

**SEROPREVALENCE OF *MYCOBACTERIUM BOVIS* ANTIBODIES IN
CATTLE AND WILDLIFE CAPTURED IN YANKARI GAME RESERVE,
BAUCHI STATE, NIGERIA.**

BY

AMINU JOSEPH MAKERI

**DEPARTMENT OF VETERINARY MEDICINE, AHMADU BELLO UNIVERSITY,
ZARIA. NIGERIA.**

FEBRUARY, 2013.

**SEROPREVALENCE OF *MYCOBACTERIUM BOVIS* ANTIBODIES IN CATTLE AND
WILDLIFE CAPTURED IN YANKARI GAME RESERVE, BAUCHI STATE,
NIGERIA.**

BY

Aminu Joseph MAKERI (D.V.M. ABU., 1998)

(M.Sc/VET-MED/06488/2009-2010).

**DEPARTMENT OF VETERINARY MEDICINE,
AHMADU BELLO UNIVERSITY, ZARIA**

**A THESIS SUBMITTED TO SCHOOL OF POSTGRADUATE STUDIES, AHMADU
BELLO UNIVERSITY ZARIA NIGERIA IN PARTIAL FULFILLMENT FOR THE
AWARD OF THE DEGREE OF MASTER OF SCIENCE IN VETERINARY MEDICINE**

**DEPARTMENT OF VETERINARY MEDICINE,
FACULTY OF VETERINARY MEDICINE,
AHMADU BELLO UNIVERSITY ZARIA, NIGERIA**

FEBRUARY, 2013

DECLARATION

I declare that the work in this thesis entitled “**SEROPREVALENCE OF *M. BOVIS* ANTIBODIES IN CATTLE AND WILDLIFE CAPTURED IN YANKARI GAME RESERVE, BAUCHI STATE, NIGERIA**” has been performed by me in the Department of Veterinary Medicine, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria under the supervisions of Prof C. A. Kudi, Dr G. Mohammed, and Dr M. Bello. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree, diploma or certificate at any university.

Aminu Joseph MAKERI
Name of student

.....
Signature

.....
Date

CERTIFICATION

This Thesis entitled “**SEROPREVALENCE OF *M. BOVIS* ANTIBODIES IN CATTLE AND WILDLIFE CAPTURED IN YANKARI GAME RESERVE, BAUCHI STATE, NIGERIA**” by MAKERI, Aminu Joseph meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literary presentation.

Professor C. A. Kudi.
Chairman Supervisory Committee

.....
Signature

.....
Date

Dr G. Mohammed.
Member Supervisory Committee

.....
Signature

.....
Date

Dr M. Bello.
Member Supervisory Committee

.....
Signature

.....
Date

Professor A.K.B. Sackey.
Head of Department, Veterinary Medicine.
Ahmadu Bello University, Zaria.

.....
Signature

.....
Date

Professor A. A. Joshua
Dean School of Postgraduate Studies.
Ahmadu Bello University, Zaria.

.....
Signature

.....
Date

DEDICATION

This Thesis is dedicated to my late father Mr Joseph Makeri and my beloved mother Mrs. Esther Joseph Makeri for their support, encouragement and prayers.

ACKNOWLEDGEMENT

I thank almighty God for giving me the strength and good health to complete this work. My profound appreciation goes to my supervisors Professor C A Kudi, Dr G Mohammed, and Dr M Bello for their combined skills, commitment, accessibility, patience, critical review, fatherly advice and support throughout the period of this work.

I want to thank the Ministry of Agriculture Gombe State and Gombe State Government for releasing me to come for this study. I also appreciate the contribution of my brother Mr Joseph Oyamah. Thanks also go to my friends like Dr Turaki, Dr Leo, Dr Billy, Mr Gamba, Mathew Augustine, Amos Maigizoh Gideon Gamba, just to mention a few. It has been a good time being together. I also recognize the contribution of the Head of Department and staff of Veterinary Parasitology and Entomology, Ahmadu Bello University Zaria for allowing me to use their laboratory is highly appreciated. I am highly indebted to my good friend, Dr Atuman Joel for his assistance in collecting samples from wildlife.

I will want to express my deepest appreciation to Prof. Caleb Ayuba Kudi who is more of a father to me than a supervisor. Prof. Sir, how I wish everybody is like you, the world would have been a better place.

May I also use this medium to acknowledge the contribution of Dr Danladi Molta and Dr Hassan Kanti M. also my officer late Dr Edward Alison for his encouragement, may your gentle soul rest in peace. I also thank the staff of Area Vet Office Kaltungo for their encouragement also want to appreciate the chief and farmers in Dolli village in Akko LGA of Gombe State for allowing me to take samples from their cattle and to all my brothers and sister for their support.

ABSTRACT

The study was conducted with the aim of determining the prevalence of *M bovis* infection in cattle located in the periphery of the Yankari Game Reserve (YGR) and wildlife species in YGR, Bauchi State, Nigeria. The YGR is located in Alkaleri Local Government Area of the State. Twenty one cattle herds around the game reserve were identified and conveniently selected. The ages, sexes and breeds of the studied cattle were recorded. Blood samples were collected from each animal above six months of age in the selected herds. Such samples were also collected from darted wild life species during routine examinations and also from wild animals captured by hunters. Their species, sexes and estimated ages were determined at capture. Serum sample was obtained by centrifugation. The serum was analyzed using Rapid bovine TB antibodies test kits which is specific for *M bovis*. A total of 750 cattle and 250 wildlife were sampled. Of the 750 cattle sera tested 88 were positive for *M. bovis* antibodies representing 11.7%. Out of the 250 wildlife sera tested, 30 were positive for *M bovis* antibodies representing 12.0%. Of the 88 cattle that were positive for *M bovis* antibodies, 19 (11.5%) were males, while 69 (11.8%) were females. According to breed of cattle, 80 (11.4%), 5 (18.8%), and 3 (15.8%) were White Fulani, Sokoto Gudali and Red Bororo respectively were positive for *M bovis* antibodies. Amongst the age groups, 14 (11.8%) were in the age group of 6 months to 2 years, 45 (12.5%) between 2 and 5 years, while 29 (10.7%) were over 5 years of age. Of the 250 wildlife species tested 6 (19.35%) Zebras, 2 (10.0%) Elands, 3 (7.6%) Antelopes, 4 (10.0%) Baboons, 6 (15.0%) African Giant Rats, 3 (12.0%) Hares, and 6 (30.0%) Grass cutters were positive for *M bovis* antibodies. Based on the results obtained, no statistical differences ($P>0.05$) occurred in the rates of occurrence of *M bovis* antibodies between different, breeds sex and age groups of cattle examined. There was also no significant differences ($P>0.05$) in the overall rates of occurrence between the cattle

living at the periphery of the YGR and the wildlife species. The study has established the existence of *M bovis* antibodies in cattle living at the periphery of the Yankari Game Reserve and in wildlife species within the YGR, suggesting a possible transmission between cattle and wildlife species. Also the wildlife species could serve as reservoir of *M bovis* infection to cattle living at the periphery of the Game Reserve, and even to humans. To minimize encroachment of cattle into the Game Reserve watering points should be provided at the periphery of the Reserve. Likewise public awareness should be stressed on the public health implications of this finding to workers and other people including illegal hunters living at the periphery of the Game Reserve.

TABLE OF CONTENTS

Title Page	I
Declaration.....	II
Certification.....	III
Dedication.....	IV
Acknowledgement.....	V
Abstract.....	VI
Table of Content.....	VIII
List of Tables.....	XIII
List of Figures.....	XIV
List of Plates.....	XV
List of Abbreviations.....	XVI
CHAPTER ONE: INTRODUCTION.....	1
1.1. History of Bovine Tuberculosis.....	1
1.2. Statement of Research Problem.....	4
1.3. Justification.....	7
1.4. Aim of the Study.....	8
1.5. Objective of the Study.....	8
1.6. Research Question.....	8

CHAPTER TWO: LITERATURE REVIEW.....	9
1.1 Introduction.....	9
1.2 Epidemiology of <i>M. Bovis</i>	10
2.2.1. Aetiology of <i>M. bovis</i>	10
2.2.2. Survival of <i>M. bovis</i> in the environment	11
2.3. Transmission of <i>M. Bovis</i>	12
2.3.1. Wildlife to humans transmissions.....	15
2.3.2. Cattle to cattle transmissions.....	15
2.3.3. Cattle to wildlife transmissions.....	17
2.2.4. Wildlife to wildlife transmissions.....	17
2.4. Pathogenesis of <i>M. Bovis</i>	18
2.5. Clinical Signs.....	19
2.6. Diagnosis.....	20
2.6.1. Intradermal tuberculin skin test.....	20
2.6.2. Single cervical.....	20
2.6.3. Caudal fold.....	20
2.6.4. Comparative intradermal tuberculin test.....	21
2.6.5. Blood base laboratory test.....	22

2.6.6. Postmortem test.....	22
2.7. Prevention and control of <i>M. Bovis</i>	23
2.7.1. Postmortem.....	24
2.7.2. Vaccination.....	25
2.8. <i>M. Bovis</i> Infection in Goats and Sheep.....	25
2.9. <i>M. Bovis</i> Infection in Humans.....	26
2.10. Status of <i>M. Bovis</i> Infection in Africa.....	28
2.10.1. <i>M. bovis</i> infection in wildlife in Africa.....	29
2.10.2. <i>M. bovis</i> infection in domestic animals in Africa.....	30
2.10.3. <i>M. bovis</i> infection in humans in Africa.....	32
2.11. Status of <i>M. Bovis</i> Infection in Nigeria.....	33
2.11.1. <i>M bovis</i> infection in animals.....	33
2.11.2. <i>M bovis</i> infection in humans.....	35
2.12. Economic Importance of <i>M. Bovis</i>	36
2.13. Risk factors of <i>M. Bovis</i> Infection.....	36
2.13.1. Risk factors of <i>M bovis</i> infection in wildlife.....	36
2.13.2. Risk factors of <i>M bovis</i> infection in humans.....	37

2.14. Wildlife Reservoirs of <i>M. Bovis</i>	38
2.15. Factors Affecting <i>M. bovis</i> Control and Eradication in Wildlife.....	40
CHAPTER THREE: MATERIALS AND METHODS.....	42
3.1. The study Area.....	42
3.2. Sample Size Determination.....	47
3.3. Sampling Procedures.....	47
3.3.1. Blood samples collection from cattle.....	47
3.3.2. Blood Samples collection from wildlife.....	48
3.4. Sources of Testing Kits.....	48
3.5. Laboratory Analysis.....	49
3.5.1. Serum Analysis for bTB antibodies.....	49
3.5.2. Interpretations of the test results.....	49
3.5.2.1. Positive results.....	49
3.5.2.2. Negative results.....	49
3.6. Data Analysis.....	53
CHAPTER FOUR: RESULTS.....	54
4.1. Prevalence of <i>M. bovis</i> in Cattle and Wildlife.....	54

4.2. Prevalence of <i>M bovis</i> by Sex in Cattle.....	54
4.3. Prevalence of <i>M bovis</i> by Age in Cattle.....	54
4.4. Prevalence of <i>M bovis</i> by Breed in Cattle.....	55
4.5. Prevalence of <i>M bovis</i> in Wildlife Species.....	55
CHAPTER FIVE: DISCUSSIONS.....	61
CHAPTER SIX: SUMMARY, CONCLUSIONS, RECOMMENDATIONS AND LIMITATIONS.....	64
6.1. Summary.....	64
6.2. Conclusion.....	65
6.3. Recommendations.....	66
6.4. Limitation of the Study.....	66
References.....	68

LIST OF TABLES

Table:

4.1. Prevalence of <i>M bovis</i> in Cattle at the periphery and Wildlife located in YGR, Bauchi State	56
4.2. Prevalence of <i>M bovis</i> by sex in Cattle.....	57
4.3. Prevalence of <i>M bovis</i> by Age in Cattle.....	58
4.4. Prevalence of <i>M bovis</i> by Breed in Cattle.....	59
4.5. Prevalence of <i>M bovis</i> in Wildlife Species.....	60

LIST OF FIGURES

Figure:

- 4.1. Map of Bauchi State the location of Yankari Game Reserve.....44
- 4.2. Sketched map of Yankari Game Reserve showing the human settlement and major water streams.....45
- 4.3. Satellite map of Yankari Game Reserve showing boundaries and major roads46

LIST OF PLATES

Plate:

I. Test Procedures of Rapid Test Kits.....	50
II. Positive Results.....	51
III. Negative Results.....	52

LIST OF ABBREVIATIONS

<i>M. BOVIS</i>	Mycobacterium bovis
bTB	Bovine Tuberculosis
WHO	World Health Organization
OIE	Office International des Epizootics
HIV/ AIDS	Human Immune deficiency Virus/ Acquire Immune Deficiency Virus
TB	Tuberculosis
YGR	Yankari Game Reserve
BCG	Bacillus of Calmette and Guérine
USA	United States of America
UK	United Kingdom
Tb	Tuberculosis
DTH	Delayed-Type Hypersensitivity
PPD	Purified Protein Derivative
PPDB	Purified Protein Derivative Bovine
PPDA	Purified Protein Derivative Avian
BTB	Bovine Tuberculosis
df	Degree of freedom
CI	Confidence interval

CHAPTER ONE

INTRODUCTION

1.1. History of Bovine Tuberculosis

Bovine tuberculosis (bTB) caused by *Mycobacterium bovis* (*M. bovis*) is a chronic, infectious and contagious disease of livestock, wildlife and humans (O'Reilly and Daborn, 1995). The disease is an important public health concern worldwide, especially in developing countries, due to deficiencies in preventive and/or control measures (Etter *et al.*, 2006). The incidence of *M. bovis* in humans probably remains underestimated, as distinction between *M. bovis* and *M. tuberculosis*, is not systematically performed (Anonymous, 2006). Since the real incidence of *M. bovis* on human health is still unknown, it is essential to advance the eradication of bTB worldwide by means of adequate programmes, especially in developing countries (Grange, 2001). Genomic evidence showed that *M. bovis*, evolved from an ancestor shared with *Mycobacterium tuberculosis*, the cause of tuberculosis in humans. As a result of gene loss it changed its host specificity from human to cattle (Brosch *et al.*, 2002). This change in hosts from human to cattle appears to have broadened its effective capabilities, as it has one of the broadest host ranges of any known zoonotic pathogen (O'Reilly and Daborn, 1995). As a result a wide range of wildlife species and many domestic livestock species can be infected (de Lisle *et al.*, 2002). Members of the closely related phylogenetic grouping of *Mycobacterium* known collectively as the *M. tuberculosis* complex may cause tuberculosis in a range of species including man. Some members of this group are predominantly human (*M. tuberculosis*, *M. africanum*, *M. canetti*) or rodent pathogens (*M. microti*), whereas others have a wide host spectrum (*M. bovis*, *M. caprae*) (Broach *et al.*, 2002). The respiratory route is accepted as the primary method of infection spread in all species. However, it is clear that there are other less

common methods of spread such as oral, occupational, congenital and via wounds (Thoen *et al.*, 2006; Doran *et al.*, 2009). Tuberculosis has been present in humans since antiquity. The earliest unambiguous detection of *Mycobacterium tuberculosis* was in the remains of bison dated 18,000 years ago (Rothchild *et al.*, 2001). In the past, tuberculosis has been called consumption, because it seemed to consume people from within, with a bloody cough, fever, pallor and wasting. Other names included *phthisis* (Greek for consumption) and *phthisis pulmonalis*, scrofula (in adults), affecting the lymphatic system and resulting in swollen neck glands, *tabes mesenterica*, TB of the abdomen and *lupus vulgaris*, TB of the skin, wasting disease, white plague, because sufferers appear markedly pale; king's evil, because it was believed that a king's touch would heal scrofula; and Pott's disease, or gibbus of the spine and joints (Rudy, 2006). Miliary tuberculosis now commonly known as disseminated TB occurs when the infection invades the circulatory system, resulting in millet-like seeding of TB bacilli in the lungs as seen on an X-ray (Disseminated tuberculosis, 2006). It is also called Koch's disease, after the scientist Robert Koch (Bhansali, 1977). Before the Industrial Revolution, tuberculosis was sometimes regarded as vampirism. People who had TB exhibited symptoms similar to what people considered to be vampire traits. Symptoms such as red, swollen eyes (which also creates a sensitivity to bright light), pale skin, extremely low body heat, a weak heart and coughing blood, suggesting the idea that the only way for the afflicted to replenish this loss of blood was by sucking blood (Sledzik and Bellantoni, 1994). Another folk belief was that the affected individual was being forced, nightly, to attend fairy revels, so that the victim wasted away owing to lack of rest. This belief was most common when a strong connection was seen between the fairies and the dead (Kathrine, 1976). Similarly, but less commonly, it was attributed to the victims being "hagridden" being transformed into horses by witches (hags) to travel to their nightly meetings,

again resulting in a lack of rest (Kathrine, 1976). The bacillus causing tuberculosis, *Mycobacterium tuberculosis*, was identified and described on 24 March 1882 by Robert Koch. He received the Nobel Prize in physiology or medicine in 1905 for this discovery (Nobel Foundation, 1905). Koch did not believe that bovine (cattle) and human tuberculosis were similar, which delayed the recognition of infected milk as a source of infection. Later, this source was eliminated by the pasteurization process. Koch announced a glycerine extract of the tubercle bacilli as a remedy for tuberculosis in 1890, calling it "tuberculin". It was not effective, but was later adapted as a test for pre-symptomatic tuberculosis (Waddington, 2004). The first genuine success in immunizing against tuberculosis was developed from attenuated bovine-strain tuberculosis by Albert Calmette and Camille Guérin in 1906. It was called "BCG" (Bacillus of Calmette and Guérin). The BCG vaccine was first used on humans in 1921 in France (Bonah, 2005). But it was not until after World War II that BCG received widespread acceptance in the USA, Great Britain, and Germany (Comstock, 1994). Tuberculosis, or "consumption" as it was commonly known, caused the most widespread public concern in the 19th and early 20th centuries as an endemic disease of the urban poor (Tuberculosis encyclopedia). In 1815, one in four deaths in England was due to TB; by 1918 one in six deaths in France were still caused by TB. In the 20th century, tuberculosis killed an estimated 100 million people (Torrey and Yolken, 2005). After the establishment of the disease (tuberculosis) to be contagious in the 1880 the disease was made to be notifiable in Britain. This was followed by campaigns to stop spitting in public places, and that the infected poor were pressured to enter sanatoria that resembled prisons. The sanatoria for the middle and upper classes offered excellent care and constant medical attention (McCarthy, 2001). Whatever the purported benefits of the fresh air and labor in the

sanatoria, even under the best conditions, 50% of those who entered were dead within five years (McCarthy, 2001).

1.2. Statement of Research Problem

Bovine tuberculosis is a chronic disease of animals caused by infection with slow-growing, obligate bacterium *M. bovis* (OIE, 2009). It is widely distributed throughout the world affecting all age groups of animals and human. *Mycobacterium bovis* is becoming an important disease in developing countries as it affects humans (Cosivi *et al.*, 1998a). The disease remains a major costly infectious disease of cattle, other domesticated animals (goats, sheep, and camelids), and wildlife (badgers, possums, deer) (Pollock and Neill, 2002). It affects cattle health, and impacts negatively on profitability, trade and decrease genetic traits toward improved production (Boland *et al.*, 2010). It also affects the welfare of the families involved in the farming activities (Farm crisis network, 2009). The disease remains the most complex and difficult multi-species endemic disease presently facing governments and the veterinary profession and the farming industry in the UK and Ireland (Reynolds, 2006).

Expansion of ecotourism-based industries, changes in land-use practices and escalating competition for resources have increased contact between free-ranging wildlife and humans (Ferber, 2000). Although human presence in wildlife areas may provide an important economic benefit through ecotourism, exposure to human pathogens may represent a health risk for wildlife (Botswana, 1999). Persisting in the longer time. Bovine tuberculosis remains a costly disease in many countries, despite extensive eradication and control efforts (Farm Crisis Network, 2009). The disease in wildlife poses a risk to livestock, tourism economy, and wildlife conservation (Michel *et al.*, 2010). Multiple wildlife reservoirs of *M. bovis* infection found in recent decades in the USA, Europe, New Zealand, UK and South Africa play important roles in

fuelling high risks of disease in livestock. Innovative and rapid diagnostic tests for bTB are urgently needed to improve control strategies (Lyashchenko *et al.*, 2000). Bovine tuberculosis is re-emerging in a number of developed countries because of environmental changes, the movement of people and animals. Cattle movements particularly from those areas where bovine TB was reported to areas free of the disease help in spreading the disease (Gilbert *et al.*, 2005). Closer inter-species contacts is associated with larger herd size. This increase in contact between animals hence may results in increase in disease transmission and changes in animal management such as herd size, herd type and that intensively managed dairy herds where at greater risk of bovine TB outbreak than other herds (Cosivi *et al.*, 1998b). In developing countries bovine tuberculosis causes serious concerns not only for wildlife, but also for public health, food safety and the economy of livestock industries. More accurate diagnosis of bTB would reduce unnecessary killing of healthy animals hence will help control bTB (de la Rua-Domenech *et al.*, 2006).

