p-value		**0.0001**		**0.0000**					**0.0000**			**0.0001**		

Table 4.17: Respondents' socialization activities in selected Local Government Areas of Katsina State, Nigeria

LGA	No. Respondents	Socialization at night				Coughing by those socializing	
		With friends	With brothers	With sisters	With wife/husband	Yes	No
Kankara	100	71	13	6	10	7	93
Bindawa	100	66	20	2	12	16	84
Kafur	92	8	12	6	66	0	92
Mashi	100	31	13	5	50	0	100
Kaita	100	28	15	10	47	6	94
Batagarawa	100	46	2	2	50	4	96
Total	**592**	**250 (42.22%)**	**75 (12.60%)**	**31 (5.23%)**	**235 (39.60%)**	**33 (5.50%)**	**559 (94.46%)**
Chi-sqaure		**149.405**				**33.586**	
Df		**15**				**5**	
p-value		**0.0000**				**0.0001**	

CHAPTHER FIVE

5.0 DISCUSSION

From the study, many of the respondents had some form of educational background. Similar findings were made byDanbirni (2016) andIbrahim (2016) who reported many of the pastoralists having Islamic religious knowledge with few of them having western education. Their level of education could also be in line with Islamic injunctions regarding the management, treatment, prevention and control of animal diseases.

With regard to their knowledge on animal diseases, their use of radio even during grazing could expose them to livestock and general agricultural extension radio programmes regularly aired on the popular radio stations in Nigeria. It could also be through training on the job as Saidu *et al*. (1991) reported that pastoralists train their children on daily livestock handling rigors as they would one day take over the herding of the livestock. The regular gathering of pastoralists in informal meetings on market days for sharing information on livestock diseases and migration can also support this knowledge. The Livestock Rearers Workshops organized by the Department of Veterinary Surgery and Medicine of the Ahmadu Bello University, Zaria and such other workshops could also add value to their sources of knowledge on livestock production and diseases (Saidu *et al.*,1980; Saidu et al., 1986).It could similarly account for their knowledge on livestock diseases, their signs,and means of transmission and even on zoonotic diseases like brucellosis and tuberculosis (Kaltungo, 2013; Buhari, 2014; Baba, 2016).Their knowledge of fasciolosis, foot and mouth disease (FMD) and CBPP could be due to the endemicity of the diseases and their economic effects on livestock production caused by these diseases in addition to the reasons given above.

Over 70% of the respondents were aware of tuberculosis as a disease of both animals and man. This knowledge could be as stated above on their listening to radio programmes, especially that from the Federal Radio of Nigeria Kaduna that discusses on Human health, Environmental health and children killer diseases. Their knowledge on Tb Treatment Centres could be as a result of the fact that some of their family members were infected with Tb as they stated in the survey. The National Agricultural Extension Research Liaison Service electronic and print media releases could also account for their awareness on Tb and other diseases. For example,Extension Bulletin on Zoonotic diseases and their control number 54 written by Saidu (1991) and published by the National Agricultural Extension Research Liaison Service of the Ahmadu Bello University, Zaria can go a long way in enlightening the respondents among others.

Their knowledge of diseases could also be through their contact with butchers who normally buy cachectic animals from them and that such butchers could inform them of what they found in the lesions of slaughtered cattle. Their knowledge of the signs of the disease along with the route of infection in cattle could also be traced to the sources of their knowledge on diseases as earlier on stated above.

Their attitude of eating unwholesome 'Suya' and drinking fresh milk directly from the udder of cattle could expose them to the dangers of the disease, should the animals be infected with Tb, especiallyas they indicated that there was no harm in doingso. The same could be true for their exposure to soured milk ('Nono') through their consumption of Millet paste in 'Nono'.Similar findings were made by Danbirni (2016) and Ibrahim (2016) who also reported pastoralists and community members in the North East of Nigeria taking 'Nono' and millet paste and were able to demonstrate *M bovis*and *M tuberculosis*from the sputum of such pastoralists. It is therefore

possible to isolate the organism in these respondents, should their sputum and the fresh milk and even the soured milk betested for*Mycobacterium*spp.

