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CAMEL DROMEDARY TUBERCULOSIS: A REVIEW

Dereje Teshome

Oromia Agricultural Research Institute; Yabello Pastoral and Dryland Agriculture Research Center, P.O. Box 85, Yabello, Ethiopia

Email:derejeteshe@gmail.com

Abstract

Camel is an important species uniquely adapted to arid and semi-arid environments and contributes significantly to the food security of the nomadic pastoral households. Tuberculosis caused by *Maycobacterium bovis* is the most common form of tuberculosis in camels. The two known Mycobacteria causing Tuberculosis in camels are *Maycobacterium bovis* and *Maycobacterium tuberculosis*. Tuberculosis in dromedaries has been documented since 1888 and its geographic distribution is with great variations between regions and countries. Transmission of the disease is mainly occurs by inhalation. Infected animal introduced in to a non-infected herd act as a source infection. In advanced cases the signs of the disease are; weakness, erratic appetite, and emaciation as well as low grade fluctuating fever. Enlarged superficial lymph nodes provide a useful sign for diagnosis. A presumptive diagnosis of tuberculosis in camel is often made based on history, clinical findings, tuberculin skin tests, post-mortem, bacteriological and molecular techniques. Treatment is not advised for animals. Control depends on the removal of infected animals and prevention of further introduction of infection into the herd. Conventional cost intensive test-and-slaughter schemes do not appear to be appropriate control measures for animal tuberculosis in developing countries. Tuberculosis, as a zoonosis from camel to human which is caused by principal agent; *M. bovis*

plays an important role. In developing countries, the risk for contracting zoonotic tuberculosis is increased due to the higher infection rate in animals, absence of regular pasteurization of milk, cultural factors, poverty, malnutrition and a higher Human immune deficiency virus (HIV) infection rate. As a result, public awareness and appropriate control and prevention measures should be implemented to reduce the public health and economic burden of the disease. In general tuberculosis in animal as well as human is a challenging disease lack wide information on epidemiology, risk factors involved and role of *M. bovis* in human tuberculosis, so that significant further investigations are necessary for a better understanding of the disease; thus a better prevention and control of the infection in both animal and human.

Keywords: Camel dromedary, Review, Tuberculosis, Zoonosis.

1. INTRODUCTION

The dromedary camel (*Camelus dromedarius*) is an important livestock species adapted to hot and arid environments. It is most abundant in the arid lowlands of Africa, the Middle East and Western Asia. The economic importance of this multipurpose animal is evident from the numerous benefits provided by camel products (meat, milk, wool). Moreover, the camel serves for riding, as a beast of burden and as a draft animal for agriculture and transport (El Harrak *et al*., 2011).

Camels used in the development of camel dairy farms that are capable of producing camel milk on the commercial level. Camel milk and meat are considered an important source of proteins for wide range of population (Alhebabi and Alluwaimi, 2010). *Camelus dromedaries* have the ability to survive under harsh climatic conditions and have the potential to enhance pastoral household livelihoods under this distressful environment (Mahamed *et al*., 2015).

The Food and Agriculture Organization (FAO) estimates the total population of camel in the world today to be 25.89 million, of which 89% are *Camelus dromedaries.* Over 80% of the world's camel dromedary population is found in Africa with the highest concentration in North East Africa (FAO, 2013; Hussein *et al*., 2013; Sisay and Awoke, 2015).

In Ethiopia, *Camelus dromedaries* represent a subset of major livestock resources with the population estimated to be over one million. This number ranks the country third in Africa after Somalia and Sudan and fourth in the world (India included). The arid and semiarid areas

of the country that constitute more than 60% of the total area and home of 7.8 million pastoral and agro-pastoral communities are suitable for camel production (Abebe, 2000).and play a significant multi-purpose role in transporting grain, water, salt and other goods as well as for milk and meat production (Abera *et al*., 2014). In recent years, camels have become one of the national export animals for Ethiopians (Kasaye *et al*., 2013). Camel also possess several attributes as minimum contribution to environmental degradation, utilization of scarce natural resources (feed and water), minimum competition with other ruminants and good adaptation to harsh environment (Abera *et al*., 2014). Thus camels have been indispensable alternative to cope up with the escalating rangeland ecological challenges (MOA, 2013).

Camels were formerly considered resistant to most of the diseases commonly affecting livestock; but as more research was conducted, camels were found to be susceptible to a large number of pathogenic agents (Abbas and Omer, 2006). There are a number of economically important diseases that affect camels (Dia, 2006).

Respiratory diseases are among the emerging problems of camels that are causing considerable loss in production and death (Zubair *et al*., 2004). Tuberculosis (Tb) is a chronic, contagious, granulomatous disease caused by mycobacterial species belonging to the *Mycobacterium tuberculosis* complex (MTC) (Thoen *et al*., 2006). Among Mycobacterial group Mycobacterium bovis (*M. bovis*) has a wide host range and is the most commonly reported causative agent of camel TB (Mamo *et al*. 2011). Tuberculosis caused by *M. bovis*is is the most common form of tuberculosis in camels (Dubie *et al*., 2016). The organism causes granulomatous abscesses in various tissues with a predilection for lymphoid tissues and lungs (Wernery and Kaaden, 2002).