Bovine tuberculosis caused by *M. bovis*, is a zoonotic disease that affects cattle and wildlife (Nishi *et al.*, 2006). This wildlife can serve as reservoirs of infection, thus increasing the risk of human exposure and subsequent infection, especially those living at the wildlife-livestock-human interface (More *et al.*, 2005). Wildlife tuberculosis has resulted in both national and international trade restrictions for affected species (Miller and Kaneene, 2006). The disease is a key constraint to livestock production in which milk yields and animal draught power are reduced and infected carcasses are condemned. In addition, the disease is not only a major cause of economic loss to farmers and butchers but it has a serious impact on export potential. However, most important is the risk of infection to humans, particularly women and children who appear to be most susceptible to the disease (Cosivi *et al.*, 1998b). The risk increases

considerably in individuals with immunosuppression induced by HIV infection (Raviglione *et al.*, 1995). Infection has been identified wherever cattle are raised; the greatest risk at present is that Tb has potential to spread from wildlife to other animals including humans thought to be disease-free. (Kaneene and Pfeiffer, 2006).

In Nigeria there is paucity of information about the prevalence of bTB in wildlife .Yankari Game Reserve has a large population of wildlife with a good climatic condition, abundant grazing areas, fertile land and rivers that support wildlife. Lack of sufficient grazing land and water especially during the dry season, has led to the encroachment of cattle into wildlife areas such as Yankari Game Reserve in Bauchi State, Nigeria in search of free pastures and water. Farming and hunting activities also take place around the border of the game reserve. Interaction between cattle and wildlife at grazing and watering sites may serve as source of transmission of bTB between domestic and wildlife species. Hence, the need to determine the level of exposure to bTB in both group of animals in the Game Reserve.

The intradermal tuberculin skin test (TST), which detects delayed-type hypersensitivity (DTH) to tuberculin antigens, has been the mainstay of tuberculosis screening and ante -mortem diagnosis in non human primates for many years (Coombs and Gell, 1975; Monaghan *et al.*, 1994). This method is cumbersome; results are obtained in a minimum of 24 hours and require specific technical training and is also difficult to conduct in wildlife. Based on these limitations of tuberculin test in wildlife, it is essential to use one of the several new in-vitro assays that are sensitive, specific and rapid. The lateral flow method is easy to use, adaptable for multi species use, results can be obtained in 20 minutes and require a small volume of serum, plasma, or whole

blood. The test does not require sophisticated laboratory equipment or specific technical training as compared to the tuberculin test.

1.3. Justification

Wildlife tourism and ecotourism have fast become popular industry generating substantial income for developing nations with rich wildlife population, especially in Africa and India. This ever growing and increasingly popular form of tourism is providing the much needed incentive for poor nations to conserve their rich wildlife heritage. Ecotourism is now favoured by many global environmental organizations and aid agencies as a vehicle to sustainable development. It promotes conservation of biological diversity by protecting ecosystems and has the local culture, flora and fauna as the main attractions. The Yankari Game Reserve fulfills these criteria (Yankari National Park, 2000). Yankari is one of the biggest Game Reserves in Nigeria and the most popular destination for tourists in Nigeria. It therefore plays a crucial role in the development and promotion of tourism particularly ecotourism in Nigeria. It is also one of the most popular eco-destinations in West Africa. This attracts tourists from Japan, Western Europe, USA and Southeast Asia (Yankari National Park, 2000). If properly managed, it could become a significant part in the development and promotion of tourism throughout Nigeria (Nihotours, 2000). The Yankari Game Reserve is one of a few remaining areas left in West Africa where wild animals are protected in their natural habitat. The Game Reserve is well-stocked with different species of wildlife including elephants, baboons, waterbucks, bushbucks, oribis, crocodiles, hippopotamuses, roan antelopes, buffaloes and various types of monkeys and lions.

The villages that surround the Game Reserve are populated by farmers and cattle herders. Farming activities coupled with good grazing areas including the felling of trees for fire wood,

and hunting activities are the major reasons that lead to people and livestock to interact with the wildlife park. These human activities serve as points of contact between livestock and wild life and as such may lead to the transmission of bTB between cattle, humans and wildlife species. Some wild animal populations serve as source of infection for domestic livestock and humans (Gary, 2009). The level of interactions observed between cattle and wildlife in Yankari Game Reserve poses a great health hazard not only to tourists but also to those communities that use the reserve for farming, fishing, hunting and grazing of livestock. There is lack of information about the actual prevalence of bTB in the wildlife population at the Yankari Game Reserve as such it become essential to carry out this study to identify the true situation. Should wildlife be identified to serve as bTB reservoir hosts then the finding will be crucial for the implementation of effective control measures.

1.4. Aim of the Study

To determine the prevalence of *M. bovis* infection in wildlife and cattle in Yankari Game Reserve in Bauchi State.

1.5. Objectives of the Study

- To determine the prevalence of *M. bovis* in wildlife in Yankari Game Reserve
- To determine the prevalence of *M. bovis* in cattle settlements around Yankari Game Reserve

1.6. Research Question

- Does wildlife in Yankari Game Reserve harbour bovine TB?
- What is the prevalence of bovine TB in cattle grazing at the periphery of Yankari Game Reserve?
- If wildlife located at the YGR does harbour bTB, what is the prevalence like?

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

Bovine tuberculosis is a chronic debilitating disease caused by *M. bovis* that affects a broad range of mammalian species including domestic animals, wildlife and humans (Philips *et al.*, 2001; de Lisle *et al.*, 2002; Delahay *et al.*, 2007). It creates a complex of epidemiological system and is a major economic and public health problem in numerous countries (O'Relly and Daborn, 1995). The disease affects all age groups of human and animals (Alemayehu *et al* 2008), and is responsible for an increasing proportion of human tuberculosis cases (Cosivi *et al.*, 1998a). *Mycobacterium tuberculosis* was considered primarily a human pathogen and has been reported in domestic and wildlife species living in close prolonged contact with humans (Michalack *et al.*, 1998; Montali *et al.*, 2001). *Mycobacterium bovis* is present in most developing countries where surveillance and control measures are often inadequate or unavailable. As a result many epidemiological and public health aspects of the infection remain unknown (Cosivi *et al.*, 1998b). There are a variety of mechanisms by which bTB is transmitted, most notably by inhalation or ingestion but also via the skin , or pseudo vertically to suckling young, so the combination of multiple hosts and multiple transmission routes generates complex patterns of intra-species transmission.

2.2. Epidemiology of *M. Bovis*.

2.2.1 Etiology of *M. bovis*.

Bovine Tuberculosis is a member of *mycobacterium complex* which includes *M. bovis*, *Mycobacterium tuberculosis*, *Mycobacterium africanum*, and *Mycobacterium microti* (Van Sooligen *et al.*, 1994). The cause of Bovine tuberculosis (*Mycobacterium bovis*) is a small aerobic non-motile bacillus. The *Mycobacterium* is unique among the bacteria because of the waxy material in their cell wall called mycolic acids which accounts for many of its unique clinical characteristics (Reynolds, 2006). The mycolic acids give the *Mycobacterium* the ability to hold onto special stains, allowing them to be seen with the microscope. The special stain is called an acid fast stain and the *Mycobacterium* will be red while the other non *Mycobacterium* will be blue. Disease caused by *Mycobacterium* often develop very slowly and may take months to years (Krebs *et al.*, 1997; OIE, 2009). 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 vitro* (OIE, 2009), *Mycobacterium bovis* has one of the broadest host ranges of any known zoonotic pathogen (O'Reilly and Daborn, 1995). The disease other than in domesticated and feral cattle has been reported in wild animals. (Collins and Grange, 1983). It has a complex epidemiological pattern which includes the transmission of infection within and between farm animals and wildlife population (Collins and Grange, 1987)

2.2.2. Survival of *M. bovis* in the environment

Mycobacterium bovis is relatively resistant to environmental factors and under appropriate conditions like cool and protected from sunlight may persist in the environment for weeks, or months, prolonging the likelihood of transmission by ingestion (Duffield and Young, 1985; Fine *et al.*, 2011). Early work suggested that *M. bovis* is a highly resistant organism surviving in cow faeces for at least 5 months in winter, 4 months in autumn, 2 months in summer up to 2 years in soil; 4 months in liquid manure stored underground, and 1-2 months in soil during the summer months (William and Hoy, 1930). A study in Michigan, USA showed that *M. bovis* under natural weather condition survived for up to 88 days in soil, 58 days in water and hay, and 43 days on corn (Fine *et al.*, 2011). Survival on feedstuff (supplemental feeds) provides a more conceivable route of indirect transmission. The activity of sunlight and other bacteria, protozoa and fungi contribute to the breakdown of faeces appears to destroy tubercle bacilli. Also the decomposition of carcasses has been shown to destroy *M. bovis* (Fine *et al.*, 2011). The organism could not be recovered in carcasses left on pasture for upto 4 weeks. Furthermore the organism could not be recovered in 3 badger carcass buried for 2, 3 and 6 weeks. (Fine *et al.*, 2011). Kelly and Collins (1978) later suggested that the major factors influencing survival in soil and on pasture are temperature, moisture, and pH, exposure to sunlight, dissolved oxygen, presence of naturally occurring antibiotics in the soil, natural microflora and types of microflora associations. The survival period of *M. bovis* in the environment was shown to be inversely proportional to mean daily temperatures in a New Zealand study carried out between 1992 and 1993 (Jackson *et al.*, 1995). Temperatures just above 0 °C and a strong hygrometry are favourable for *M. bovis* survival, while hot and dry weather do not allow a long-time survival of *M. bovis* in the environment (Artois *et al.*, 2004).

2.3. Transmission of *M. Bovis*

The respiratory route is accepted as the primary method of infection in all species. However, it is clear that there are other less common methods of spread such as oral, occupational, congenital and via wounds (Thoen *et al.*, 2006; Doran *et al.*, 2009). The principal route of transmission of bovine TB in housed and even at pasture is via the respiratory system involving direct aerosol transmission between animals in close contact (Cassidy, 2006). Through nose to nose. Ingestion of unpasteurized dairy products or ingestion of contaminated feeds, feed trough and drinking water. However a large infective dose is required (Radostits, *et al.*, 2000). Consumption of undercooked venison, carnivores may become infected with *M. bovis* by ingesting infected carcasses, sniffing and licking wound of an infected animal (Sauter and Moris, 1995; Nugent, 2005). Ingestion of infected milk by young animals. Percutaneous is as a result of exposure to *M. bovis* during field dressing of tuberculous animal as a result of injury sustained during dressing (Wilkins *et al.*, 2008). Also abattoir workers and veterinarians are infected during slaughter or post mortem examination of cattle (Robinson *et al.*, 1988; Cousins and Dawson, 1999)

The combination of multiple hosts and multiple transmission routes generates complex patterns of intra-and inter species transmission (Nugent, 2011). Intra-species transmission is likely to occur as a result of cannibalism (Ragg *et al.*, 2000), among other interactions, and where the densities are very high. Other uncommon routes include intrauterine infection at coitus, by the use of infected semen or uterine pipettes, and intramammary infection by the use of contaminated teat siphons or infected cusps of milking machines (Radostits *et al.*, 2000). In wildlife aggregation of animals around housing, feeders and water sources act as source of transmission, during scavenging, sniffing and licking wound of infected animals (Sauter and Moris, 1995; Nugent, 2005).

The transmission dynamics of infectious diseases depends critically on what is frequently termed reservoir or maintenance hosts. Any host complex in which disease persists indefinitely is termed a reservoir (Ashford, 1997). Maintenance host is a host complex in which the pathogen can persist as a short term source of infection. Host status depends on the characteristic of individual host, host density, nature and frequency of contact it has with other potentially infected individual (Begon, 2008). Reservoir host should have one of these characteristics (a) it must be susceptible, (b) able to transmit the disease and (c) high density (Corner, 2006). Transmission of *M. bovis* from domestic animals to wildlife (spillover) and subsequent transmission from wildlife to domestic animals (spillback) is common in different regions of the world. Both spillover and spillback have been facilitated by factors such as encroachment on wildlife habitat, animal translocation, or supplemental feeding of wildlife (Daszak *et al.*, 2000). The scrutiny of wildlife reservoir hosts is essential in control or elimination of *M. bovis* from domestic animals (Ryan *et al.*, 2006). Infected cattle were generally considered the source of human infection with *M. bovis*, with transmission being through ingestion of unpasteurized milk and other dairy products (Grange, 2001). Also, abattoir workers and veterinarians were infected during slaughter or postmortem examination of cattle, or as a result of ingestion of undercook infected meat (Robinson *et al.*, 1988; Corner *et al.*, 2006). The role of each animal species in spreading the disease depends on (a) how the transmission occurs, (b) on the abundance of each host, and (c) on the interspecies interactions between hosts at the wildlife-domestic animals' interface both of which facilitate disease persistence (Cartensen and Doncarlos, 2011). The multiple-host epidemiology of bTB is therefore immensely variable, with every location tending to have a unique set of conditions underlying the emergence and persistence of this pathogen in wildlife. Management system of animals contributes to the spread of this disease. Intensive, as opposed to

extensive livestock systems facilitate close contact between animals and favour the spread of respiratory disease including tuberculosis (Griffin, *et al.*, 1993). Calves which are housed with cows are exposed to constant risk of infection by the respiratory route, than those not housed together (Griffin *et al.*, 1993). Also cattle grazing in an open range, in wild cervidae and in feral cattle the prevalence of TB is only 1-5% whereas in dairy cows and farmed deer the prevalence was between 25-50% because the deer were housed, and because of their average life span (Wagner, 1993). Under extensive pastoral system of husbandry factors such as congregation of livestock from different sources at watering sites, or gathering of animal in an enclosure overnight lead to increase aerosol transmission of infection and individual with high disease prevalence might be encountered (Radostits *et al.*, 2000). Herd size also contributes to the transmission of infection as cited by Francis in Great Britain in which herds with a large number of animals showed high prevalence of tuberculosis than those with small number of animals (Garnett, *et al.*, 2002). Transmission of *M. bovis* infection from human to cattle is direct and through the respiratory route and by indirect via beddings and or hay contaminated by urine from human excreta has been reported in Germany and Netherlands (Huitema, 1963). In non-human primate tuberculosis is a common problem in captivity and the new World monkeys are known to be more resistant than the old World monkeys (Wilson *et al.*, 1984). In the Masai Mara game reserve in Kenya there was reported case of tuberculosis due to *M. bovis* in wild baboons (*Papio cynocephalus Anubis*, Lesion) (Sapolsky and Else, 1987). It was concluded that the infection was contracted by the animals feeding on village slaughterhouse offal of *M. bovis* infected cows (Sapolsky and Else, 1987). *M. bovis* was also isolated from 2 tuberculin positive female baboons (*Papio papio*) quarantine at the Biological Resources Laboratory primate facility at the University of Illinois, USA (Thoen *et al.*, 1977). They had tuberculous lesions in their liver,

spleen, lungs, and media sternal lymph nodes. *M. bovis* infection in wild and feral cervidae. Cases of *M. bovis* infection have been reported in the USA (Wagner, 1993), Hungary (Kormendy, 1993). New Zealand and Great Britain (Rose, 1987). In a recent literature review on tuberculosis in deer it was reported that the prevalence of the disease in wild deer was less than 5%. Transmission of *M. bovis* among badgers is by respiratory route with infection more frequently in young animals due to pseudo-vertical transmission from mother to cub (Anderson and Trehwella, 1985). Some transmission may occur as a result of bite wounds caused by fighting between males, pastures contaminated with badgers urine has been reported as a source of infection to cattle (Brown *et al.*, 1994).

2.3.1. Wildlife to human transmission;

Hunters are exposed to *M. bovis* during the field dressing of tuberculous animal as a result of injury sustained during dressing or the consumption of undercooked venison products (Wilkins, *et al.*, 2008).

2.3.2. Cattle to cattle transmission;

Cattle-to-cattle transmission can be facilitated by close contact, poor ventilation systems in barns and sheds, and the herd density (Neill *et al.*, 1991). Mycobacteria are shed through feces, milk, discharging lesions, saliva, and urine and are transmitted through different routes (Menzies and Neill, 2000). The most common spots for nose to nose or mouth to mouth contact among animals are at the salt supplementation and feeding points. Especially in large herds with small-sized feeders (Parra *et al.*, 2005). Animals under intensive farming management and confined to spaces or corrals allowing close physical contact before and during milking are more stressed

(Brown *et al.*, 1998). The transmission of *M. bovis* between cattle is dependent on a number of factors, including frequency of excretion, route of infection, the infective dose, the period of communicability, and host susceptibility. It is also possible that a range of highly specific conditions must occur for fine aerosols to be produced and for transmission to take place (Griffin and Dolan, 1995). Field experience also indicates that cattle in the early stages of disease or with discrete walled-off lesions do not commonly transmit *M. bovis* to in-contact animals (Griffin and Dolan, 1995; Olea-Popelka *et al.*, 2008). Animals excrete *M. bovis* in exhaled air, sputum, urine, faeces and pus, so the disease can be transmitted by direct contact, contact with the excreta of an infected animal, or inhalation of aerosols (Cosivi *et al.*, 1998a). Other factors that contribute to bTB transmission include; stocking densities, type of housing, and farm habitat type, livestock production intensity and rotational versus strip grazing (Johnston *et al.*, 2011). Herd- to- herd transmission include cattle movement and trading, purchase of for addition to cattle from the market or from infected herds increase risk of infection for the receiving herds (Johnston *et al.*, 2011). At pasture transmission is enhanced through stocking densities, rotational versus strip grazing, livestock production intensity (Johnston *et al.*, 2011). Farm management system including herd size, herd type, herd location, and other management practices such as spreading of slurry may also play a role (Griffin *et al.*, 1993). Use of certain housing types such as having multiple premises may also be important (Johnston *et al.*, 2005). Nomadic transhumance relies on the movement of livestock to follow grazing and water over considerable distances following seasonal changes. During the wet season, animals graze in pastures shared by several farmers. During the dry season, several herds are gathered in mobile groups migrating together, and share grazing areas and watering sources along the way (Oloya *et al.*, 2007). Transhumance was recently associated with an increased bTB status (Munyeme *et al.*, 2008).

2.3.3. Cattle to wildlife transmission

Direct contact between wildlife and cattle is rare, but wild animals reaching a late stage of clinical tuberculosis may show modified behaviour, they lose fear, active in day light, attract cattle (Norton *et al.*, 2005). Cattle might also become infected by smell, sniff, or lick discharges from a dead or dying wildlife as reported by Zuckerman (1980) and Griffin *et al.* (1999). Indirect contact between cattle and infected wildlife faeces, urine and wound discharges resulted in transmission (Palmer *et al.*, 2004). Also storing wildlife manure indoors and type of housing increase the risk of transmitting bTB (Garnett *et al.*, 2002; Roper *et al.*, 2003). In Great Britain it was suggested that routes of transmission between badgers and cattle included direct contact between cattle and badgers at pastures (Ward *et al.*, 2010). Further indirect contact between cattle and infected badgers faeces, urine and wound discharges, this is increase where cattle can access badger setts and latrines or where badgers access cattle feed(including feed in stores, maize, silage and feeds in trough and or water troughs or visit to farmlands (Garnett *et al.*, 2002., Roper *et al.*, 2003). Also close contact between ungulate and cattle at the interface is the cause of interspecies transmission (Renwick *et al.*, 2007).

2.3.4. Wildlife to wildlife transmission;

Intraspecies transmission of bTB among wildlife species is seen in those groups of wildlife that live in large herds such as African buffalo and the Kafue lechwe (Munyeme, *et al.*, 2010). Interspecies transmission between prey and predators has been reported in Kruger National Park in South Africa and affected by factors such as group composition of the herd augmented with group social behavioral pattern under favourable ecological disposition (Bengis, *et al.*, 2002). Same family groups are more likely to share the same feed from the same sources, participate in mutual grooming and spend time within distances favourable to aerosol transmission (O'Brien *et*

al., 2002). Intraspecies transmission is likely to occur as a result of cannibalism and other interactions and where densities are high (Ragg *et al.*, 2000).