The extensive management system as mostly practiced by most of the pastoralists has been abundantly shown to facilitate the spread of animal diseases as animals of unknown status could meet with susceptibleones (Kaltungo, 2013; Baba, 2016). Similarly, their sharing of watering points could result in the spread of Tb, especially that *Mycobacterium* spp has been shown to be released in faeces and urine of infected animals (Phillips *et al*., 2003).The practice of the respondents in socialization at night with friends and family members could be another avenue for the spread of communicable diseases like Tb, should any one of them be infected, especially that they indicated that some of such friends were coughing. It has been abundantly shown that tuberculosis could be transmitted through aerosols via inhalation when people are in close contact as occasioned by evening chats(Abdulkadir, 1989).

The practice of herdsmen to use communal grazing and watering points is capable of increasing chances of transmission and even spreading infections among livestock. For example Baba (2016) reported that horses grazing in the same communalgrazing areas were seen to have seroprevalence for brucellosis. Similarly, Kaltungo (2013 reported high seroprevalence of brucellosis in small ruminants which were in cattle herds that had hygroma due to brucellosis.

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CHAPTHER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

1. The study has shown that 76.10% and 81.70%..of the respondents were aware of tuberculosis in cattle and humans respectively and indicated the signs of the disease in cattle to be coughing(61.48%), weight loss (18.90%), and death (16.80%) among other signs while the signs and symptoms of the disease in humans to be coughing (47.46%), weight loss (22.29%), fever (18.50%) and death (8.78%).
2. The respondents indicated that the routes of transmission of the disease, tuberculosis, in animals to be ingestion (15.20%), drinking of contaminated water (36.60%), and closeness of susceptible animals with infected animals (35.90%) and with man (10.49%) while the routes of infection for humans to be consumption of contaminated meat (33.10%), drinking contaminated milk (36.48%) and closeness with infected humans (30.40%).
3. The respondents' eating (19.42%) while milking their cattle and not considering any adverse effect (10.97%) in doing so along with having evening socialization with friends and family members who could be suffering from tuberculosis could enhance the spread of the disease among animals and humans.
4. The respondents' drinking milk (66.04%) directly from the udder of their milking cows could result in them coming down with bovine tuberculosis should such cows be infected with *Mycobacterium* species.

6.2 Recomendations

Other areas for further study include:

1. The need to determine the prevalence of bovine Tb in cattle and humans in the study area in view of the closeness of people to livestock, especially cattle in the study areas;
2. The need to educate pastoralists and the general public in the study areas on the dangers of bovine Tb, especially with regard to the consumption of poorly cooked meat and unpasteurized milk that are common in the study areas;
3. There is the need to study the epidemiology of bovine tuberculosis more closely in the study areas in view of the economic and public health importance of the disease since it has the ability to spread and cause harm to both animals and humans..

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Appendix 1

DEPARTMENT OF VETERINARY MEDICINE

FACULTY OF VETERINARY MEDICINE

AHMADU BELLO UNIVERSITY, ZARIA

STRUCTURED QUESTIONAIRE FOR DETERMINATION OF PASTORALISTS AND RURAL COMMUNITIES PERCEPTION ON THE EPIDEMIOLOGIC FACTORS ASSOCIATED WITH BOVINE TUBERCULOSIS IN SELECTED LOCAL GOVERNMENT AREAS OF KATSINA STATE, NIGERIASECTION

A: RESPONDENT'S BIODATA

1. Location……WARD……
   …LGA……Date……..
2. Age(Years)……..Sex……
   …
3. Literacy Level: Post-Secondary/Secondary/Primary/Islamic Knowledge/Adult education
4. Occupation: Crop farming / Livestock keeping/Mixed farming/livestock trade
5. Number of persons in household:<5 /6-10 /11-15 / >15
6. Location of household: Ruga /Within community/town

SECTION B: ANIMAL HUSBANDRY PRACTICES

1. Animal keeping method: extensive/semi-intensive /intensive
2. Location of grazing area: country side/within village/community grazing area