Tuberculosis is a serious chronic infectious disease of humans and animals worldwide (Thoen *et al*., 2009; Ndukum *et al*., 2010). Tuberculosis, as a zoonosis from camel to human which is caused by principal agent; *M. bovis* plays an important role among nomadic people where milk and milk products are consumed raw (Seifert, 1992; Krauss *et al*., 2003).Moreover, close physical contact with their animals create a potential public health concern for transmission of zoonotic diseases such as tuberculosis (TB) from animals to the pastoralist (Mamo *et al*., 2011).In particular in pastoralists of the Horn of Africa where no treatment of milk is practiced either it is consumed raw or when it just soured (Zubair *et al*., 2004).

The camel rearing people are at high risk of contracting TB if their camels get infected by *Mycobacterium* species. Because, the society lack general awareness of TB and its zoonotic importance and family members share the same living house with their camels during the

night time, there is high possibility of transmission of the infection between humans and camels. On top of that, only few of them have the habit of boiling milk before consumption. Raw camel milk consumer of the camel rearing society and their urban customers are in higher health risk (Beyi *et al*., 2014).

Tuberculosis in humans remains one of the major global reportable diseases, and a rise in its incidence has caused the World Health Organization (WHO) to declare the disease a global emergency. Therefore this review paper is done with the objectives: To review general information available on Camel (*Camelus dromedaries*) Tuberculosis and To forward recommendations toward the future study and investigations of camel Tuberculosis, control and prevention approaches.

2. LITERATURE REVIEW

2.1. Definition

Tuberculosis is a chronic, contagious, granulomatous disease caused by mycobacterial species belonging to the Mycobacterium tuberculosis complex (Wernery and Kinne, 2012). Tuberculosis caused by *M. bovis*is the most common form of tuberculosis in camels. The organism causes granulomatous abscesses in various tissues with a predilection for lymphoid tissues and lungs (Wernery and Kaaden, 2002).

2.2. Etiology

The genus *Mycobacterium* of the family *Mycobacteriaceae* includes non-motile and non-sporing acid-fast rods of various lengths. There are approximately 100 members of *Mycobacterium* genus and although most are saprophytic organisms that live in the environment. Some are strict parasites inhabiting the mucus membranes of their host and *mycobacteria* are cytochemical, Gram positive, the high lipid and mycolic acid content of their cell walls prevents uptake of the dyes employed in the gram stain (Quinn and Markey, 2003).

The following species are grouped in the MTC: *M. tuberculosis*, *M. canettii*, *M. africanum*, *M. bovis*,*M. pinnipedii*, *M. caprae* and *M. microti;*of these, *M. tuberculosis*, *M. bovis*, *M.pinnipedii*, *M. caprae*and *M. microti* have been isolated from camelids (Wernery and Kinne, 2012). Among Mycobacterial group Mycobacterium bovis (M. bovis) has a wide host range

and is the most commonly reported causative agent of camel TB (Mamo *et al*. 2011). *M. tuberculosis reported* from tissue lesions (Zerom *et al*., 2012).

The causative agents of TB in Camel dromedaries are broadly classified as typical and atypical. The two most common Mycobacteria causing TB in camels are *M. bovis* and *M. tuberculosis*. Some of atypical Mycobacteria rarely causing TB in camels are *M. kansassi*, *M. aquae*, *M. aquae var. ureolyticum*, *M. microti*, *M. fortuitum* and *M. smegmatis*. The atypical species of *Mycobacvterium* cause disease in immune-compromised camel (Dubie *et al*., 2016).

Bacterial species within the complex share 99.9% or greater similarity at a nucleotide level and have a virtually identical 16rDNA gene sequence. *M.bovis* is zoonotic, while infection with *M.tuberculosis* has been sporadically reported in domestic and wild animal species, most frequently in animals living in prolonged, close contact with humans (Ameni *et al*., 2010).

2.3. Epidemiology

There is little published information on the epidemiology of Tb specifically relating to camelids (Wernery and Kinne, 2012).Tuberculosis occurs worldwide in people, wild and domesticated or captive animals. Tuberculosis (TB) in dromedaries has been documented since 1888. The geographic distribution is with great variations between regions and countries (Kasaye *et al*., 2013).

Tuberculosis has been found worldwide. European Countries as well as the United States, Canada, Japan, and New Zealand reported a prevalence of bovine infection lower than 0.1%. A few countries including Australia, Denmark, Sweden, Norway, and Finland are considered to be free of bovine tuberculosis. However the disease is endemic in all most all countries of Africa (Dubie *et al*., 2016).