2.4. Pathogenesis of *M. Bovis*

The most common route of infection is through inhalation, the inhaled bacilli lodge in the terminal air space of the lung, where they enter and replicate within the endosomes of alveolar macrophages (Houben *et al.*, 2006). T lymphocytes secrete cytokines such as interferon gamma, which activates macrophages to destroy the bacteria with which they are infected (Kaufmann, 2002). Cytotoxic T cells can also directly kill infected cells, by secreting perforin and granulysin (Houben *et al.*, 2006). The infection can spread hematogenously to lymph nodes and other areas of the body and cause smaller, 2-3 mm in diameter, tubercles. The formation of these smaller tubercles is known as “miliary tuberculosis” (Kim *et al.*, 2003). Macrophages, T- lymphocytes, B- lymphocytes and fibroblasts are among the cells that aggregate to form a granuloma, with lymphocytes surrounding the infected macrophages. The granulomas function not only to prevent dissemination of the mycobacterial organism but also provide a local environment for communication of cells of the immune system. The bacteria are not always eliminated within the granuloma, but can become dormant, resulting in a latent infection (Kumar *et al.*, 2007). *Mycobacterium bovis* infection results in the formation of primary focus located in the lungs and thoracic lymph nodes (Kaneen and Thoen, 2004). In animals lymphatic drainage from the primary focus leads to the formation of caseous lesions in the adjacent lymph nodes. This lesion, together with the primary focus is term primary complex. This primary complex seldom heals in animals, the disease progresses for some years during which the humoral immune response appears in the more advanced stages of the disease (Kaneen and Thoen, 2004). The natural and

acquired immune response mechanism of host often help in limiting the proliferation of tubercle bacilli and the development of progressive disease (De la Rúa-Domench *et al.*, 2006).

Another feature of the granulomas of human tuberculosis is the development of abnormal cell death, also called necrosis, in the center of the tubercles. To the naked eye this has the texture of soft white cheese and was termed caseous necrosis (Grosset, 2003). Tissue destruction and necrosis are balanced by healing and fibrosis (Grosset, 2003). Affected tissue is replaced by scarring and cavities filled with cheese-like white necrotic material. During active disease, some of these cavities are joined to the air passages bronchi and this material can be coughed up. It contains living bacteria and can therefore pass on infection to others (Grosset, 2003). Development of overt disease after infection under field conditions may be dependent on the number of virulent organisms to which a susceptible host is exposed, the frequency of exposure and route of infection, as well as the general health and immunological status of the animal

2.5. Clinical Signs

Clinical signs are manifested as emaciation, depression, and intolerance to exercise. Because infection often involves the lungs, coughing, nasal discharges, and difficulty in breathing can occur in severe cases (Cassidy, 2006). In some instances, superficial lymph nodes in the neck will develop large abscesses that may rupture and drain through the skin. Affected animals may have yellow to tan, pea-sized nodules in the chest cavity or lungs (Radostits *et al.*, 2000). It is usually characterized by formation of nodular granulomas known as tubercles. Any body tissue can be affected, but lesions are most frequently observed in the lymph nodes (particularly of the head and thorax), lungs, intestines, liver, spleen, pleura, and peritoneum (Menzies and Neill,

2000). The distribution of lesions will depend on the infecting dose, route of infection and the incubation period before examination.

2.6. Diagnosis

2.6.1. Intradermal tuberculin skin test.

This has been the mainstay of tuberculosis screening and antemortem diagnosis of *M. bovis* in nonhuman primates and is currently the most widely applied method for tuberculosis testing of animals in primary import quarantine (NRC, 1980; Roberts and Andrews, 2008; Monaghan *et al.*, 1994).

2.6.2. Single cervical

This involves the injection of purified protein Derivative (PPD), which is prepared from culture of *M. bovis* grown on synthetic media (OIE, 2009). The injection site is the cervical region. A fold of skin is picked up in the center of the lateral aspect of the neck. The result is read between 48 to 96 hours after injection. A positive reaction constitutes a diffused swelling at the injection site; the injection site is measured before and after the injection with a caliper (Monaghan *et al.*, 1994). The subjective method of palpation is more accurate.

2.6.3. Caudal fold

The PPD is injected into anal or caudal fold at the base of the tail (Radostits *et al.*, 2000). The injection site must be clipped and cleaned before injecting the PPD. The results are read after 72 hours (OIE, 2009). In the caudal fold test, a short needle, bevel edge outwards, is inserted obliquely into the deeper layers of the skin on the lateral aspect of the caudal fold, midway along the fold and midway between the hairline and the ventral aspect of the fold. The standard

interpretation is that any palpable or visible change is deemed to be a reaction. a positive test is any palpable or visible swelling at the site of the injection that has a caudal fold thickness difference of 4 mm when compared with the thickness of the opposite caudal fold. If an animal has only one caudal fold, it is considered to be test positive if the caudal fold thickness is 8 mm or more (OIE, 2009)

2.6.4. Comparative intradermal tuberculin test

The test is used to differentiate between animals infected with *M. bovis* and those responding to bovine tuberculin as a result of exposure to other mycobacterial organisms (Radostits *et al.*, 2000). This sensitization can be attributed to the antigenic cross-reactivity among mycobacterial species and related genera. The test involves the intradermal injection of bovine tuberculin (PPD-B) and avian tuberculin (PPD-A) into different sites, usually on the same side of the neck at 12-15 cm apart and measuring the thickness of the skin with a caliper 72 hours later (OIE 2009). In young animals in which there is no room to separate the sites sufficiently on one side of the neck, injection is made on each side of the neck at identical position in the centre of the middle third of the neck. In the interpretation of the intradermal comparative test, a reaction is usually considered to be positive if the increase in skin thickness at the bovine site of injection is more than 4 mm greater than the reaction shown at the site of the avian injection. The reaction is considered to be inconclusive if the increase in skin thickness at the bovine site of injection is from 1 to 4 mm greater than the avian reaction. The reaction is considered to be negative if the increase in skin thickness at the bovine site of injection is less than or equal to the increase in the skin reaction at the avian site of injection (Grooms and Molesworth, 2000).

2.6.5. Blood-based laboratory tests

Diagnostic blood tests are now available and they include the gamma interferon assay, which uses an enzyme-linked immunosorbent assay (ELISA) as the detection method for interferon, the lymphocyte proliferation assay, which detects cell-mediated immune responses, and the indirect ELISA, which detects antibody responses. The logistics and laboratory execution of some of these tests may be a limiting factor. Lateral flow-based rapid test, has been shown to be useful for detecting tuberculous animals, particularly in some domestic animals, wildlife (Lyashchenko *et al.*, 2008). And zoo animals such as South American camelids, badgers (Greenwald *et al.*, 2003).

2.6.6. Post-mortem tests

The preliminary diagnosis of tuberculosis at slaughter is by the identification of TB tubercles. In approximately 90 percent cases of tuberculosis in cattle, lesions primarily involved the lymph nodes of the respiratory system. Lesions can also be found in the thoracic cavity, head, and mesenteric lymph nodes. Approximately half of the lung lesions were located in the distal part of the diaphragmatic lobes (Menzies and Neill, 2000).

Other methods include, histopathology, examination of Ziehl-Neelsen (ZN) stained smears or contact tissues sections for acid-fast bacilli (AFB), or tuberculosis-like lesions provides presumptive diagnosis. The isolation of mycobacteria on selective media and their subsequent identification by cultural and biochemical tests or DNA technique such as PCR can confirm the infection (De Lisle *et al.*, 2002) . Although expensive and extremely time-consuming, bacteriological culture is considered the reference test for the diagnosis of TB, as most other

techniques lack sensitivity and/or specificity (De Lisle, 2002; O'Brien *et al.*, 2004; Gavier-Widen *et al.*, 2009).

2.7. Prevention and Control of *M. Bovis*

Maintenance hosts are critical in disease epidemiology and control because without intervention, disease will persist indefinitely. Therefore to control the disease efforts should aim at the maintenance host (Ryan *et al.*, 2006). Bovine tuberculosis control strategies should be based on prevention, control, and eradication, fundamental activities concerning animal husbandry, removal of known sources of infection, early diagnosis, quarantine, movement control, and environmental hygiene must be sound (Kaneene *et al.*, 2002). Transmission of *M. bovis* across the wildlife-domestic animal interface represents a significant obstacle to bovine tuberculosis eradication efforts in many countries around the world. The combination of tuberculin testing, monitoring at meat inspection, movement control, and destruction of exposed animals, milk pasteurization, animal health surveillance, generally have been successful in eliminating the disease, except where a reservoir of infection exists outside the cattle population (Nahid *et al.*, 2006; FSAI, 2008). The eradication of the disease in livestock has been impeded in several countries by the presence of tuberculosis in wild animals (Kaneene *et al.*, 2006). The lack of efficient diagnostic tools for most species and the absence of an effective vaccine make it currently impossible to contain and control this disease within an infected free-ranging ecosystem. Veterinary researchers and policy makers have recognized the need to intensify research on this disease and the need to develop tools for control, initially targeting buffaloes and lions, and then other species (Miller and Kaneene, 2006). Meat inspection programme should be strengthened and designed to prevent the consumption of contaminated products by people. All

animals entering the food chain should be subjected to ante-mortem and postmortem inspection. The tuberculin test is valuable in the control of zoonotic tuberculosis because early recognition of preclinical infection in animals intended for food production and early removal of infected animals from the herd eliminates a future source of infection for other animals and for humans. Milk should be pasteurized or effectively treated with heat or further processing also meat be properly cook prior to human consumption these measures help to prevent transmission of zoonotic tuberculosis through milk and meat (FSAI, 2008). There should be an increased enlightenment of the public on the possible risks of *M .bovis* infection in man. Farmers and other occupationally at-risk individuals should be required to adopt appropriate measures to minimize exposure of employees and farm visitors to infections that can be transmitted to humans from animals (HPA, 2009). Animal husbandry practices should be improved upon to reduce contact between domestic livestock and wild ruminants especially during grazing (FSAI, 2008).

2.7.1. Post-mortem

During meat inspection presence of tubercles in the lungs as occasioned by palpation and incision of lymph nodes to detect the presence of gritty sound may indicate tuberculosis (Radostits *et al.*, 2000) Detecting these infected animals prevents unsafe meat from entering the food chain and allows veterinary services to trace-back to the herd of origin of the infected animal which can then be tested and eliminated if needed. Treatment of infected animals is rarely attempted because of the high cost, lengthy time and the larger goal of eliminating the disease (FSAI, 2008).

2.7.2. Vaccination

Is currently considered the leading prospective control strategy in wildlife in England and Michigan, and is under consideration in other countries such as Canada, New Zealand, the republic of Ireland, South Africa, and Wales (Buddle *et al.*, 2011). Presently, *M. bovis* strain Bacilli Calmette-Guérin (BCG) has been used as a vaccine and showed protection of naturally occurring tuberculosis in Silka deer (*Cervus Nippon*) (Shilang and Shanzhi, 1985), and in experimental infection of red deer (Griffin *et al.*, 1999; Griffin *et al.*, 2006). In wildlife control is through reduction in density (measures that reduce animal aggregation) through hunting, or elimination through supplemental feeding and baiting (Rudolph *et al.*, 2006). Monitoring of both wildlife and domestic livestock can be done through hunter-killed surveys, carnivores and omnivores surveillance, and whole herd tuberculin testing of cattle. The use of potential measures for minimizing contacts between cattle and wildlife through fencing of feeding areas to exclude cattle herds (VerCauteren *et al.*, 2006) and the use of guard dogs (VerCauteren *et al.*, 2008b) to preventing transmission of bovine tuberculosis .

2.8. *M. Bovis* Infection in Goats and Sheep

Tuberculosis in goats and sheep is caused by *M. bovis* and *M. caprea* (Sharpe *et al* 2010; Hiko and Agga, 2011). Epidemiological studies showed that the disease is distributed globally, and has been reported in various countries like New Zealand, Sudan, Spain, Nigeria, UK, Italy, Algeria and Ethiopia (Hiko and Agga, 2011). Cadmus *et al.* (2009) reported *M. bovis* and *M. tuberculosis* in goats in Ibadan Nigeria. In Ethiopia work done by Gezahegne *et al.* (2012) showed a prevalence of 4.2% based on abattoir examination and 3.1% using single intradermal tuberculin test. Haruna *et al.* (2012) reported *M. bovis* infection in sheep and goats in Kaduna State,

Nigeria, with an overall and individual prevalence of 13.56% and 10.64% (54/498) for sheep, 16.41% (84/512) for goats respectively, The Female sheep and goat had an overall prevalence of 8.8% and an individual prevalence of 14.98% as compared to the male with 4.73% and 11.54% respectively. This showed that sheep and goats could play an important role in transmission of *M. bovis* (Haruna *et al.*, 2012)

2.9. *M. Bovis* Infection in Humans

Transmission of the disease to humans is via consumption of contaminated milk from infected cows (Collins and Grange, 1987). People with high risk of infection are slaughterhouse and rural workers (Ritaco and de Kantor, 1992). individuals at high risk include persons involved with potentially infected animals such as veterinarians, abattoir workers, meat inspectors, autopsy personnel, farmers, milkers, animal keepers (those in the zoo), animal dealers, laboratory personnel and owners of potential tuberculous pets such as monkeys (O'Donahue *et al.*, 1985; Yumi and Tooru, 2007). Indirectly, man acquires the disease from animal sources by ingestion of meat and meat products from slaughtered infected cattle and consumption of unpasteurized infected milk (Cosivi *et al.*, 1998a; Radostits *et al.*, 2000; Thoen *et al.*, 2006). The incidence of *M. bovis* infection in humans probably remains underestimated, as a distinction between the various *Mycobacterium* species like *M. bovis* and *M. tuberculosis*, is not systematically performed (Anonymous 2006). Since the real incidence of *M. bovis* in human health is still unknown, it is essential to advance the eradication of bTB worldwide by means of adequate programmes, especially in developing countries (Grange, 2001). Even if the risk to human health is low in most developed countries, the HIV pandemic in developing countries raises concern about its impact on the transmission of *M. bovis* to and between humans (Grange 2001). The

highest risk groups are actually individuals with concomitant HIV/AIDS infection (Ayele *et al* 2004). HIV is the major factor responsible for the progression of tuberculosis infection to active tuberculosis disease (Dabon and Grange, 1993). In countries where tuberculosis in cattle had been common, about 10% of cases of clinical tuberculosis in humans were assumed to be caused by *M. bovis* infection (Schliesser, 1992). Francis (1947) stated that in Great Britain 5% of all deaths from tuberculosis at all ages were due to bovine type of bacillus, but in children under 5 years the proportion was 30%. About 8% of raw chunk milk and nearly all of the 3000 gallon tanks in which milk is often brought to the city contain tubercle bacilli. Human cases of tuberculosis diagnosed in different countries were as a result of *M. bovis* especially in Argentina. Relatively high prevalence of tuberculosis in cattle coincided with bacteriological diagnosis of human tuberculosis, the percentages of human tuberculosis to *M. bovis* range from 0.4 to 6.2%, and most of the patients infected with *M. bovis* were slaughterhouse or rural workers (Ritaco and Kantor, 1992). In Santa Fe province from 1984-1989, *M. bovis* was responsible for 2.4 to 6.2% of human cases of tuberculosis and about 64% of the patients were slaughterhouse or rural workers (Latini *et al.*, 1990). In South America the highest infection rate was found in milk-producing regions surrounding large cities (Acha and Szyfres, 1987). In Australia reports of *Mycobacterium bovis* pulmonary infection in abattoir workers highlighted the aerosol route of infection as an occupational hazard (Robinson *et al* 1988; Georghiou *et al.*, 1989). In Alberta, Canada one veterinarian became infected with *M. bovis* while examining a tuberculous elk and several workers became tuberculin positive following exposure to carcass of tuberculous elk (Fanning and Edwards, 1991).

Tuberculosis is a major opportunistic infection in HIV infected persons. The epidemic of HIV infection in developing countries, particularly countries in which *M. bovis* infection is present in

animals and the conditions favour zoonotic transmission, could make zoonotic TB a serious public health threat to persons at risk (Moda *et al.*, 1996; Daborn *et al.*, 1997). Tuberculosis due to *M. bovis* is significant in sub Saharan Africa due to high prevalence of HIV infection in human population. Human Immunodeficiency Virus (HIV) infection suppresses the immune system. Thus Farmers infected with the organism will be at greater risk of developing tuberculosis, which in turn can lead to the transmission of tuberculosis to their cattle as a result of their close contact with their animals (MOH, 1997). In 1995 the WHO estimated that 5.6 million people were co-infected and by the of the century, tuberculosis is likely to be the leading cause of death among HIV positive people. High prevalence of HIV in patients with tuberculosis suggested that an epidemic of reactivating tuberculosis was arising in those infected with HIV. AIDS patients infected with *M. tuberculosis* develop active tuberculosis (Cowley *et al.*, 1992). Human Immunodeficiency Virus positive individual who are also infected with *M tuberculosis* are 30 times more likely to develop clinical tuberculosis than HIV negative people infected with the tubercle bacillus (Shimao, 1995). *Mycobacterium bovis* has been isolated from HIV infected person in developed countries (Bouvet *et al.*, 1993). 186 Serious concerns was expressed that HIV pandemic would result in an increase of human tuberculosis due to *M. bovis* infection. Public Health Laboratory services in South-East England have diagnosed 2 cases of *M. bovis* infection in HIV positive patients (Daborn and Grange, 1993).

2.10. Status of *M. Bovis* Infection in Africa

Mycobacterium bovis infection in humans is under-reported as a result of the diagnostic limitations of many laboratories in distinguishing *M. bovis* from *M. tuberculosis* (Ayele *et al.*, 2004). None of the national reports submitted to the OIE and WHO by African member states

mention the importance of *M. bovis* in human TB cases. Consumption of unpasteurized milk and poorly heat-treated meat and close contact with *infected* animals represent the main sources of infection for humans (Ayele *et al.*, 2004).

2.10.1. *M. bovis* in wildlife in Africa

Tuberculosis in wildlife, caused by *Mycobacterium bovis*, has emerged as an increasingly important disease of free-ranging wildlife populations (Acha and Szyfres, 1987).

Bovine tuberculosis in wildlife was first diagnosed in African buffalo in the southern region of the Kruger National Park, South Africa, in 1990 (Cornuzi *et al.*, 1991). *M. bovis* was later diagnosed in Cheetah (*Acinonyx jubatus*), two lions (*Panthera leo*) and a Chacma baboon (*Papio ursinas*) (Keet *et al.*, 1996). These animals were assumed to have become infected either directly or indirectly from tuberculous buffalo.

In lions *M. bovis* infection is generally alimentary, which later spreads to other sites. Peripheral lymph nodes were also frequently affected, probably due to infected fight wounds. *Mycobacterium bovis* infection of the mammary tissue was also identified in a few lionesses, and Lion cubs as young as six months have been found to be infected (Keet *et al.*, 1996). Members of the family Bovidae in the wild are generally the maintenance hosts of *M. bovis* in Africa and are gregarious. They include Kafue lechwe antelope (*Kobus leche kafuensis*) in Zambia (Clancey, 1997) and the African buffalo in Uganda (Guilbride, 1963 and Woodford, 1982) and South Africa (Cornuzi *et al.*, 1991; Keet *et al.*, 1994). Greater kudu may also have maintenance host potential, but are generally a lower density species (Bengies and Keet, 1998). In 1963, Guilbride and his 10 workers reported eight cases of tuberculosis in African buffalo that were shot in the Ruwenzori/Queen Elizabeth National Park in Uganda. *Mycobacterium bovis* infected leopard

(Panthera pardus) was diagnosed in the Kruger National Park (Bengis, unpublished findings), the animal had lesions typical of alimentary infection Keet *et al.* (1996) reported *M. bovis* infection in Baboons which might have been due to scavenging on infected buffalo, either in the veld or at the necropsy facility at Skukuza in the Kruger National Park (Keet *et al.*, 1996). The greater kudu was the first wildlife species in Africa documented to be infected with tuberculosis (Hilsberg and Van-Hoven, 1999). The first Tuberculosis caused by *M. bovis* was also recognised in the same area in a few common duiker (*Sylvicapra grimmia*) and in a bushbuck (*Tragelaphus scriptus*). Subsequently, the infection appears to have spread to springbok (*Antidorcas marsupialis*), bushpigs (Lungton *et al.*, 1998; OIE, 2000) (*Potamochoerus larvatus*) and hares (*Lepus* spp.),

Work done by Timothy *et al.* (2001) on Buffaloes at the Kruger National Park (KNP) South Africa showed a prevalence of *M. bovis* infection of 0%, 4.4% (60.6%), and 27.1% (61.4%), in the north, central, and south zones of KNP, respectively.

In Zambia prevalence of *M. bovis* in African Buffaloes (*Syncerus caffer*) was investigated from different herds by Hetron *et al.* (2011) showed a prevalence of 5.8% only on avian reactors

2.10.2. *M. bovis* in domestic animals in Africa

Mycobacterium bovis was probably introduced into Africa during the colonial era of the 1800s or early 1900s, by cattle imported from Europe which became a source of infection for natives' breeds of cattle (Hilsberg and VanHoven, 1999). Subsequently, infection was transmitted to wildlife that had a shared habitat with infected cattle. In Egypt De Lisle *et al.* (1993) reported *M. bovis* infection in cattle and buffaloes using tuberculin tests the results showed a prevalence rate of 2-9% in cattle and buffalo in 1920. In 1981-1986 a national programme was commenced to cover the entire country (De Lisle *et al.*, 1993; Buddie *et al.*, 1995). This programme was based

on compulsory periodical testing of females aged over six months and bulls for breeding, followed by slaughter of reactors and compensation. In 1981 the overall proportion of positive reactors in two of the controlled governorates were 6.16% and 9.40%, respectively; in 1985 reactivity dropped to around 2.60% .