3. Possibility of mixing with other herds: Yes/No

4. If No. 3 above is yes, how often: Daily/Regular/Once in a while/never

5. Knowledge of history of such other herds: Yes /No

6. Do animals in such herds cough? Yes/No

7. Distance of grazing area from homestead. 1km/2km/3km

8. Location of watering point: Community pond? Earth dam where people take water/where other cattle take water

9. Do you go on annual dry season grazing to other states? Yes/No

10. If above (no. 9) is yes, for how long: 1 month/2 months / 3 months

11. Do you go on alone or with other herds: alone/with others

12. Have you ever experienced coughing in the other herds? Yes/No

13. Have you ever experienced coughing in your herd subsequently? Yes /No

14. Did you ever find the cause of coughing in such herds? Yes/No

SECTION C: MANAGEMENT PRACTICES

1. What do youdo if your animals are sick? Report to Vet / sell /Treat traditionally
2. How do you know your animals are sick? Weight loss/ diarrhea/coughing/ sudden death
3. Do you have any animal with prolong cough? Yes /No
4. What do you do in such instances: call vet/ sell/ do nothing
5. Do you know the outcome of the cough if you sell the animal? Yes/No

6. If above is yes, what was the outcome? CBPP/TB
7. What did you do to the rest of the animals ?Nothing/ treatment / prevention
8. How many animal diseases do you know? 5/ 10 /15
9. List five most important cattle diseases you know:

   a)……..……..……b)……

   …c)……..…….d)…….

   …….e)…….…….

10. Do you vaccinate against cattle diseases? Yes/ No
11. Who vaccinate them for you? self/Government vet / private

SECTION D: KNOWLEDGE OF TUBERCULOSIS

1. Do you know Tuberculosis? Yes/ No
2. What is the source of your awareness? Vet/Hospital/friend/fellow livestock keepers /media
3. Since when have you known of tuberculosis? 2 years/ 5 years/ >5 years
4. Do animals acquire infection with tubercle bacilli? Yes/No
5. What are the signs of tuberculosis on animals? Coughing/weight loss/death

6. Howdo cattle acquire infection with tubercle bacilli? Ingestion/drinking contaminated water /closeness with infected animals /from infected humans

7. Do humans acquire infection with tubercle bacilli? Yes/No

8. If yes, what are the signs and symptoms of the disease in man/ Coughing/ Weight loss/fever/death?

9. How do humans acquire infection with tubercle? Eating contaminated meat/drinking

Contaminated milk/closeness to infected humans.

10. Can cattle acquire infection directly from man? Yes/no.

11. Can man acquire infection from animals directly? Yes/No

12. Do you know anybody with tuberculosis? Yes/No

13. Do you know how he acquired the disease? Yes/No

14. Did anybody in his family develop the disease later? Yes/No

SECTION E: ATTITUDE TOWARDS TUBERCULOSIS

1. Do you drink fresh milk directly from cattle? Yes/No
2. Does any member of your herd drink milk directly from the udder of your cattle? Yes/ No
3. Do you drink milk directly from sheep and goats? Yes/No
4. Do you think taking milk directly from animals has no bad effect? Yes/No
5. Is there any disease that can be acquired by drinking fresh milk from animals? Yes/No
6. How far is your Buka from the cattle overnight resting point? <5meters/5 meters/10 meters/>10 meters.
7. How often do you eat suya meat? Daily/once a week/ once a month
8. How often do you drink Nono? Daily/ once a week/ once a month
9. Do you stay with people known to have tuberculosis? Yes/No
10. Is there any Tuberculosis treatment center close to your village/Ruga? Yes/No

11. Have you ever visited such center? Yes/No
12. What is your experience in seeing people with tuberculosis?

SECTION F: PRACTICES WITH REGARD TO TUBERCULOSIS

1. Do you eat while milking your cattle? Yes/No
2. If yes, why? No effect/ milk is safe/ others (specify)
3. If no, why? Fear of transmission of diseases/ want to milk cattle fast
4. Do you or others in herd drink milk directly from the teat? Yes/No
5. Do you allow your children to receive childhood vaccination? Yes/No
6. Which of the vaccinations do they receive? BCG/Polio/Measles/Smallpox
7. If you find any of your cattle with Tuberculosis, what will you do? Report to Government vet/Sell/Leave in herd/ do nothing
8. At where do you spend the night rest? With friends in nearby Ruga/ With brothers/With sisters/ with wife (husband)
9. Do such people cough? Yes/No
10. How often do you put meat in your soup? Daily/once a week/ once a month
11. Do butchers in your area slaughter their cattle at designated Government approved points? Yes/No
12. Are there meat inspections in government approved points? Yes/No
13. Do butchers allow their animals to be condemned if infected? Yes/No