De Lisle *et al.* (1993) reported the occurrence of *M. bovis* infection in 34 herds in South Africa. The prevalence in the cattle population dropped from 0.17% in 1981 to 0.04% in 1992.

In Cote d'Ivoire cattle that were totally condemned at slaughtered in abattoir, tuberculosis was reported in 50% of the cases (approximately 10% in sheep and goats) by De Lisle *et al.* (1993).

In Mali, De Lisle *et al.* (1993) reported that a total of 237 cattle and 124 sheep were found to be infected with tuberculosis during 1992, and their entire carcasses were condemned (De Lisle *et al.*, 1993). Dairy cattle and animals in artificial insemination centres were tuberculin tested, and those yielding positive results were slaughtered. In Morocco bovine tuberculosis was diagnosed in some intensive cattle units and dairy farms as reported by De Lisle *et al.* (1993), in some districts, slaughtered female cattle were found to be heavily infected, with isolation rates of 30% for *M. bovis* and 9.7% for *M. tuberculosis* (Gallagher *et al.*, 1998)

In Somalia Buddie *et al.* (1995) reported the prevalence bovine tuberculosis in cattle, the proportion of cattle infected with BTB was 4.54-10.2%.

In Ethiopia a case control study was conducted between October 2004 and April 2005 to determine the prevalence of bTB in cattle in central Ethiopia by Alemayehu *et al.* (2008) using the comparative intradermal cervical tuberculin test (CITT) in cattle, while clinical symptoms, chest x-ray, and Ziehl-Neelsen staining were used for the diagnosis of tuberculosis in farmers, showed a prevalence of 24.3% in cattle owned by farmers with active tuberculosis than those owned by farmers who did not have active tuberculosis (8.6%) (Alemayehu *et al.*, 2008)

Work done by Awah-Ndukum *et al.* (2010) in Cameroon reported a 4.2% prevalence of bovine tuberculosis from slaughter records, also analysis of tissue and sera showed a prevalence of 31% (Ziel-Neelsen), 51%(culture), and 60% (antibody detection).

2.10.3. *M. bovis* in humans in Africa

The current increasing incidence of tuberculosis in humans, particularly in immunocompromised persons, has given rise to a renewed interest in the zoonotic importance of *M. bovis*, especially in developing countries (Radostits *et al.*, 2000) .A close physical association between humans and potentially infected animals has been reported in some traditional African communities (Carmichael, 1938). Approximately 90% of the total volume of milk produced in sub-Saharan Africa is consumed fresh or soured, and only a very small proportion of the total production follows official marketing channels (Walshe *et al.*, 1991). According to Cosivi *et al.* (1998a), preliminary studies conducted in Africa indicate that a proportion (approximately 5 - 7%) of human tuberculosis cases is caused by *M. bovis*. In Tanzania, work done by Bologne (2007) showed that 10.5% of people with stomach or lymph gland tuberculosis were infected with *M. bovis* and the proportion of extrapulmonary tuberculosis among all forms of tuberculosis stands at nearly 16%. A study in Egypt revealed that nine of twenty randomly selected patients with tuberculousperitonitis were infected with *M. bovis*, and the remaining with *M. tuberculosis* (Nafeh *et al.*, 1992; WHO, 1992). Also Buddie *et al.* (1995) in Egypt reported human cases of *M. bovis* results showed that approximately 63% of these patients were from rural areas (Buddie *et al.*, 1995). In a recent investigation, nine of twenty randomly-selected mycobacterial samples isolated from patients with abdominal tuberculosis were found to be *M. bovis* (Cross *et al.*, 2000) Other authors reported that 5% of 300 mycobacterial cultured from human sputum were *M. bovis*

(Briones *et al.*, 2000). The observed *M. bovis* occurrence was attributed to the fact that most patients lived in the Cairo abattoir area, and some were workers at the abattoir.

In Zaire (Congo Democratic Republic), *M. bovis* was isolated from gastric secretions in two of five patients with pulmonary tuberculosis (Mphoshy *et al.*, 1983), with the prevalence of the disease in local cattle determined to be approximately 8% by tuberculin testing and isolation of *M. bovis* (Cosivit *et al.*, 1998b). Work done by Kidane *et al.* (2002) and Shitaye *et al.* (2007) in Ethiopia showed a prevalence of *M. bovis* was found to be a cause for tuberculous lymphadenitis in 17.1% of 29 human tuberculosis cases and 16.7% of 42 human isolates respectively. These findings show that the role of *M. bovis* in causing human tuberculosis seemed to be significantly important. HIV seroprevalence rates have been found in over 40% of tuberculous patients in a number of African countries (Narain *et al.*, 1992).

2.11. Status of *M. Bovis* in Nigeria

2.11.1. *M. bovis* in animals

In Nigeria work done by Kudi *et al.* (2012) on camels in Northern Nigeria using a one-step antibody detection assay employing a cocktail of selected *M tuberculosis* and *M. bovis* antigens with a blue latex-based signal detection system was used, it showed a prevalence of *M. bovis* of 17% of the 1375 of the camels tested to be positive (Kudi *et al.*, 2011). Another work done in Nigeria by Bello *et al.* (2012) on slaughter camels(*Camelus dromedarus*) based on postmortem meat inspection and Zeihl-Nielsen stain showed that out of the 83 suspected positive samples, 36 were males with prevalence of 19.1% and 47 were females with prevalence of 15.1%. A survey on the prevalence of tuberculosis in cattle slaughtered in Maiduguri Central abattoir was carried out during the month of May to June 2008 by Raufu and Ameh (2010) showed that out of the

265,722 cattle slaughtered during the period of the survey, 2,902(1.1%) were positive for pulmonary tuberculosis. The annual prevalence during the study varied between 0.5- 6.4%. The monthly (mean) prevalence of bovine tuberculosis was highest in the month of July, with prevalence rate of 1.4% (Raufu and Ameh, 2010). Work done by Abubakar *et al.* (2011) on slaughtered Camels in Kano State abattoir, Nigeria showed, the prevalence of *M. bovis* to be 19.1% in males and 16.6% in females. Work done by Cadmus *et al.* (2004) in a private farm in Ibadan, Nigeria using comparative intradermal tuberculin test reported the prevalence of Bovine tuberculosis 10.5%. All the smear samples obtained were positive for acid-fast bacilli; cultural isolation confirmed the growth of mycobacterial on pyruvate-enriched Loewenstein-Jensen medium, which were identified by molecular typing to be *M. bovis*. This study demonstrates widespread infection in this cattle herd and potential risk of infection for the human population with *M. bovis* (Cadmus *et al.*, 2004).

Work done by Darbirni (2009) in 4 intensive dairy farms of 200 cattle and semi managed farms which produced milk for yoghurt in some part of Kaduna state using Rapid test and Ziel-Neelsen stain. The rapid test result showed 17.5% (35/200) of the lactating dairy cows to be positive. Fresh milk from cows positive for rapid test and also pack yoghurt made from those positive and negative cows were subjected to Ziel-Neelsen stain, the result showed 17.1%(6/35) to be positive. Work done by Salisu *et al.* (2012), in Jigawa State Nigeria between September 2008 and March 2009 using comparative intradermal tuberculin test in cattle showed a prevalence of *M. bovis* 2% while the herd men had a prevalence of 5%. The isolation and identification of *M. bovis* in fresh and sour milk as sold in local market, sputum and tissue samples from humans especially among Fulani herdsman, abattoir and slaughter houses has been reported what has therefore been established is that bovine tuberculosis occurs in cattle and humans in Nigeria.

2.11.2. *M. bovis* in humans

Bovine tuberculosis has been documented in human by different authors in Nigeria. In a study in Nigeria, it was reported that one of the ten mycobacterial isolated from sputum-positive cultures was *M. bovis* (Idrisu and Schnurrenberger, 1977). Also, Ofukwu (2006) reported that *M. bovis* account for 5% of all cases of tuberculosis in humans and up to 3% of cases in children less than 5 years of age. Alhaji (1976) found the presence of *M. bovis* in the sputum of market milk (“nono”) sellers in Zaria. Kolo (1991) in his study at the Ahmadu Bello University Teaching Hospital, Zaria, revealed that out of 300 samples of urine, pus, peritoneal and pleural fluid, bone marrow and lymph nodes collected from patients, 75% of the isolates were *M. tuberculosis* while 3% was *M. bovis*. Fadiran *et al* (1999) reported a case of the sternum caused by *M. bovis* in a 3-year old Nigerian (Fadiran *et al.*, 1999) supported the earlier findings of other authors. More recently, Abubakar (2007) in his work showed that there was a high prevalence of both bovine and human tuberculosis amongst herders in the Federal Capital Territory, Abuja. Ofukwu (2006) in his study covering hospitals in Benue State reported that 2.4% of 124 samples of pus, urine and sputum collected from patients were characterized as *M. bovis* while *M. tuberculosis* accounted for 82.3%. Another study by Ofukwu *et al.* (2008) on milk samples (*nono*) collected from a market in Benue State revealed the presence of *M. bovis*. These findings evoke serious public health concern taking into consideration the large proportion of the Nigerian population exposed to beef, milk and their products. Kovayov (1989) reported an isolation of *M. bovis* from sputum samples of patients with pulmonary TB Of 102 *M. tuberculosis* complex isolates 4 (3.9%) were *M. bovis* (Kovalyov, 1989). Another study by Livingstone (1992) in Nigeria reported that one of 10 mycobacterial isolated from sputum-positive cultures was *M. bovis*.

2.12. Economic Importance of *M. Bovis*

Bovine tuberculosis is considered by the World Organization for Animal Health OIE (2009) to be an important zoonotic disease of major socio-economic and public health importance, with an impact on international trade of animals and animal products. In dairy cattle, the disease causes weight loss (36%), decreased milk production (13%), and lowered reproductive rate (12%) (Suazo, *et al.*, 2003). The costs of diagnosis and treatment of cattle and humans and the costs of correct disposal of infected animal carcasses have an additional impact. The disease is re-emerging in a number of developed countries because of environmental changes, the movement of people and animals, closer inter-species contacts, and changes in animal management (Abalos and Retamal, 2004 and Miller *et al.*, 2006). The disease is a threat to wildlife conservation in sub-Saharan Africa as it affects several wildlife species especially African buffalo (*Syncerus caffer*) and Kafue lechwe Kobus (*leche kafuensis*), (Munyeme *et al.*, 2010). The disease is also associated with high mortalities that have linked to population reductions (Renwick *et al.*, 2007).

2.13. Risk Factors of *M. Bovis*

2.13.1. Risk factors of *M. bovis* in wildlife

Fencing or housing for wildlife zoos increases the rate of contact among animals which increases the chances of disease transmission. This may increase the chances of mating among close relatives, and contribute to a reduced genetic variability and reduced disease resistance. Moreover, fencing or housing is commonly associated with well known bTB risk factors such as feeding and translocation and high density (Gortazar *et al.*, 2006). Artificial feeding and watering causes spatial aggregation and allows maintaining ungulate densities above carrying capacity of a given habitat. Diseases prevalence has been linked to special aggregation and high densities

(Acevedo *et al.*, 2007; Vincente *et al.* 2007). Environmental factors such as forest availability have been associated with increased bTB risk in red deer and wild boar in central Spain (Vincente *et al.*, 2007). Miller *et al.*, (2003) suggested that woodland areas provide shady, moist conditions under which *M. bovis* might survive longer in the environment. Scavenging, including hunting gut pile consumption is most probably a significant risk factor for wild boar and carnivores. Infection through consumption of contaminated materials may increase the probability of contacting *M. bovis* (Gortazar *et al.*, 2008). Another risk factor is long life span. Some wildlife like female deer can live for up to two decades longer than any of the main hosts, deer infected while young can sometimes survive in an infected state for many years (Nugent, 2005). Latently infected deer acts as key temporal vector carrying bTB through time. Movement of wildlife from endemic area (deep forest) to the boundary between forest and farmland, where they are often die or are killed by hunters, feeding on the infected carcass by other wildlife or livestock may aid in spreading the disease (Byrom *et al.*, 2005). Proximity of cattle herd to forest parks remain a significant factor associated with easy contact between cattle and wildlife, hence increase risk of bTB transmission, translocation of wildlife from one park to another is also associated with increased risk of bTB transmission (Porphyre *et al.*, 2008).

2.13.2. Risk factors of *M. bovis* in humans

The existing eating culture (eating of raw meat and drinking of raw milk), close contact of animals with humans (most common in rural areas), inadequate meat inspection and the prevailing low standard of hygienic practices are potential risk factors that favour the spreading of zoonotic tuberculosis (Shitaye *et al.*, 2007). WHO (1992) reported that development and spread of multidrug resistant strains and increased immigrant population from infected area to free zone or communities have been reported to increase the risk of infection (WHO, 1992).

People with HIV/AIDS, other forms of immunosuppression and debilitating disorders such as chronic renal disease, cancer and diabetes, among others have been reported to be at risk of being infected on exposure to tuberculosis (Harries, 1990; Hamburg and Frieden, 1994). HIV induced immunosuppression could well lower the host defenses leading to overt disease after infection (Cosivi *et al.*, 1998b).

2.14. Wildlife Reservoir of *M. Bovis*

In some countries, the maintenance of *M. bovis* infection by a wildlife species has been the major impediment to eradication of bTB (Corner, 2006). The best known examples are bTB presence in possums (*Trichosrus vulpecula*) in New Zealand and White-tailed deer (*Odocoileus virginianus*) in Michigan, USA. feral cattle and buffalo in Australia, and in badgers (*Meles meles*) in Britain and Ireland (Corner, 2006). In south Africa, a substantial number of other wildlife species are also infected (Coleman and Cooke, 2001; Michel *et al.*, 2006; O'Brien *et al* 2006; Delahay *et al.*, 2007). Wild boar in the Iberian Peninsula (Portugal and Spain) (Vincente *et al.*, 2006). A single main wildlife host also capable of maintaining bTB as seen in White-tailed deer in Michigan and badgers in Britain (O'Brien, *et al* 2006; Delahay *et al.*, 2007). In one ecosystem a particular species may act as a maintenance host as seen in white-tailed deer in Michigan and wild boar in the Iberian Peninsula (Naranjo *et al.*, 2008) while in another ecosystem the same species may act as a spillover host as seen in white-tailed deer in Minasota, US. And feral pigs in Newzealand and Australia (Corner *et al.*, 1981; McInerney *et al.*, 1995; Cartensen and Doncarlos, 2011; Nugent *et al.*, 2011.). These different roles are likely due to factors such as animal density, environment, and contrasting agricultural and cultural practices (Daszak *et al.*, 2000). There are also small groups of species each of which may either independently or jointly contribute to

bTB persistence, as exemplified by the combination of wild boar (*S scrofa*) and red deer (*Cervus elaphus*) in part of Spain (Gortazar *et al* 2008). And possums and ferrets (*Mustela furo*) in some places in New Zealand (Caley and Hone, 2005). In some places large proportion of mammalian communities may be involved, as in South Africa where buffalo (*Syncerus caffer*) and greater kudu (*Tragelaphus strepsiceros*) are regarded as key sources of infection for a wide range of other species that have potential to contribute to bTB persistence (Renwick *et al.*, 2007). Establishment of these reservoirs is the result of factors such as spillover from domestic livestock, translocation of wildlife, supplemental feeding of wildlife, and wildlife population densities beyond normal habitat carrying capacities (Daszak *et al.*, 2000). As many countries attempt to eradicate the disease in domestic animals efforts are hampered by spillback from wildlife reservoirs. In these countries, eradication of bTB in domestic livestock will only be achieved through the concurrent control of the disease in the wildlife maintenance hosts. Partial control of the disease has been achieved by reducing the density of the animals or banning artificial feeding that causes local high density of animals (Griffin *et al* 2005; Livingstone *et al.*, 2006; O'Brien *et al.*, 2006). Where there is a desire to control or eliminate bTB in a multi-host complex, it is important to identify which species are the principal drivers of bTB persistence. Management of such species is essential. Other species may be infected but do not contribute to disease persistence as in the case for feral pigs (*Suis scrofa*) in Australia (McInerney *et al.*, 1995). Knowing which species are epidemiologically unimportant, and which therefore do not require management, is also crucial in avoiding wastage of control resources. This also results in avoiding the issue of killing or otherwise controlling wild animals (Haydon, 2008). Understanding host status both with or without management is therefore intuitively a critical first step in designing a programme for disease control in wildlife (Haydon, 2008). Wildlife species

can be classified as a maintenance host where infection can persist by intraspecies transmission alone or as a spillover host, where infection will not persist indefinitely unless there is re-infection from another species. Although both types of host act as disease vectors, control of the disease in the maintenance host should prevent the disease

Isolations of *M bovis* have been made from different species of domestic and wildlife (O'Reilly and Dabon, 1995; de Lisle *et al.*, 2002)

2.15. Factors Affecting *M. Bovis* Control and Eradication in Wildlife

Control and eradication of bTB in wildlife is inherently much more difficult than when only livestock are involved. This is due to many reasons like different wildlife species are involved in the transmission, the ecology of bovine tuberculosis is poorly understood, and difficulty in determining the distribution, movement, and numbers of wild animals with high accuracy (Abalos and Retamal, 2004). It is difficult to obtain adequate samples from wildlife populations to determine disease at low prevalence. The cost to capture wild animals for samples collection and testing is prohibitive and generally impractical. As a result postmortem samples are used which are equally not the ideal. Lack of specific diagnostic tests validated for use in wildlife species. Legislation that provides the authority for elimination of tuberculosis in livestock may not be applicable to wild animals. There are multiple stakeholders with different objectives, responsibilities, and views of the need for management. While there may be general support for the principle of tuberculosis eradication, there may be less support for specific methods (Dorn and Mertig, 2005). Furthermore due to resources of conservation, it is inherently difficult to reduce populations of many wild species, or to maintain them at low density, without using

methods that have low public acceptance. Management of disease may involve risks to biodiversity and ecological integrity that are unacceptable to large segments of the society.

CHAPTER THREE

MATERIALS AND METHODS

3.1. The Study Area

The Yankari Game Reserve is one of the largest wildlife parks located in the south-central part of Bauchi State in the North-East zone of Nigeria (Fig 1). It lies between latitude 9.750000 North and longitude 10.500005 West. It covers an area of about 2,244 km² and is home to several natural springs, as well as to a wide variety of flora and fauna. The Game Reserve is situated in the heartland of the West African savanna and has characteristic savanna vegetation, including swamps with river floodplains, grasslands, and thick bushes (Odunlami, 2000).

The Yankari Game Reserve was established as a game reserve in 1956 and designated a national park status in 1991 (Yankari National Park, 2000). As the most popular tourist destination in Nigeria, it is rich in wildlife, including baboons, crocodiles, elephants, giraffes, hippopotamuses, hyenas, leopards, lions, and several species of antelopes. It is also one of the most popular eco-destinations in West Africa (Ajayi *et al.*, 1975). The Yankari Game Reserve main entrance is at Mainamaji village, about 29 km from Dindima (Fig 2 and 3). It is located within the Duguri, Pali, and Gwana districts of Alkaleri LGA in Bauchi State. This LGA has a population 208,202 people occupying a total land area of 7,457.78 km². The park features four warm water spring and one cool water springs. Other Special features are ancient sandstone cisterns carved by former inhabitants for water storage, as well as cave dwellings and rock paintings (Olokesusi, 1990). The Game Reserve is an area of great natural beauty, providing crucial habitat to both animal and bird life. Its designation as a Game Reserve serves to protect the environment and

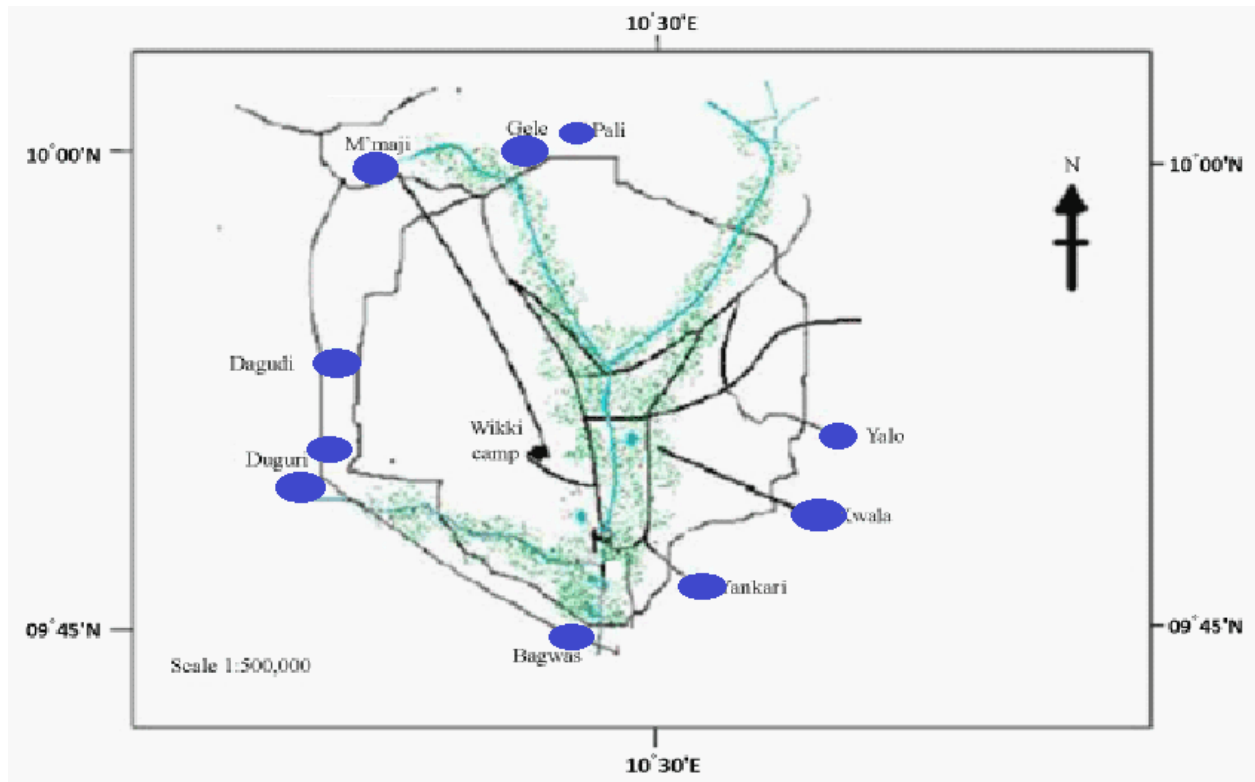
provide for recreational pleasure, at the same time contributing to the nation's economy being the largest tourist attraction It is an example of a symbiotic relationship where both man and creation benefit (Odunlami, 2003).

Annual rainfall in the Yankari Game Reserve is between 900 mm and 1,000 mm. The rainy season is from May to September. Temperatures range between 18⁰ C and 35⁰ C. (Nihotours, 2000). During the dry season, the larger wildlife species in the Yankari Game Reserve depend on the Gaji River and its tributaries for their water needs (Marshal, 1985). This river which serves as the only watershed in the Yankari Game reserve, divided it into two. The estimated expanse of the Gaji River valley used by the elephants in the dry season is at about 40 km² (Marshal, 1985). Yankari Game Reserve has four warm water springs, these springs' serves as water and feeding source for cattle and wildlife especially in the dry season. Feeding and watering causes spatial aggregation and allows maintaining wildlife densities in that area. Disease prevalence has been linked to spatial aggregation and high density (Falade, 1999; Acevedo *et al* 2007; Vicente *et al* 2007). As the Yankari Game Reserve has a fertile land, and lush grasses people living around it encroach into the area for the purpose of farming and livestock grazing activities. Sometimes people carry out hunting activities or collect fire wood from the reserve. Some wildlife enter the settlements around and destroy crops and animals (Yankari National Park, 2000) These levels of interactions between human, livestock and wildlife do facilitate the transmission of bTB between infected animal (domestic or wildlife) and or humans (WHO, 2009).



Fig 1. Map of Bauchi State showing LGAS and the location of Yankari Game Reserve



Bauchi State Map. Source <https://maps.google.com.ng/maps?hl=en&q=bauchi+state+map&ie=UTF-8&hq=&hnear=0x11074dbebe298d97:0x806bd2a58b5c2c3f,Bauchi&gl=ng&ei=C1A4UdybEonT0QW96oDQCA&sqi=2&ved=0CC0Q8gEwAA>



Source: <http://www.omicsgroup.org/journals/2167-6801/images/2167-6801-1-105-g001.html>

Fig. 2: Sketched map of YGR showing human settlements and major streams

Key

-  = Human settlements.
-  = Major streams.

3.2. Sample Size Determination

Convenience sampling and purposive sampling were used to select cattle and wildlife species respectively. Based on this 1000 samples were collected, consisting of 750 cattle and 250 wildlife.

3.3. Sampling Procedure

Convenience sampling was used to identify the herds to be sampled. Any herd with 10 cattle and above living around the Yankari Game Reserve was identified and from each herd blood samples were collected from cattle over 6 months of age. As for the wildlife species, identified animals were darted in order to collect blood samples. Sick wildlife under treatment by the resident veterinarian and captured wildlife staff and hunters were also used to obtain the samples.

3.3.1. Blood sample collection from cattle

The ages, sexes, and breeds of cattle that were sampled were recorded. The age was determined by the use of permanent incisors teeth as described by Pace and Wakeman (2003). The different breeds were determined by the use of body characteristics as described by Mason (1996), Tawah and Rege (1996), and Rege and Tawah (1999) for Red Bororo, Sokoto Gudali and White Fulani respectively. Sexes were also determined as described by Tawah and Rege (1996). Each animal was physically restrained and 5mls of jugular blood was obtained using a sterile disposable 10mls syringe to which an 18 G needle was attached (Plate 1). The syringe was kept in a slanting position to allow the serum to separate from the blood, the serum was carefully dispensed into a 20 ml sterile sample bottle and appropriately labeled. A total of 750 cattle were sampled. The samples were stored at National Veterinary Research Institute State office Bauchi. The samples

were then transported over ice to Protozoology Laboratory Department of Veterinary Parasitology and Entomology, Ahmadu Bello University Zaria, where they were stored at -20°C until used.

3.3.2. Blood sample collection from wildlife species

Blood samples were obtained from different wild animals associated with the Yankari Game Reserve. A total of 250 wildlife were sampled. Healthy and sick wildlife species located in the Reserve and as well as wild animals captured by hunters were sampled. Wild animals were chemically restrained using etorphine via dart gun administered by wildlife staff. Blood samples were then taken from the wildlife through the jugular vein and tarsal vein by the resident veterinarian during the sedation period. Serum were then separated from each sampled blood, appropriately labeled and stored at -20°C until used.

3.4. Sources of Test Kits

The Immunochromatography Test Kits. Rapid bTB Antibodies (RbTBAb) test kit - Bionote Incorporated (Seogu-dong, Hwaseong-si, Gyeonggi-do, South Korea) was used for the detection of *M. bovis* antibodies in the serum samples from sampled cattle and wildlife species. The RbTBAb test kit is based on a chromatographic immunoassay for the quantitative detection of IgG and IgM antibodies against *M. bovis* in serum, plasma, or whole blood. The MPB70 is a specie-specific protein produced by *M. bovis* and is a major antigen from culture filtrate protein of *M. bovis*. It has a sensitivity of 90% and a specificity of 98% (Wiker, 2009).

3.5. Laboratory Analysis

3.5.1. Serum analysis for *M. bovis* antibodies

The test kit has a sample hole and developing buffer hole (Plate 111). The serological test was carried out according to the manufacturer's instructions as follows;

- (a) Stored sera were removed from the freezer and allowed to thaw to room temperature
- (b) One drop of the test serum was added to the sample hole (S) using a capillary tube and after 1 minute, 3 drops of the developing buffer was added into the developing buffer hole
- (c) The result was interpreted within 20 minutes, and beyond 20 minutes the result was considered invalid

3.5.2. Interpretation of the test results

3.5.2.1. Positive results

The presence of two red color bands ('T' band and 'C' band) within the result window no matter which band appeared first indicated a positive result (Plate 1V). Even if the intensity of the red band color was faint, it was interpreted as positive result.

3.5.2.2. Negative results

The presence of only 1 red color band within the "C" result window indicated a negative result (Plate V).

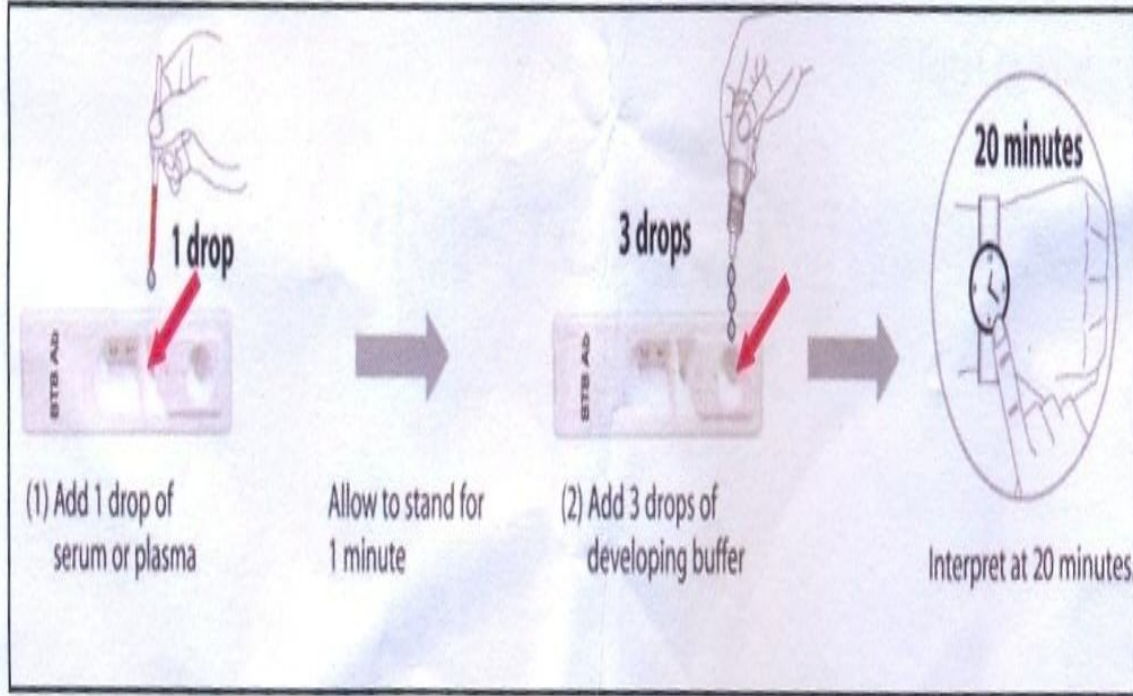


Plate 1: Steps in the procedure used in the application of the bTB Rapid Test Kit

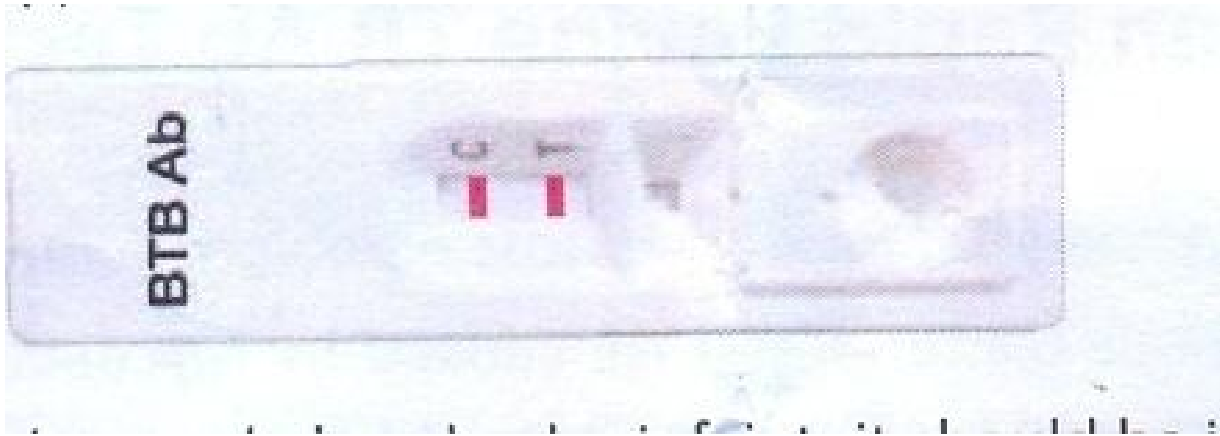


Plate 11: Positive test showing two red bands in the results window

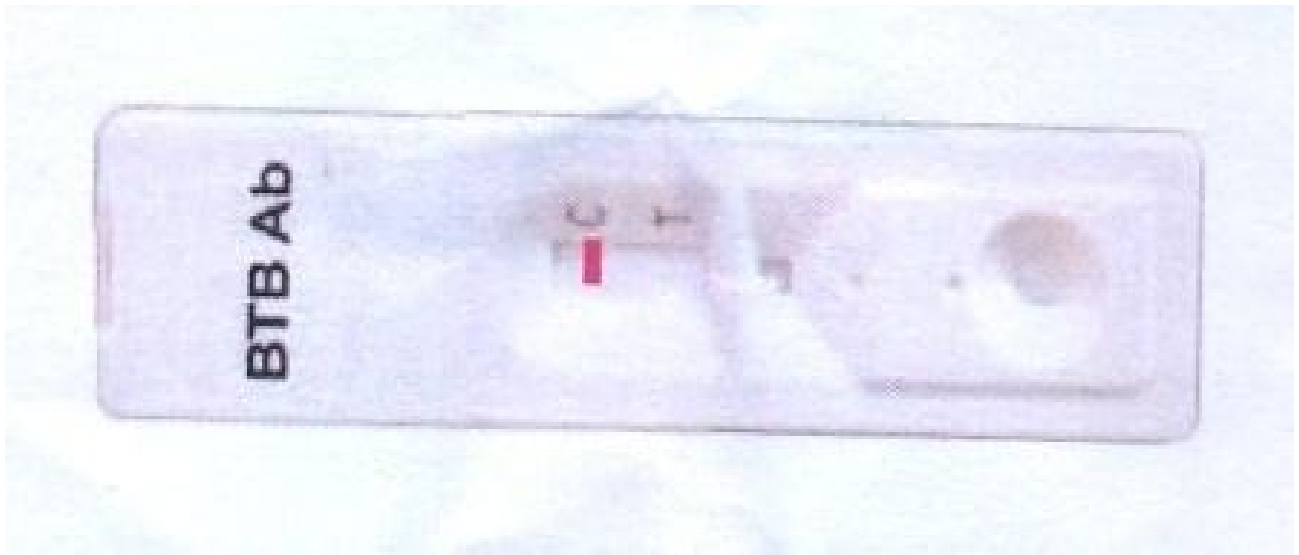


Plate III: Negative Test showing one red band in the result window

3.6. Data Analysis

Data obtained were expressed as percentages in tables and graphs where necessary. Chi square test was used to test for the association between the presence of antibodies and the age, sex, breed of cattle and wildlife type. Graphpadprism Version 4.0 for Windows (SanDiego, California, USA) was used for the data analysis, while the level of significance at 95% confidence interval and $P < 0.05$ was considered significant.

CHAPTER FOUR

RESULTS

4.1. Prevalence of *M. Bovis* in Cattle and Wildlife

A total of 1000 blood samples for sera were collected from cattle at the periphery of the Yankari Game Reserve and wildlife in the Reserve. These samples comprise 750 from cattle and 250 from wildlife. The sera were used for the determination of the presence of *M. bovis* antibodies using the rapid test kits from the results. Eighty eight (11.73%) of the 750 sera from cattle were positive, while 30 (12.0%) of the 250 sera from wildlife were similarly positive for *M. bovis* antibodies. (Table 4.1). There was no significant statistical difference in the infection of cattle and wildlife at the YGR. (Odd Ratio =0.9748 p=0.9101 and CI of 0.6268-1.516.

4.2. Prevalence of *M. Bovis* by Sex in Cattle

Of the 750 cattle sampled 585 were females while the remaining 165 were males. Of the 585 female cattle 66 (11.79%) were seropositive while 19 (11.79%) of the 165 male cattle were positive for *M. bovis* (Table 4.2). There was no significant statistical difference by sex in the prevalence of *M. bovis* among the cattle studied (OR =0.9232; p=1.00 and CI at 0.5670-1.670).

4.3. Prevalence of *M. Bovis* by Age in Cattle

Fourteen (11.77%), 45 (12.54%) and 29 (10.66%) cattle of the age brackets of 6 months to 2 years, 2 to 5 years and above 5 years respectively were seropositive for *M. bovis* (Table 4.3). There was no significant statistical difference of *M. bovis* among the different age groups of the cattle ($X^2=0.6103$, df=2 and p=0.7370).

4.4. Prevalence of *M. Bovis* by Breeds in Cattle.

The prevalence of *M. bovis* among the different breeds of cattle sampled is given in Table 4.4. Of the 750 serum sampled from cattle studied 19, 27 and 704 were from Red Bororo, Sokoto Gudali and White Fulani respectively. Among them 3 (15.79%), 5 (18.79%) and 80 (11.36%) Red Bororo, Sokoto Gudali and White Fulani cattle respectively were seropositive for *M. bovis*. (Table 4.4). There was no significant statistical difference among the breeds of cattle studied ($X^2=1.595$, $df=2$ and $p=0.4505$).

4.5. Prevalence of *M. Bovis* in Wildlife Species

Among the 250 wildlife studied 31 were Zebra, 10 Western Heart Beast, 15 Water Bucks, 20 Eland, 39 Antelopes, 40 of each of Baboons and African Giant Rats, 25 Hares, and 20 Grass cutters. (Table 4.5). Out of these 6 (19.38%) Zebras, 2 (10.0%) Elands, 3 (7.6%) Antelopes, 4 (10.0%), Baboons, 5 (15.0%) African Giant Rats, 3 (12.0%) Hares and 6 (30.0%) Grass cutters were seropositive for *M. bovis* (Table 4.5). Wildlife that were seronegative to *M. bovis* include Western Heart Beast and Water Bucks. There was no significant statistical difference among the wildlife that were seropositive for *M. bovis* ($p=0.1315$).

Table 4.1: Prevalence of *M. bovis* in cattle and wildlife at the periphery and in YGR, Bauchi State

Animal type	Total number sampled	No positive (%)	Odd Ratio	CI	P value
Cattle	750	88 (11.73)			
Wild life	250	30 (12.0)			
Total	1000	118 (11.8)	0.9748	0.6268-1.516	0.9101

Table 4.2: Prevalence of *M. bovis* by sex in cattle living at the periphery of YGR, Bauchi State.

Sex	Total number sampled	No positive (%)	Odd Ratio	CI	P value
Male	165	19 (11.5)			
Female	585	69 (11.8)			
Total	750	88 (11.73)	0.9732	0.5670-1.670	1.00

Table 4.3: Prevalence of *M. bovis* in cattle living at the periphery of YGR according to age groups.

Age	Total number sampled	No positive (%)	X²	df	P value
6 months to 2 yrs	119	14 (11.77)			
2 -5 years	359	45 (12.54)			
Above 5 yrs	272	29 (10.66)			
Total	750	88 (11.73)	0.6103	2	0.7370

Table 4.4: Prevalence of *M. bovis* in cattle living at the periphery of YGR, Bauchi State according to breeds.

Breed	Total sampled	Number (%) positive	X²	df	P value
Red Bororo	19	3 (15.79)			
Sokoto	27	5 (18.79)			
Gudali					
White Fulani	704	80 (11.36)			
Total	750	88 (11.73)	1.595	2	0.4505

Table 4.5: Prevalence of *M. bovis* in different species of wildlife in YGR, Bauchi State.

Wildlife species	Total number sampled	Number positive(%)	Total% positive	X²	df	P value
Zebra	31	6(19.35)	2.4			
Western Heart beast	10	0(0.0)	0.0			
Water bucks	15	0(0.0)	0.0			
Elands	20	2(10.0)	0.8			
Antelopes	39	3(7.6)	1.2			
Baboons	40	4(10.0)	1.6			
African Giant Rat	40	5(15.0)	2.0			
Hares	25	3(12.0)	1.2			
Grass cutters	20	6(30.0)	2.4			
Total	250	30(12.0)	12.0	13.75	9	0.1315

CHAPTER FIVE

DISCUSSION

From this study it was shown that bTB affects both cattle and wildlife. This was in agreement with Philips *et al.* (2001), de Lissle *et al.* (2002) and Delahay *et al.* (2007) who reported *M. bovis* infection in cattle and wildlife. The seeing of *M. bovis* in the wildlife in the YGR could be due to the entry of cattle resident in the periphery of YGR as attracted by the abundant grazing facilities in the Reserve. This is possible, especially during the dry season when grazing land in the community at the periphery of the Reserve could be said to be scarce (Yankari National Park, 2000). The fact that wildlife in the Reserve also migrate into the community beyond the Reserve could lead to their interaction with domestic animals, especially at the watering points.

Feeding of wildlife on dead carcasses could also lead to such wildlife becoming infected with *M. bovis* (Norton *et al.*, 2005). The habit of some people to have special interest in buying ‘bush meat’ may lead them to become infected with *M. bovis*, should the meat from such wildlife be infected with *M. bovis*. Similarly hunters may become infected with *M. bovis* through consumption of carcasses infected with *M. bovis*. This view was supported by Zuckerman (1980) and Griffin *et al.* (1996) that cattle could be exposed to *M. bovis* through smell, sniffing or licking discharges from dead or dying wildlife.

The findings of all ages and sexes of cattle with Seropositivity for *M. bovis* is in agreement with the reports of Bonsu *et al.* (2000). The fact that more females were sampled in the herds studied could be due to their greater number in the herds, since the males are normally sold, leaving the females for the reproduction and milk production (Zanini *et al.* 1998) Infection in calves could have resulted as a result of pseudo vertical transmission or through contaminated milk from the

dams. While close contact with such infected dams could also result in infection. This observation could be supported by the reports of Philips *et al.* (2003) and Ozygit *et al.* (2007) that calves could be infected from their dams through grooming and congenitally. The duration of exposure of susceptible animals with infected ones will certainly aggravate the infection as shown by Munroe *et al.* (1999) in a study in Ethiopia. The finding of *M. bovis* infection in some wildlife in this study, especially in Baboons is significant in view of the fact that these baboons are subject of attraction by the tourists coming to the YGR from far and near. Similar findings were also made by Sapolsky and Else (1977) in Masai Mara Game Reserve in Kenya, and Thoen *et al.* (1977) in the Biological Research Laboratory Primate Facility in the University of Illinois USA in Baboons. Such Baboons might have been infected by feeding on infected carcasses or coming into contact with contaminated feeds and water since all wildlife use the same feeding and especially the watering points for their livelihood as they can acquire the infection through close contact as the play with them. Daborn *et al.* (1997) similarly reported *M. bovis* in Eland in Zambia. It should be noted that even though the seroprevalence in low the dangers to the public is high since such animals may be caught by hunters and either be killed for consumption or sold by those who have interest in keeping such animals as a hobby. Zebras were found to be seropositive in this study. Their infection could be as a result of feeding on contaminated pastures or coming into contact with cattle at the watering points. Once infected it is foreseeable that carnivores like lions, sheeters and leopards in the YGR can be exposed to *M. bovis*, should they hunt them for their meals. This way the infection can spread to other carnivorous wildlife through close contact. The non finding of Seropositivity for *M. bovis* in Western Heart Beast and Water bucks could be as a result of their way of life. The finding of Hares and Grass cutters being seropositive for *M. bovis* is significant as these wild animals are usually liked by the

general public who find delicacies in eating 'bush meat' from these animals. Kantor *et al.* (1994) reported Hares being infected with *M. bovis* in Argentina and New Zealand. The Hares and Grass cutters in this study might have being infected through consumption of contaminated grasses at the periphery of the YGR since dead wildlife that might have died of the disease could release the organism in nature, especially that Hares are gregarious in their feeding habits (Kantor *et al.*, 1984). The fact that Elands and Antelopes were found to be seropositive for *M. bovis* in this study calls for closely attention in the habit of some people in raising them in their homes, should such Elands be infected with *M. bovis*. A great majority of such people are not aware of the dangers such infection could result in them.

CHAPTER SIX

SUMMARY, CONCLUSIONS, RECOMMENDATIONS AND LIMITATIONS

6.1. Summary

In this study to determine the prevalence of *M. bovis* in cattle living at the periphery of the Yankari Game Reserve of Bauchi State Nigeria and the wildlife living within the Reserve showed that of the 750 cattle and 250 wildlife examined 88 (11.73%) and 30 (12.0%) of the cattle and wildlife respectively were seropositive for the Mycobacterium.

The presence of lush pastures, streams and water springs are the major reasons that cattle encroached into the Game Reserve, especially during the dry season for the purpose of grazing and watering activities. Contact between cattle and wildlife at the grazing and watering sites, or indirect contact with feces, urine and wound discharges contaminated with *M bovis* might have served as a source of transmission of *M bovis* between cattle and wildlife.

There was no significant statistical difference between age, sex, and breed of cattle and bTB infection ($P>0.05$). This showed that bTB affect cattle irrespective of age sex and breed. In terms of age the younger ones age 6 months to 2 years might have become infected through ingestion of contaminated colostrum/milk from their dams. Older cattle (2 years and above) were more likely to have been exposed than younger ones, due to longer period of life, they had higher probability to have come into contact with more contiguous herds at grazing and watering sites and this increase the risk of cattle-to-cattle transmission.

The cows were probably infected due to the fact that the herders kept more female for the purpose of breeding and milk production.

In terms of breeds, white Fulani cattle were the predominant breeds compared with other breeds (Red Bororo and Sokoto Gudali). They have large herd size as a result grazed in large areas as a result might have come into contact with other contiguous herds at grazing and watering sites leading to transmission of bTB between the infected and susceptible cattle. The Red Bororo and Sokoto Gudali due to their small size were confined in an enclosure, especially in the night this might have led them to be congregated in a small area, hence increased contact among them, leading to increase aerosol transmission of infection and individual with high disease prevalence might be encountered.

The YGR has different species of wildlife, but only, Zebras, Elands, Antelopes, Baboons, African Giant Rats, Hares and Grass cutters showed positive for *M bovis*. Some of the wildlife are gregarious (Hares, Grass cutters, African Giant Rats and Antelopes) while others are carnivorous (Zebras, Elands) others are omnivores (Baboons) gregarious ones might have become infected by ingestion of pastures contaminated with *M bovis*, while the carnivores were infected by ingestion of contaminated carcasses while omnivores might become infected by ingestion of contaminated pastures and carcasses. Supplemental feeding or baiting practice in the Reserve leads to aggregation of wildlife this also helps in the spread of *M bovis*.

6.2. Conclusions

This study showed that

- Cattle grazing at the periphery of YGR exhibit *M. bovis* antibodies
- Wildlife in the Yankari Reserve exhibit *M. bovis* antibodies
- Cattle might have served as a source of infection to wildlife at grazing and watering points and vice versa.

- The high prevalence of *M. bovis* in cattle and wildlife is of public health significance to those living at the periphery of the Game Reserve and tourists due to possible transmission to humans.
- No significant statistical difference between age, sex, and breed of cattle and bTB infection ($P > 0.05$). This indicated that bTB could affect cattle irrespective of age, sex and breed, hence making it one of the most versatile infectious diseases

6.3. Recommendations

- Bauchi State Government should provide logistics for active surveillance against illegal encroachment of cattle, hunting and poaching.
- There is the need to screen cattle for bTb at the periphery of the Game Reserve and removal of positive animals from the herds
- Watering points should be provided especially in the dry season to those herders living at the periphery of the Game Reserve to reduce contact between cattle and wildlife.
- Contact between baboons and staff or tourists should be discouraged to forestall possible transmission of *M. bovis* to humans.
- Public enlightenment of herders on the dangers of this disease is advocated
- There should be annual programme of capture and testing of wildlife in YGR
- Positive wildlife that were transported to various zoos, should be investigated
- Further study is required for isolation and characterization of *M. bovis* in cattle, humans and wildlife in the Game Reserve.

6.4. Limitations of the Study

- It was difficult to obtain adequate samples from wildlife populations; blood collection from wildlife was relied from treated wildlife from the resident veterinarian, and wildlife capture from hunters.
- The risk and cost of capturing wild animals for in vivo testing was high.

REFERENCES

- Abalos, P. and Retamal, P.(2004). Tuberculosis: zoonosis re-emergente? *Rev Sci Tech* 23: 583–594.
- Abubakar, U. B., Ameh, J. I., Abdulkadir, I. A., Salisu, I., Okaiyeto, S. O. and . Kudi, A. C.(2011). Bovine Tuberculosis in Nigeria. A review. *Veterinary Research Journal*, 4: 24-247
- Abubakar, I. A. (2007). Epidemiology of human and bovine tuberculosis in Federal Capital Territory and Kaduna State of Nigeria. A PhD thesis, University of Plymouth, U.K.
- Acevedo, P., Vincente, J., Hofle, U., Cassinello, J., Ruiz-Fons, F. and Gortazar, C .(2007). Estimation of European wild boar relative abundance and aggregation; a novel methods in epidemiological risk assessment *Epidemiology of Infectious disease*. 135,519-527
- Acha, P. N. and Szyfres, B. (1987). Zoonosis and communicable diseases common to man and animals (2nd ed). Washington DC, *Pan American Health Organization Publication*, 503: 963
- Ajayi, S.S., Milligan, K. R.N. and Ulansky, G.(1975). The wildlife of Nigeria: a guide to Yankari Game and Borgu Game Reserves(Ibadan): Dept of Forest Resources Management, University of Ibadan, Nigeria
- Alemayehu, R., Girmay, M. and Gobena, A. (2008). Bovine tuberculosis is more prevalent in cattle owned by farmers with active tuberculosis in central Ethiopia. *The Veterinary Journal* 178; 119-125
- Alhaji, I. (1976). Bovine Tuberculosis: A general review with special reference to *Nigeria*. *Veterinary Bulletin*, 46(11): 829-841.
- Ameni, G., Aseffa, A., Engers, H., Young, D., Hewinson, G. and Vordermeier, M.(2006). Cattle husbandry in Ethiopia is a predominant factor affecting the pathology of bovine tuberculosis and gamma interferon responses to mycobacterial antigens. *Clin. Vaccine Immunol*. 13:1030–1036.
- Anderson, R. M. and Trewhella, W. (1985). Population dynamics of the badger(*Meles meles*) and the epidemiology of bovine tuberculosis(*M.bovis*).*Philos Trans R Soc, London(Biol)*, 310: 327-381.
- Anigen Rapid Bovine TB Ab Test Kit; Cat No: RB 23-02 (2011). In diagnostic Test Kits for Industrial Animal: Bionote Product catalog; 3rd Ed CIA03-03, BioNote Incorporated. Seogu-dong Hwaseong-si, Gyeonggi-do. Korea. (445-170).
- Anonymous.(2006). European Food Safety Authority reports on zoonotic diseases in the European Union. *Veterinary. Records*. 2006;158:2.

- Artois, M., Loukiadis, E., Garin-Bastuji, B., Thorel, M. F. and Hars, J.(2004). Infection of wild mammals with *M. bovis*, risk of transmission in domestic cattle French Agency for health security and food. *Bulletin of Epidemiology* ,13; 1-3
- Ashford, R. W. (1997). What it takes to be a reservoir host. *Belgium Journal of Zoology*. 127, 85-90
- Awah-Ndukum, J., Kudi, A. C.,Bah, G.S., Bradley, G., Tebug, S.F., Dickmu, P.I., Njakoi, H.N. and Agharih, W.N(2012).Bovine tuberculosis in Cattle in the Highlands of Cameroon: Seroprevalence estimates and Rates of Tuberculin Skin Test Reactors at Modified Cut-offs. *Veterinary Medicine International*, 2012 : 1-13 Article ID 798502.doi:10.1155/2012/798502
- Ayele, W. Y., Neill, S. D., Zinsstag, J., Weiss, M. G. and Pavlik, I. (2004). Bovine tuberculosis an old disease but a threat to Africa. *International tuberculosis Lung Diseases*, 8: 924-937
- Barlow, N.D.(1997). A simulation model for the spread of bovine tuberculosis within New Zealand cattle herds. *Prev. Vet. Med*, 32:57–75.
- Bauchi State map. Source;
<https://maps.google.com.ng/maps?hl=en&q=bauchi+state+map&ie=UTF-8&hq=&hnear=0x11074dbebe298d97:0x806bd2a58b5c2c3f,Bauchi&gl=ng&ei=C1A4UdyEonT0QW96oDQCA&sqi=2&ved=0CC0Q8gEwAA>
- Begon, M. (2008). Effect of host diversity on disease dynamics In; Ostfeld, S., Keesing F, Eviner V T, (Eds). *Infectious Disease Ecology; Effects of ecosystems on disease and of Disease on Ecosystem*. Princeton University Press, *NewZealand Journal*, page 12-29.
- Bello, U.A., Kudi, A.C.,Abdulkadir, I.A., Okayeto, S.O. and Ibrahim, S.(2012).Prevalence of tuberculosis in slaughter camels(*Camelus dromedarus*) based on post mortem meat inspection and Zeihl-Neelsen stain in Nigeria. *Journal of Camel Practice and Research*, 19: 1-4
- Bengis, R.G., Kriek, N.P.J., Keet, D.F., Raath, J. P., De Vos ,V. and Huchzermeyer, H.F.A.K. (1996). An outbreak of tuberculosis in a free-living African buffalo (*Syncerus caffer*, Sparrman) population in the Kruger National Park: A preliminary report. *Onderstepoort Journal Veterinary Research*, 63: 15.
- Bengis, R.G., Kock, R.A. and Fischer, J. (2002). Infectious animal diseases, the wildlife/livestock interface, *Revue Scientifique d'OIE*, 21: 53-65

- Bengis, R. G. and Keet, D. F. (1998). - Bovine tuberculosis in free-ranging kudu (*Tragelaphus strepsiceros*) in the Greater Kruger National Park Complex. *In Proc. Agricultural Research Council-Onderstepoort/Office International des Epizooties International Congress with World Health Organization co-sponsorship on anthrax, brucellosis, contagious bovine pleuropneumonia, clostridial and mycobacterial diseases, 9-15 August, Berg-en-Dal, Kruger National Park, South Africa. Onderstepoort Veterinary Institute, Onderstepoort, 418-421.*
- Bhansali, S.K. (1977). "Abdominal tuberculosis. Experiences with 300 cases". *America. Journal of Gastroenterology*. 67 (4): 324–37.
- Boland, F., Kelly, M. and More, S. J.(2010).Bovine tuberculosis and milk production in infected dairy herds in Ireland, *Preventive Veterinary Medicine*, 93: 153-161.
- Bonah, C. (2005). "The 'experimental stable' of the BCG vaccine: safety, efficacy, proof, and standards, 1921–1933". *Stud Hist Philos Biol Biomed Sci* 36 (4): 696–721.
- Bonsu, O. A., Laing, E. and Akanmori, B. D.(2000).Prevalence of tuberculosis in cattle in the Dagme-West district of Ghana, public health implication. *Acta Tropical Journal*, 76: 9-14
- Botswana National Tuberculosis Program. Annual report, Epidemiology Section. Gaborone, Botswana. Ministry of Health. 1999
- Bouvet, E., Casalino, E. and Mendoza-Sassi, G.(1993). A nosocomial outbreak of multidrug-resistant *M. bovis* among HIV infected patients. A case-control study. *AIDS*, 7: 1453-1460
- Briones, V. , de Juan, L., Sanchez, C., Vela, A. I., Galka, M., Montero, N., Goyache, J., Aranaz A., Mateois, A. and Dominguez, L. (2000). - Bovine tuberculosis and the endangered Iberian lynx. *Emerg. infect. Dis.*, 6, 189-191.
- Brosch, R., Gordon, S. V. and Marmiesse, M. (2002) A new evolutionary scenario for the *Mycobacterium tuberculosis* complex. *Proceedings of the National Academy of Sciences of the United States of America*. 99(6), 3684–3689.
- Brown, J. A., Harries, S. and White, P.C.L.(1994). Persistence of *M.bovis* in cattle. *Trends in Microbiology*, 2: 43-46.
- Brown, W. H., Hernández de. and Anda, J.(1998). Tuberculosis in adult beef cattle of Mexican origin shipped direct-to-slaughter into Texas. *Journal America Veterinary Medical Association* 212: 557–559.

- Byrom, A., Nugent, G. and Yockney, I. (2005). The role of ferrets in landscape-scale spread of bovine TB in the high country of New Zealand's South Island. In: Proceeding of the 13th Australian Vertebrates pest conference, Te Papa, Wellington, pp 262-266.
- Buddle, B. M., Wedlock, D. N., Denis, M., Vordermeier, H.M. and Hewinson, G. (2011). Update on vaccination of cattle and wildlife populations against tuberculosis. *Veterinary Microbiology*, 151: 14-21
- Buddie, B. M., Nolan, A., McCarthy, A. R., Heslop, J., Aldwell, F. E., Jackson, R. and Pfeiffer, D.U. (1995). Evaluation of three serological assays for the diagnosis of *Mycobacterium bovis* infection in brushtail possums. *N.Z. vet. J.*, 43, 91-95.
- Cadmus, S .B., Atsanda, N. N., Oni, S. S. and Akang, E.E. (2004). Bovine tuberculosis in one herd in Ibadan, Nigeria. *Czech Journal of Veterinary Medicine*, 49: 406-412
- Cadmus, S. I., Adesokan, H. K., Jenkins, A. O. and Vansoolingen, D. (2009). *Mycobacterium bovis* and *M. tuberculosis* in goats, Ibadan, Nigeria. *Emergent Infectious Diseases*, 15(12); 2066-2067
- Caley, P. and Hone, J. (2005). Assessing the host disease status of wildlife and the implication for disease control *M.bovis* infection in feral ferret. *Journal of Applied Ecology* ,42:708-718
- Carmichael, J. (1938). Tuberculosis investigation in Uganda. *East Afr. med. J*, 15; 220-231.
- Cartensen, M. and DonCarlos, M. W. (2011). Preventing the establishment of a wildlife disease reservoir; A case study of a bovine tuberculosis in wild deer in Minasota, USA. *Veterinary Medicine International*, vol. 2011 page 1-10
- Cassidy, J. P. (2006). The pathogenesis and pathology of bovine tuberculosis with insight from studies of tuberculosis in humans and laboratory animals models, *Veterinary Microbiology*, 112: 151-161
- Clancey, J. K. (1997). The incidence of tuberculosis in lechwe (Marsh Antelope). *Tubercle*, 58, 151-156.
- Cleaveland, S., Shaw, D. J., Mfinanga, S. G., Shirima, G., Kazwala, R. R., Eblate, E. and Sharp M. (2007). *M. bovis* in rural Tanzania: risk factors for infection in human and cattle populations. *Tuberculosis*. 87: 30-43.
- Coleman, J. D. and Cooke, M. M. (2001). *M. bovis* infection in wildlife in New Zealand. *Tuberculosis* 81: 191-202.

- Collins, C. H. and Grange, J. M.(1987). Zoonotic implications of *M.bovis* infection. *Ireland Veterinary Journal*, 41: 363-366.
- Collins, C. H. and Grange, J. M.(1983). A review. The bovine tubercle bacillus. *Journal of Applied Bacteriology*, 55: 825-826
- Comstock, G. (1994). "The International Tuberculosis Campaign: a pioneering venture in mass vaccination and research". *Clinical Infectious Diseases* **19** (3): 528–40
- Corner, L. A., Barrett, R. H.and Leper, A.W. (1981). A survey of mycobacteriosis of feral pigs in the Northern Territory, *Australian Veterinary Journal*, vol 57 page 537-542
- Corner, L.A. (2006). The role of wild animal populations in the epidemiology of tuberculosis in domestic animals, how to assess the risk. *Veterinary Microbiology*. 112: 302-312.
- Cornuzi, I., Fitting, J. W., Beer, V. and Chave, J. P. (1991).*Mycobacterium bovis* and Cosivi, O., Grange, J.M., Daborn, C.J., Raviglione, M.C., Fujikura, T., Cousins, D., Robinson, R.A., Huchzermeyer, H.F., de Kantor, I and Meslin, F.X .(1998). Zoonotic tuberculosis due to *Mycobacterium bovis* in developing countries. *Emerg. Infect. Dis.*, 4: 1-17.
- Coryn, H. D.(2006). Badgers, tuberculosis and modern farming practice. *Veterinary Record*. 158: 604.
- Cross, M. L., Labes, R. E., Griffin, J. F. and Mackintosh, C.G.(2000). Systemic but not intra-intestinal vaccination with BCG reduces the severity of tuberculosis infection in ferrets.
- Cosivi, O., Grange, J. M., Daborn, C. J., Raviglione, M.C., Fujikura, T., Cousins, D, Robinson, R. A., Huchzermeyer, H. F., de Kantor, I. and Meslin, F. X. (1998a). Zoonotic tuberculosis due to *M.bovis* in developing countries. *Emergent Infectious Diseases* 4: 59–70.
- Cosivi, O., Grange, J.M., Daborn, C. J., Raviglione, M.C., Fujikura, T., Cousins, D., Robinson, R.A., Huchzermeyer, H. F., de Kantor, I, and Meslin, F.X. (1998b). Zoonotic tuberculosis due to *M.bovis* in developing countries. *Emergence Infectious Diseases*, 4: 1-17.
- Cousins, D. V. and Dawson, D. J. (1999). Tuberculosis due to *M.bovis* in the Australian population; cases recorded during 1970-1994. *International Journal of Tuberculosis and Lung diseases*, 3: 715-721.
- Coombs, R.R.A. and Gell, P.G.P.(1975). Classification of allergic reactions responsible for clinical hypersensitivity and disease, In; *Clinical Aspects of Immunology*. Edited by Gell, P.G.H, Coombs, R.R.A. and Lachmann, P.J., Blackwell Scientific Publication,Oxford, 3rd Edition. p.761.

- Cowley, G., Lenard, E. A. and Hager, M. A.(1992). A deadly return. *Newsweek*, March 16: 53-57.
- Danbirni, S. (2009). Detection of *M.bovis* antibodies using Immunochromatographic Quantitative Rapid Test in four yoghurt producing herds in Kaduna and Environs, Nigeria. Student MSc thesis, Dept of Vet Med. ABU Zaria.
- Daborn, C. J. and Grange, J. M.(1993).HIV/AIDS and its implications for the control of animal tuberculosis. *Britain Veterinary Journal*, 149: 405-417
- Daborn, C. J., Grange, J. M. and Kazwala, R. R. (1997). The bovine tuberculosis cycle an African perspective. *Journal of Applied Bacteriology*. 81: 27S-32S.
- Daszak, P., Cunningham, A. A. and Hyatt, A. D.(2000). Emerging infectious disease of wildlife threats to biodiversity and human health. *Science Journal* vol 287 page 443-449
- Delahay, R J., Smith, G. C., Barlow, A .M., Walker, N., Harris, A., Clifton-Hadley, R S. and Cheaseman, C .I.(2007). Bovine tuberculosis infection in wild mammals in the south-west region of England: a survey of prevalence and a semi-quantitative assessment of the relative risks to cattle. *Veterinary Journal*. 173: 287-301.
- de Kantor, I.N., de la Vegas, E. and Bernadelli, A. (1984). Infeccion por *M.bovis* en liebres en la provincial de Buenos Aires, *Argentina. Rev Med Vet*, 65: 268-270.
- De la Rua-Domenech, R., Goodchild, A.T., Vordermeier, H.M., Hewinson, R. G., Christiansen, K. H. and Clifton-Hardley, R. S. (2006). Ante mortem diagnosis of tuberculosis in cattle, a review of the tuberculin tests, gamma interferon assay and other ancillary diagnostic techniques, *Research in Veterinary Science*, 81: 190-210
- De Lisle, G., Bengis, R., Schmitt, S. and O'Brien, D. (2002) Tuberculosis in free-ranging wildlife: detection, diagnosis and management. *Rev Sci Tech Office International Epizootic* 21: 317–33
- de Lisle, G .W., Mackintosh, G .C. and Bengis, R. G. (2002).*M.bovis* in free ranging and captive wildlife, including , farmed deer. *Revised Science Teaching. O.I.E.* 20, 86-111.
- De Lisle, G. W., Yates, G. F. and Collins, D. M. (1993). -Paratuberculosis in farmed deer; case reports and DNA characterization of isolates of *Mycobacterium paratuberculosis*.*J. vet. diagn. Invest*, 5, 567-571.
- Doran, P., Carson, J., Costello, E. and More, S. J.(2009). An outbreak of tuberculosis affecting cattle and people on an Irish dairy farm, following the consumption of raw milk. *Irish Veterinary Journal*, 62(6) : 390–397

- Dorn, M. L. and Mertig, A.G.(2005). Bovine tuberculosis in Michigan: Stakeholder attitudes and implications for eradication efforts. *Wildlife Social Bulletin*. 33: 539–552.
- Duffield, D. L. and Young, D. A.(1985). Survival of *M.bovis* in defined environmental conditions, *Veterinary Microbiology*, 10: 193-197
- Etter, E., Donado, P., Jori, F., Caron, A., Goutard, F.and Roger, F.(2006).Risk analysis and bovine tuberculosis, a re-emerging zoonosis. *New York. Academic of Science*. 1081, 61–73.
- Fadiran, O.A., Kintan, B.and Oluwole, S. F. (1999). Tuberculous orchitis coexisting with tuberculosis of the sternum-case report. *Central Afr. J.Med*, 45(2): 45-47.
- Falade, O (1999). Understanding tourism in Nigeria. Ibadan: JIS Printing Press. ISBN 9789782906175
- Fanning, A. and Edwards, S. (1991). Mycobacterium infection in human beings in contact with elk(*Cervus elaphus*) in Alberta, *Canada, Lancet*, 339: 1253-1255
- Farm Crisis Network.(2009).http://www.farmcrisisnetwork.co.uk/latestnews/stress-and-loss_a_report-on-the-impact-of-bovine-tb-on-farming-families.
- Ferber, D. (2000) Human diseases threaten great apes. *Science*. 289: 1277–8.
- Fine, A. E., Bolin, J. C. and Gardiner. (2011). A study of the persistence of *M.bovis* in the environment under Natural Weather Condition in Michigan, USA, *Veterinary Medicine International*, 2011: 765430.
- Food Safety Authority of Ireland (FSAI) (2008). Zoonotic Tuberculosis and Food Safety, 2nd Edition. Food Safety Authority of Ireland,Abbey Court, Dublin 1, Ireland.
- Francis, J.(1947). Bovine tuberculosis including a contrast with human tuberculosis. London; Staples press Ltd page 220
- Gallagher, J., Monies, R., Gavier-Widen, M. and Rule, B. (1998). Role of infected, non-diseased badgers in the pathogenesis of tuberculosis in the badger. *Vet. Rec.*, 142, 710-714.
- Garnett, B .T., Delahay, R. J. and Roper, T. J. (2002).Use of cattle farm resources by badgers (meles meles) and risk of bTB transmission to cattle. *Proceedings of the Royal society Biology*, 1269 : 1487-1491

- Gary, W. (2009). Bovine Tuberculosis in Canadian wildlife: an updated history review article compte rend. *Canadian Veterinary Journal*, 50(11):1169–1176.
- Gavier-Widen, D., Cooke, M., Gallagher, J., Chambers, M. and Gortazar, C. (2009). A review of infection of wildlife hosts with *M. bovis* and the diagnostic difficulties of the “no visible lesion” presentation. *New Zealand Veterinary Journal*, 57(3): 122–131.
- Georghiou, P., Patel, A. M. and Konstantinos, A. (1989). *M. bovis* as an occupational hazard in abattoir workers. *Australian, New Zealand Journal of Medicine*, 19: 701-703
- Gezahegne, M. K., Fekadu, A., Yalelet, W., Mengistu, L., Girmay, M., Gunner, B. and Gobena, A. (2012). Tuberculosis in goats and sheep in a far pastoral Region of Ethiopia and isolation of *Mycobacterium tuberculosis* from Goats. *Veterinary Medicine International* 2012;Pg 8.
- Gilbert, M., Mitchell, A., Bourn, D., Mawdsley, J., Clifton-Hardley, R. and Wint, W.(2005). Cattle movements and bovine tuberculosis in Great Britain. *Nature Journal* 435: 491-496
- Gortazar, C., Acevedo, P., Ruiz-Fons, F. and Vincente, J. (2006). Disease risks and overabundance of game species. *European Journal of Wildlife Resources*. 52,81-87.
- Gortazar, C., Torres, M. J., Vincente, J., Acevedo, P., Reglero, M., de la Fuente, J., Negro, J. J. and Aznar-Martins, J. (2008). Bovine tuberculosis in Donana Biosphere Reserve; The role of wild ungulate as disease reservoirs in the last *Iberian lynx stronghold*. 10,137.
- Grange, J. M. (2001). *M.bovis* infection in human beings. *Edinburgh Journal Tuberculosis*, 81, 71–77.
- Greenwald, R., Lyashchenko, O., Esfandiari, J., Miller, M., Mikota, S., Olsen, J. H., Ball, R., Dumonceaux, G., Schmitt, D., Moller, T., Payeur, J. B., Harris, B., Sofranko, D., Waters, W.R. and Lyashchenko, K.P. (2009). Highly Accurate Antibody assays for early and rapid detection of tuberculosis in African and Asian elephants. *Clin. Vaccine Immunol.*, **16** (5), 605–612
- Greenwald, R., Esfandiari J., Lesellier S., Houghton R., Pollock J., Aagaard C., Andersen P., Hewinson, R.G., Chambers, M. and Lyashchenko, K. (2003). Improved serodetection of *M.bovis* infection in badgers (*Meles meles*) using multiantigen test formats. *Diagn. Microbiol. Infect. Dis.*, **46** (3), 197–203.
- Griffin, J. F., Mackintosh, C.G. and Slobbe, S. (1999). Vaccine protocols to optimize the protective efficacy of BCG, *Journal of Tuberculosis and Lung diseases*, 79: 135-143

- Griffin, J. F. T., Mackintosh, C. G, and Rogers, C.R. (2006). Factors influencing the protective efficacy of a BCG homologous prime-boost vaccination regime against tuberculosis vaccine, 24: 835-845.
- Griffin, J. M., Hahesty, T., Lynch, K., Salman, M. D., McCarthy, J. and Hurley, T. (1993). The association of cattle husbandry practices, environmental factors and farmers characteristics with the occurrence of chronic bovine tuberculosis in dairy herds in the Republic of Ireland, *Preventive Veterinary Medicine*, 17: 145-160
- Griffin, J M., More, S J., Clegg, T A., Collins, J D, O'Boyle, I.,William, D.H., Kelly, G. E., Costello, E., Sleeman, D. P.(2005). Tuberculosis in cattle , the result of the four area project. *Ireland Veterinary Journal*.58,629-636
- Griffin, J. M., Martin, S. W., Thorburn, M. A., Eves, J. A. and Hammond, R. F.(1996).A case-control study on the association of selected risk factors with the occurrence of bovine tuberculosis in the Republic of Ireland. *Preventive Veterinary. Medicine*, 27:75–87.
- Griffin, J.M. and Dolan, L. A. (1995). The role of cattle-to-cattle transmission of *M.bovis* in the epidemiology of tuberculosis in cattle in the Republic of Ireland: a review. *Irish Veterinary Journal*, 48, 228–234.
- Grooms, D. and Molesworth, J.(2000). The Comparative Cervical Tuberculin Test. Michigan State University Extension. Bovine TB Notes. *Extension Buletin* E-2731.
- Grosset, J. (2003). "*Mycobacterium tuberculosis* in the extracellular compartment an underestimated adversary". *Antimicrobial Agents Chemotherapy* 47 (3): 833–6. doi:10.1128/AAC.47.3.833-836.2003
- Guilbride, P. D. L., Rollinson, D. H. L., McAnulty, E. G., Alley, J. G. and Wells E.A. (1963). - Tuberculosis in the free living African (Cape) buffalo (*Syncerus caffer caffer*, Sparrman). *J. comp. Pathol*, 73, 337-348.
- Hamburg, M. A. and Frieden, T. R. (1994). Tuberculosis transmission in the 1990s. *New Zealand Journal of Medicine*. 330; 387-390.
- Haagsma, J. (1993). Working Paper on Recent Advances in the Field of Tuberculosis Control and Research. World Health Organization Meeting on Zoonotic Tuberculosis with Particular Reference to *M.bovis*, 15 November 1993, Geneva, Switzerland.
- Harries, A. D. (1990). Tuberculosis and human immunodeficiency virus (HIV) in developing countries. *Lancel*. 335; 387-390.

- Haruna, E., Kudi, A. C., Bello, M, and Ajogi, H. (2012). Detection of *M.bovis* infection using the lateral flow technique in small ruminants in Kaduna state, Nigeria. Student Thesis 2012
- Haydon, D. T. (2008). Cross-disiplinary demands of multihost pathogens. *Journal of Animal Ecology* 77, 1079-1081.
- Hector, J. and Weisner, H. (1996).Recent studies on ballistic of remote injection system. Proceedings of the first meeting of the European Association of Zoo Veterinarians, 129-133
- Hetron, M. M., Victor, S., Wigganson, M., Andrew, N., John, B.M., Aaro, S.M. and Musso,M. (2011) Comparative intradermal tuberculin testing of free-ranging African Buffaloes(*Syncerus caffer*) captured for ex situ.conservaion in the Kafue basin ecosystem in *Zambia Veterinary Medicine International*, 2011: 1-5.
- Hiko, A. and Agga, G. E. (2011). First-time detection of Mycobacterium species from goats in Ethiopia. *Tropical Animal Health Production* 43: 133-139
- Hilsberg, S. and Van Hoven, W. (1999). - Tuberculosis in wild animals in Africa: a review with special reference to the Kruger National Park. *Infect Dis. Rev.*, 1, 248-252.
- Houben, E., Nguyen, L. and Pieters, J. (2006). "Interaction of pathogenic mycobacteria with the host immune system". *Curr Opin Microbiol* 9 (1): 76–85.
- HPA(Health Protection Agency 2009). Reducing the risk of human M.bovis infection Information for farmers.
<http://www.hpa.org.uk/webw/HPAweb&Page&HPAwebAutoListName/PAge/1204619502284?p=1204619502284>. Accessed on 28th October 2012
- <http://www.omicsgroup.org/journals/2167-6801/images/2167-6801'1'105-goo1.html>
- Huitema, H.(1963).The eradication of bovine tuberculosis in the Netherlands and the significance of man as a source of infection in cattle. The royal Netherlands tuberculosis Association, selected papers, 12: 870-874
- Idrisu, A. and Schnurrenberger, P. (1977). Public health significance of bovine tuberculosis in four northern states of Nigeria: a mycobacteriologic study. *Nigerian Medical Journa*,7:384-7.
- Jackson, R., De Lisle, G. W. and Morris, R. S.(1995). A study of the environmental survival of *M.bovis* on a farm in New Zealand. *New Zealand. Veterinary Journal*, 43:346–352.
- Johnston, W. T., Fial, F. and Gettingy, G. (2011). Herd-level risk factors of bovine tuberculosis in England and Wales after the 2001 Foot and Mouth disease epidemic. *International Journal of Infectious Diseases*, 15(12) : 833-840

- Johnston, W.T., Gettinby, G. and Cox, D.R. (2005). Herd-level risk factors associated with tuberculosis break down among cattle herds in England before 2001 foot and mouth disease epidemic. *Biology Letters*, 1: 53-56
- Kaneene, J. B. and Pfeiffer, D. (2006). Epidemiology of *M.bovis*. In: Thoen CO, Steele J H, Gildsorf MJ, editors. *M.bovis* Infection in Animals and Humans. 2nd ed. Ames, Iowa: Blackwell Publ; 2006. pp. 34–48.
- Kaneene, J. B., Bruning-Fann, C. S., Granger, L. M., Miller, R. and Porter-Spalding, B. A. (2002). Environmental and farm management factors associated with tuberculosis on cattle farms in northeastern Michigan. *Journal Americana Veterinary Medical Association*, 221: 837–842.
- Kaneene, J. B and Thoen, C. O. (2004). Tuberculosis, Zoonoses Update. *America Journal of Veterinary Medicine*, 224(5); 685-691
- Katharine, B.(1976) "Consumption" ,*An Encyclopedia of Fairies*, Pantheon Books, p. 80. ISBN 0-394-73467-X
- Kaufmann, S. (2002)."Protection against tuberculosis: cytokines, T cells, and macrophages". *Ann Rheum Dis* 61 Suppl, 54–8.
- Keet, D.F., Kriek, N. P., Penrith, M. L., Michel, A. and Huchzermeyer, H. (1996). - Tuberculosis in buffaloes (*Syncerus caffer*) in the Kruger National Park: spread of the disease to other species. *Onderstepoort J. vet. Res.*, 63, 239-244.
- Kelly, W. R. and Collins, J. D. (1978). The health significance of some infectious agents present in animal effluents. *Vet. Sci. Communication*, 2: 95–103.
- Kidane, D., Olobo, J.O., Habte, A., Negesse, Y., Aseffs, A., Abate, G., Yassin, M.A., Betreda, K. and Harboe, M. (2002). Identification of the causative organism of tuberculosis lymphadenitis in Ethiopia by PCR. *J. Clin.Microbiol*, 40: 4230-4234.
- Kim, J., Park, Y., Kim, Y., Kang, S., Shin, J., Park, I, and Choi, B. (2003). "Miliary tuberculosis and acute respiratory distress syndrome". *Int J Tuberc Lung Dis* 7 (4): 359–64.
- Kolo, I. (1991). Bovine and Human Tuberculosis in Nigeria; A Mycobacterial study. Ph.D Thesis, Department of Microbiology,Ahmadu Bello University, Zaria, p. 21.
- Kormendy, B.(1993).Report of meetings of IUATLD, scientific committee on tuberculosis in animals, Paris October 15-16, 1992, IUATLD *Newsletter* , 14-16.
- Kovalyov, G. K. (1989). - On human tuberculosis due to *M. bovis*. A review. *J. Hyg.,Epidemiol, Microbiol. Immunol*, 33 (2), 199-206

- Krebs, J., Anderson, R., Clutton-Brock, T., Morrison, I., Young, D. and Donnelly, C. (1997). Bovine tuberculosis in cattle and badgers. Ministry of Agriculture, Fisheries and Food (MAFF) Publications, London, Pp 191.
- Kudi, A.C., Bello, A. and Julius, A. N. (2012). Prevalence of bovine tuberculosis in Camels in Northern Nigeria. *Journal of Camel Practice and Research*, 19: 1-6
- Kumar, V. A., Abul, K. F. N. and Mitchell, R. N.(2007). Robbins Basic Pathology (8th ed.). *Saunders Elsevier*, 516–522.
- Latini, M. S., Latini, O. A., Lopez, M. L. and Cecconi, J.O. (1990). Tuberculosis bovina en seres humanos. *Revised Argentina Torax* 51: 13-16.
- Livingstone, P. G. (1992). - Tuberculosis in New Zealand - Current status and control Policies. *Surveillance*, 19 (1), 14-18.
- Livingstone, P. G., Ryan, T.J., Hancox, N.G., Crews, K.B., Bosson, M.A., Knowles, G.J. and McCook, W.(2006). Regionalization; a strategy that will assist with bovine tuberculosis control and facilitate trade. *Vet Microbiology*, 112: 291-301
- Lugton, I.W., Wilson, P. R., Morris, R. S. and Nugent, G. (1998) . Epidemiology and pathogenesis of *Mycobacterium bovis* infection of red deer (*Cervus elaphus*) in New Zealand. *New Zealand Vet. Journal*, 46, 147-156.
- Lyashchenko, K. P., Greenwald, R., Esfandiari, J., Chambers, M. A., Vicente, J., Gortazar, C., Santos, N., Correia-Neves, M., Buddle, B.M., Jackson, R., O'brien, D. J., Schmitt S., Palmer M.V., Delahay R. J. and Waters, W.R. (2008). Animal-side serologic assay for rapid detection of *M.bovis* infection in multiple species of free-ranging wildlife. *Vet. Microbiol.*, **132** (3–4), 283–292.
- Lyashchenko, K. P., Singh, M., Colangeli, R. and Gennaro, M. L. (2000). A multiple antigen print immunoassay for the serological diagnosis of infectious diseases. *Journal of Immunological Methods*, 242: 91-100.
- Marshall, P. J. (1985). "A new method of censusing, Elephants and hippopotamus on Yankari Game Reserve." *Nigeria Field* 50: 5-11
- Mason, I.L.(1996). A World Dictionary of Livestock Breeds, Types and Varieties. Fourth Edition. *Canadian Agric Bulletin International*. Pp 273.
- McCarthy, O. R. (2001). "[The key to the sanatoria](#)". *J R Soc Med* **94** (8): 413–7. [PMC 1281640](#). [PMID 11461990](#).
- McInerney, J., Small, K. J. and Caley, P. (1995). Prevalence of *M.bovis* infection in feral pigs in Northern Territory. *Australian Veterinary Journal*, vol 72, page 448-451

- Menzies, F. D. and Neill, S. D. (2000). Cattle-to-cattle transmission of bovine tuberculosis. *Veterinary Journal* 160: 92–106.
- Michalak, K., Austin, C., Diesel, S., Maichle, B. J., Zimmerman, P. and Maslow, J.N.(1998) *Mycobacterium tuberculosis* infection as a zoonotic disease: transmission between humans and elephants. *Emerg Infect Dis.* 4:283–287.
- Michel, A. L., Bengis, R. G., Keet, D. F., Hofmeyr, M., De Klerk, L. M., Cross, P. C., Jolles, A. E., Cooper, D., Whyte, I. J., Buss, P. and Godfroid, J. (2006). Wildlife tuberculosis in South African conservation areas: implication and challenges. *Veterinary Microbiology.* 112: 91-100
- Michel, A.I., Muller, B. and Van-Helden, P. D. (2010). *M.bovis* at the animal-human interface, a problem or not. *Veterinary Microbiology.* 140: 371-381.
- Miller, R. A. and Kaneene, J. B.(2006). Evaluation of historical factors influencing the occurrence and distribution of *M.bovis* infection among wildlife in Michigan. *American Journal of Veterinary Research.* 2006 Apr; 67 (4): 604-615.
- Miller, R., Kaneen, J. B., Fidge, S. D. and Schmitt, S.M.(2003). Evaluation of the influence of supplemental feeding of white tailed deer on the prevalence of bovine tuberculosis in the Michigan wild deer population. *Journal of Wildlife Diseases .* 39: 84-95.
- Ministry of Agriculture, Fisheries and Food(1994). Bovine tuberculosis in badgers, 17th Report. London, HMSO
- Moda, G., Daborn, C. J., Grange, J.M. and Cosivi, O. (1996). The zoonotic importance of *Mycobacterium bovis*. *Tubercle and Lung Dis.* 77: 103-108.
- MOH(1997). National tuberculosis and leprosy control programme manual, first edition. Addis Ababa, Ethiopia
- Monaghan, M. L., Doherty, M. L., Collins, J. D., Kazda, J. F. and Quinn, P. J.(1994). The tuberculin test. *Vet Microbiol* 40: 111–124.
- Montali, R.J., Mikota, S.K. and Cheng, L.I.(2001). *Mycobacterium tuberculosis* in zoo and wildlife species. *Rev Sci Tech.* 2001;20:291–303.
- Mposhy, M., Binemo-Madi, C. and Mudakikwa, B. (1983). Incidence de la tuberculose bovine sur la santé des populations du Nord-Kivu (Zaïre). *Rev. Elev. Med. Vet. Pays. Trop,* 36: 15-18.
- More, S. J., Collins, J. D., Gormley, E., Good, M., Skuce, R.A. and Pollock, J. M. (2005). Fourth International Conference on *M.bovis*: workshop reports. *Veterinary Microbiology,* 112: 383-391.

- Munroe, F. A., Dohoo, I. R., McNab, W. B. and Spangler, L. (1999). Risk factors for the between-herd spread of *M.bovis* in Canadian cattle and cervids between 1985 and 1994. *Preventive Veterinary Medicine* 41: 119–133.
- Munyeme, M., Muma, J. B., Siamudalaah, V. M., Skjerve, E. and Tryland, M. (2010). Tuberculosis in Kafue lechwe antelopes (*Kobus leche Kafuensis*) of the Kafue Basin in Zambia, *Preventive Veterinary Medicine*, 95: 305-308
- Munyeme, M., Muma. J. B., Sjkerve, E., Nambota, A. M., Phiri, I. G. K. and Samui, K. L.(2008) Risk factors associated with bovine tuberculosis in traditional cattle of the livestock/wildlife interface areas in the Kafue basin of Zambia. *Preventive Veterinary Medicine*, 85:317–328.
- Nafeh, M. A., Medhat, A., Abdul-Hameed, A. G., Ahmad, Y .A., Rashwan, N. M. and Strickland G.T. (1992). Tuberculous peritonitis in Egypt: the value of laparoscopy in diagnosis. *Am. J. trop. Med. Hyg.*, 47 (4), 470-477.
- Nahid, P., Pai, M. and Hopewell, P. (2006). "Advances in the diagnosis and treatment of tuberculosis". *Procedure of American Thoracic Society*, 3 (1): 103–10.
- Naranjo, V., Gortazar, C. and Vincente, J. (2008). Evidence of the role of European wild boars as a reservoir of *Mycobacterium tuberculosis* complex, *Veterinary Microbiology*, 127: 1-9
- Narain, J. P., Raviglione, M. C. and Kochi, A. (1992). HIV associated tuberculosis in developing countries, epidemiology and strategies for prevention. *Tubercle and Lung Dis.*, 73,311-321.
- Neill, S. D., O'Brien, J. J. and Hanna, J. (1991). A mathematical model for *M.bovis* excretion from tuberculous cattle. *Veterinary Microbiology*, 28: 103–109.
- Nihotours. (2000). *A Bulletin of the National Institute for Hospitality and tourism Studies*. Kano, Nigeria. 1(1): 8-9.
- Nishi, J. S., Shury, T. and Elkin, B. T. (2006). Wildlife reservoirs for bovine tuberculosis(*M.bovis*) in Canada: strategies for management and research. *Veterinary Microbiology*. 112, 325-338
- Nobel Foundation. The Nobel Prize in Physiology or Medicine 1905.. Retrieved 7 October 2006.
- Norton, S., Corner, L.A. L. and Morris, R. S. (2005). Rangling behavior and duration of survival of wild brushtail possum (*Trichosurus vulpecula*) infected with *Mycobacterium bovis*. *New Zealand Veterinary Journal*, 53; 293-300.
- NRC [National Research Council].(1980).Laboratory Animal Management: Nonhuman Primates. ILAR News XXIII(2-3). Washington, National Academy Press.

- Nugent, G. (2005). The role of wild deer in the epidemiology and management of bovine tuberculosis in Newzealand . Unpublished PhD thesis , Lincoln University, NewZealand, Page 170.
- Nugent, G.(2011). Maintenance, spillover and spillback transmission of bovine tuberculosis in multi-host wildlife complexes; A Newzealand case study. *Veterinary Microbiology*, 151(2011) 34-42
- Nugent, G., Whitfort, J. and Yockney, I. J.(2011). Reduced spillover transmission of *M.bovis* to feral pigs (*Sus scrofa*) following population control of brushtail possums (*Trichosurus vulpecula*). *Epidemiology of Infection*, page 1-12.
- O'Brien, D.J., Schmitt, S. M., Fitzgerald, S. D., Berry, D. E. and Hickling, G. (2006).Managing the wildlife reservoir of *M.bovis*: The Michigan USA, experience *Veterinary Microbiology*. 112. 313-323.
- O'Donahue ,W. J., Bedi, S., Bittner, M. J. and Preheim, L. C. (1985). Short Course Chemotherapy for Pulmonary Infection due to *M. bovis*. *Arch. Int. Med.* 145: 703-705.
- O'Reilly, L. M. and Daborn, C. J.(1995). The epidemiology of *M.bovis* infections in animals and man: a review. *Tubercle and Lung Diseases*, 76; supplement1,1-46.
- O'Brien, D., Schmitt, S., Berry, D., Fitzgerald, S. and Vanneste, J. (2004) Estimating the true prevalence of *M.bovis* in hunter-harvested white-tailed deer in Michigan. *Journal of Wildlife Diseases*, 40(1): 42-52.
- O'Brien, D.J., Schmitt, S.M., Fierke, J. S.(2002). Epidemiology of *MycobacteriumM.bovis* in free-ranging white-tailed deer, Michigan, USA, 1995-2000, *Preventive Veterinary Medicine*, 54: 47-63
- Odunlami, S.S. (2003). An Assessment of the Ecotourism Potential of Yankari National Park, Nigeria International Ecotourism Club.
- Odunlami, S.S.S. (2000). "Parks: Vanguard of Ecotourism Promotion." *The Host Magazine* 2(1): 25
- Ofukwu, R.A. (2006). Studies on the Epidemiology of Bovine and Human Tuberculosis in Benue State, Nigeria. A Ph.D Dissertation, Faculty of Veterinary Medicine, University of Nigeria, Nsukka, p. 15.
- Ofukwu, R.A., Oboegbulem, S.I. and Akwuobu, C.A. (2008). Zoonotic Mycobacterium species in fresh cow milk and fresh skimmed,unpasteurised market milk (nono) in Makurdi, Nigeria: implications for public health. *J. Anim. Plant. Sci.*, 1(1): 21-25.

- OIE. (2000). Manual of Standards for Diagnostic Tests and Vaccines. 4th Edition, p. 77-92
- OIE. (2009). Office International des Epizootics(OIE). Terrestrial Manual; chapter 2.4.7. Bovine tuberculosis, World Health Organization for animal Health, Paris
- Olea-Popelka, F. J., Costello, E. and White, P. (2008). Risk factors for disclosure of additional tuberculous cattle in attested-clear herds that had one animal with a confirmed lesion of tuberculosis at slaughter during 2003 in Ireland. *Preventive Veterinary Medicine*. 85(1-2):81–91.
- Olokesusi, F.(1990).Assessment of the Yankari Game Reserve, Nigeria: Problems and Prospects. Butterworth Heineman Ltd. Pp 153-155
- Oloya, J., Muma, J. B., Opuda-Asibo, J., Djonne, B., Kazwala, R. and Skjerve, E.(2007). Risk factors for herd-level bovine tuberculosis seropositivity in transhumant cattle in Uganda. *Preventive. Veterinar Medicine*, 80:318–329.
- Ozyigit, M. O., Senturk, S. and Akkoc, A.(2007) Suspected congenital generalised tuberculosis in a newborn calf. *Vet. Rec*, 160:307–308.
- Pace, J. F. and Wakeman, D. L. (2003). Determining the age of cattle by their teeth. IFAS University of Florida, 235.
- Palmer, M.V., Waters, W.R. and Whipple, D.L.(2004). Investigation of the transmission of *MycobacteriuM.bovis* from deer to cattle through indirect contact. *American Journal of Vet Res* 65(11): 1483-9.
- Parra, A., Larrasa, J., García, A., Alonso, J. M. and de Mendoza, J. H.(2005). Molecular epidemiology of bovine tuberculosis in wild animals in Spain: a first approach to risk factor analysis. *Veterinary Microbiology* 110: 293–300.
- Phillips, C .J. C., Foster, C. R. W., Morris, P. A. and Teverson, R.(2003) The transmission of *M.bovis* infection in cattle. *Research Veterinary Science*, 74; 1–15.
- Phillips, C.J.C., Foster, C.R.W., Morris, P.A. and Teverson, R. (2001). The transmission of *M.bovis* infection to cattle. *Research in Veterinary Science*, 74: 1-15
- Pollock, J.M. and Neill, S. D.(2002). *M.bovis* infection and tuberculosis in cattle. *The Veterinary Journal* 2: 115-127
- Porphyre, T., Stevenson, M.A. and McKenzie, J.(2008). Risk factors for bovine tuberculosis in Newzealand cattle farms and their relationship with possum control strategies . *Preventive Veterinary Medicine*, 86(1-2): 93-106

- Radostits, O. M., Gay, C.C., Blood, D. C. and Hincheliff, K.W. (2000). Disease caused by bacteria – Mycobacterium. In: *Veterinary Medicine: A Text Book of Disease of Cattle, Sheep, Pig, Goat and Horses*. 9th ed. Harcourt Publisher Ltd., London, 909-918.
- Ragg, J. R., McIntosh, C. G. and Moller, H.(2000). The scavenging behavior of ferrets (*Mustela furo*), feral cats (*Felis domesticus*), Possums (*Trichosurus vulpecula*), hedgehogs (*Erinaceus europaeus*), and Harrier Hawks (*Circus approximans*) on pastoral farmland in New Zealand, implication for bovine tuberculosis transmission, *New Zealand Veterinary Journal*, 48: 166-175
- Raufu, I. A. and Ameh, J. A. (2010). Prevalence of Bovine Tuberculosis in Maidguri Nigeria –an abattoire study. *Bulletin of Animal Health and Production in Africa*, 58: 2
- Raviglione, M.C., Snider, D.E. and Koch, A.(1995). A global epidemiology of tuberculosis. *JAMA*, 273; 220-226
- Rege, J.E.O. and Tawah, C.L. (1999). The state of African cattle genetic resources II. Geographical distribution, characteristics and uses of present-day breeds and strains. *FAO/UNEP Animal Genetic Resources Information Bulletin*. 26:1-26.
- Reilly, L. A. and Courtenay.(2007). Husbandry practices Badgers sett, density and habitat composition as risk factors for transients and persistent bovine tuberculosis on UK farms. *Preventive Veterinary Medicine*, 80: 129-142
- Renwick, A. R., White, P.C.L. and Bengis, R. G. (2007). Bovine tuberculosis in Southern African wildlife: a multi-species host –pathogen system . *Epidemiology of Infectious Diseases*. 135, 529-540.
- Reynolds, D. (2006). A review of tuberculosis science and policy in Great Britain, *Veterinary Microbiology*, 112: 119-126
- Ritacco, V. and de Kantor, I.N.(1992). Zoonotic tuberculosis in latin America, *Journal of Clinical Microbiology*, 30: 3299-3300
- Roberts, J. A. and Andrews, K.(2008). Nonhuman primate quarantine: Its evolution and practice. *ILAR Journal*, 49: 145-156.
- Robinson, P., Morris, D. and Antic, R. (1988). *M.bovis* as an occupational hazard in abattoir workers, *Australian and NewZealand Journal of Medicine*, 18 :701-703

- Roper, T. J., Garnett, B. T. and Delahay, R. J. (2003). Visits to farm building and cattle trough by Badgers (*Mele meles*), a potential route for transmission of bTB transmission between badgers and cattle. *Cattle practice* 11: 9-12
- Rose, H. R. (1987). Bovine tuberculosis in deer. *Deer Journal*, 7: 78.
- Rothschild, B., Martin, L., Lev, G., Bercovier, H., Bar-Gal, G., Greenblatt, C., Donoghue, H., Spigelman, M. and Brittain, D. (2001). "*Mycobacterium tuberculosis* complex DNA from an extinct bison dated 17,000 years before the present". *Clin Infect Dis* 33 (3): 305–11.
- Rudolph, B.A., Riley, S. J., Hickling, G.J., Frawley, B.J., Garner, M.S. and Winter-Stein, S.R. (2006). Regulating hunter baiting for white-tailed deer in Michigan: biological and social considerations. *Wildlife Social Bulletin*, 34: 314-321
- "Rudy's List of Archaic Medical Terms", *English Glossary of Archaic Medical Terms, Diseases and Causes of Death*. Retrieved 9 October 2006.
- Ryan, T. J., Livingstone, P.G. and Ramsey, D.S. (2006). Advances in understanding disease epidemiology and implications for control and eradication of tuberculosis in livestock; the experience from Newzealand, *Veterinary Microbiology*, 12; 211-219
- Salisu, I., Cadmus, S.I.B., Umoh, J.U., Ajogi, I., Frouk, U.M., Abubakar, U.B. and Kudi, A.C. (2012) Tuberculosis in Humans and Cattle in Jigawa State Nigeria: Risk Factors Analysis. *Veterinary Medicine International*, vol 2012: 1-5
- Sapolsky, R. M. and Else, J. G. (1987). Bovine tuberculosis in wild baboons population, epidemiological aspects *Journal of Medicine Primatol*, 16, 229-235.
- Sauter, C. M. and Morris, R. S. (1995). Behavioural studies on the potential for direct transmission of tuberculosis from feral ferrets and possums to farmed livestock. *NewZealand Veterinary Journal*. 43, 294-300
- Schliesser, T. (1992). *M. bovis* infection in man. In Moussa, A.A.M., Lofti, O., Mahir, O, *et al*, eds. Proceedings of the International conference on Animal Tuberculosis in Africa and Middle East, Cairo. The General Organization for Veterinary Services, Cairo, 193-194.
- Sharpe, E. A., Brady, C. P., Johnson, A. J., Bryne, W., Kenny, K. and Costello, E. (2010). Concurrent outbreak of tuberculosis and caseous lymphadenitis in a goat herd *Veterinary Records*, 166: 591-592.
- Shilang, Z. and Shanzhi (1985). Prevention of tuberculosis in Sika deer (*Cervus nipon*). *Biology of Deer production* 22, 154
- Shimao, T. (1995). Disaster awaits Asia as TB and Aids are neglected. *Tuberculosis & HIV* 5: 2

- Shitaye, J.E., Getahun, B., Alemayehu, T., Skoric, M., Treml, F., Fictum, P., Vrbas, V. and Pavlik, I. (2006). A prevalence study of bovine tuberculosis by using abattoir meat inspection and tuberculin skin testing data, histopathological and IS6110 PCR examination of tissues with tuberculous lesions in cattle in Ethiopia. *Vet. Med*, 51: 512-522.
- Shitaye, J.E., Tsegaye, W. Pavlik, I. (2007). Bovine tuberculosis infection in animal and human populations in Ethiopia: A review. *Vet. Med*. 52(8): 317-332.
- Sledzik, P. and Bellantoni, N. (1994). "Brief communication: Bioarcheological and biocultural evidence for the New England vampire folk belief". *Am J Phys Anthropol* **94** (2): 269–74. doi:10.1002/ajpa.1330940210. PMID 8085617.
- Suazo, F. M., Escalera, A. M. and Torres, R. M. (2003) A review of *M. bovis* BCG protection against TB in cattle and other animals species. *Preventive Veterinary Medicine* 58: 1–13.
- Tawah C.L. and Rege J.E.O. 1996. Gudali Cattle of West and Central Africa. *FAO Animal Genetic Resources Information Bulletin*. **17**:159-170.
- The satellite image with roads is from Google Earth (C) 2012 Google (C) 2012 Cnes/Spot Image
- Thoen, C., LoBue, P. and De Kantor, I. (2006). The Importance of *M.bovis* as a zoonosis. *Veterinary Microbiology*, 112(2-4): 339-345
- Thoen, C.O., Beluhan, F. Z., Elmer, M. H., Capek, V. and Taylor B.(1977). *Mycobacterium bovis* infection in baboons(*Papio papio*). *Arch Pathol Lab Med*, 101: 291-293.
- Thoen, C.O., Richards, W.D. and Jarnagin, J. L(1977). Mycobacteria isolated from exotic animals. *America Journal of Vet Med Association*, 170: 987-990.
- Timothy, C.R., Nick, P. K., Roy, G. B., Ian, J.W., Petri, C.V., Valerious de Vos. and Walter, M.B(2001). Prevalence of bovine tuberculosis in African Buffaloes at Kruger National Park. *Journal of Wildlife Diseases*, 37(2): 258-264
- Torrey, E. F. and Yolken, R. H.(2005). Their bugs are worse than their bite. *Washington Post*, Birdflubook.com. Retrieve 2010, p 01
- Tuberculosis through history. *Encyclopædia Britannica*. Vaccines. 4th Edition, p. 77-92
- Van-Soolingen, D., de-Haas, P.E. W. and Haagsma, J. *et al.*, (1994). Use of various genetic markers in differentiation of *M.bovis* strains from animals and humans and for studying epidemiology of bovine tuberculosis. *Journal of Clinical Microbiology*, 32: 2425-2433

- Vercauteren, K. C., Lavelle, M. J. and Hygstrom, S.(2006).Fences and deer danger management, a review of design and efficacy. *Wildlife Social Bulletin*, 34: 191-200
- VerCauteren, K. C., Lavelle, M. J. and Philips, G. E.(2008b). Livestock protection dogs for deterring deer from cattle and feed, *Journal of Wildlife Management*. 72: 1443-1448
- Veterinary Laboratories Agency (2000). A multivariate analysis of risk factors of TB transmission associated with farm management practices, Final Report of the Milk Development Council Project 98/R1/16, UK, p. 5.
- Vicente, J., Delahay, R. J., Walker, N. J. and Cheeseman, C. L. (2007).Social organization and movement influence the incidence of bovine tuberculosis in an undisturbed high density badger(*Meles meles*) population. *Journal of Animal Ecology*. 76, 348-360.
- Vincente, J., Hofle, U. and Garridol, J. M.(2006). Wild boar and red deer display high prevalences of tuberculosis-like lesions in Spain, *Veterinary Research*, 37: 107-119
- Waddington, K. (2004). "To stamp out "so terrible a malady": bovine tuberculosis and tuberculin testing in Britain, 1890–1939". *Med Hist* 48 (1): 29–48. PMC 546294. PMID 14968644.
- Wagner, B. (1993). Risk assessment for *M.bovis* in cervidae. *Animal Health Insight, summer*, 22-32
- Walshe, M. J., Grindle, I. , Nell, A. and Bachmann, M. (1991). - Dairy development in sub-Saharan Africa. World Bank Technical Paper No. 135. African Technical Department
- Ward, A. I. Judge, J. and Delahay, R. J. (2010). Farm husbandary and badger behavior , opportunities to manage badger to cattle transmission of *M.bovis*. *Preventive Veterinary Medicine*, 93: 2-10
- Wiker, H. K. (2009). MPB70 and MPB80 major antigens of *Mycobacterium bovis*. *Scandinavian Journal of Immunology*, 69(6); 492-499
- Wilkins, M. J., Meyerson, P. C. and Barlett, *et al.*(2008). Human *M.bovis* infection and bovine tuberculosis outbreak, Michigan 1994-2007. *Emergent Infectious Diseases*, 14: 657-660.
- Williams, R. S, and Hoy, W. A. (1930). The Viability of *Bovinus* (*Bovinus*) on Pasture Land, in Stored Faeces and in Liquid Manure. *Journal of Hygiene*. 30:413–419.
- Wilson, P., Weavers, E., West B., Taylor, M., Kavanagh, J. and Jones, P. (1984). *M.bovis* infection in primates in Dublin Zoo, epidemiological aspects and implications for management *Lab Animals*, 18: 383-387.
- World Health Organization (2009). "Epidemiology". Global tuberculosis control: epidemiology, Yankari and Borgu Game Reserves.(Ibadan): Dept of Forest Resources Management,

University of Ibadan, Nigeria

WHO. (1992). - Report of the WHO Working Group Meeting on Animal Tuberculosis. Cairo, Egypt, 27 April. Document WHO/CDS/VPH/92.112. WHO, Geneva, 24 pp.

Woodford, M. H. (1982). Tuberculosis in wildlife in the Ruwenzori National Park, Uganda (Part I). *Trop. anim. Hlth Prod.*, 14, 81-88.

Yankari National Park (2000). A Handbill of the Yankari National Park, Nigeria.

Yumi, U, and Tooru, M. (2007). Tuberculosis as a zoonosis. From a Veterinary Perspective. *Comp. Immunology Infectious Diseases*, 30: 415-425.

Zanini, M. S., Moreira E., Lopes, M. T., Mota, P. and Salas, C. E.(1998). Detection of *M.bovis* in milk by polymerase chain reaction. *Journal. of Veterinary Medicine*, 45:473–479.

Zuckerman, L.(1980).Badgers, cattle and tuberculosis. Report to Rt Hon Peter Walker MP, London. HMSO, pp 107