Mustafa *et al*., (1987) mentioned in a brief review that disease was more commonly observed in farmed camels and those in close proximity to cattle but appeared to be rare among nomadic camels, suggesting that close contact facilitates transmission between domesticated animals. In 1991, Abdurrahman and Bornstein (1991) reported the disease to be relatively rare in Somalia, a country which at that time had one of the largest populations of old world camels (OWCs) in the world. Study on Tuberculosis outbreak in a dromedary racing herd up on rapid serological detection of infected camels a prevalence of 5.17% were reported by Wernery *et al*., (2007) as cited by Dubie *et al*., (2016).

Globally the status of camel tuberculosis reported from different countries. In the study conducted on 874 Bacterian camels in Russia they were 107 cases of tuberculosis resulting in

12.2% incidence rate, but only 68% of the camel with tuberculosis had positive tuberculin reaction. M. bovis strain was isolated from 46 pooled milk sample positive tuberculin reaction. M. bovis strains were isolated from 46 pooled milk samples from 712 lactating camel cows (kinne *et al*., 2006). Recently Wernery et al., (2007); described TB cases in dromedary in United Arab Emirates with typical lesion in both lungs. Outbreak in 58 camels of which 3 are infected with tuberculosis and the disease was confirmed at necropsy by finding gross lesion from *M. bovis* was isolated. Wernery et al., (2007) described TB cases in dromedary in United Arab Emirates with typical lesion in both lungs.

The study conducted in India on Pathology and diagnosis of *Mycobacterium bovis* in naturally infected dromedary camels (*Camelus dromedarius*) showed that a total of 18 (19.56 %) camels out of 92 examined based on gross lesions compatible with TB at post-mortem (Narnaware *et al*., 2015).

In Nigeria the prevalence of camel tuberculosis conducted in Northern Nigeria indicated prevalence of 17% of the 1395 animals tested showed positive reactions in the rapid test with a variable prevalence according to age and sex. The age of the animal was more important factor than sex for antibody detection rates recorded. Positive reactions increased significantly ($P<0.05$) with age (camels older than 10 years: 9.82%) and more ($P<0.05$) females (11.40%) than male camels showed positive test results (Caleb *et al*., 2012). prevalence of 22.6 % of tuberculosis in slaughter camels (*Camelus dromedarius*) at Kano abattoir, Nigeria based on lateral-flow technology, also reported (Abubakar *et al*. 2014).

A cross sectional study of camel tuberculosis conducted in Ethiopia to describe its prevalence and isolate *Mycobacterium bovis*. In the study a total of 276 dromedary camels slaughtered at Dire Dawa abattoir and examined for the presence of gross tuberculosis lesions and further cultured to isolate Mycobacterium bovis. The study revealed 14 (5.07%) prevalence based on postmortem examination (Mamo *et al*., 2009). Study in Ethiopian abattoirs has suggested a prevalence of 10.4%, based on the identification of gross lesions in 906 apparently healthy camels (Mamo *et al*., 2011).

A recent cross sectional study was conducted on 420 apparently healthy camels slaughtered at Akaki abattoir to determine the prevalence of camel tuberculosis and to see its association with sex, age, and origin and body condition of camels. The study indicated the overall prevalence of 4.52% based on gross tuberculosis lesion detection; (Kasaye *et al*., 2013). Study conducted to investigate bovine tuberculosis in Camel dromedary in Eastern part of Ethiopia

has also showed prevalence rate of 8.3% (33/398) based on the post mortem examination and 6.0% (29/480) at cut off >4 mm based on the tuberculin test (Beyi *et al*., 2014).

2.3.1. Host range and the role of reservoirs

All species, including human beings, and age groups are susceptible to *M. bovis* with cattle, goat and pigs most susceptible and sheep and Horses showing a high natural resistance (Radostits *et al.,* 2007). Although bovine tuberculosis was once found worldwide, control programs have eliminated or nearly eliminated this disease from domesticated animals in many countries (Srivastava *et al*., 2008).

In Northern America, the bison herds (Bison bison) have long been known to maintain *M. bovis*, and with elk (*Cervus Canadensis*). They provide an important reservoir in certain extensive range of conditions. In New Zealand, the brush tail possum (*Trichosuron Vulpecula*), and in England and Republic of Ireland, the badgers (*Melesmeles*), are implicated as significant reservoirs. In Africa, a reservoir of M. bovis is known to exist in Cape buffalo (*Synceruscaffert, Lewchwe*), the Cape kudu (*Strep sicercus species*) and Cape duiker (*Sylvicaprospecies*) (Dubie *et al*., 2016).

2.3.2. Risk factors

The host risk factor: all species including human beings, body conditions, sex and age groups are susceptible to *M. bovis* (Mamo *et al*., 2011). The occurrences of TB lesions in camels were relatively higher in the younger and older camels than other age groups which could be due to the fact that older animals have weaker immune system. The higher frequency of lesion in younger camels could be due to the less developed immunity (Menzies *et al*., 2000). Young camels can also be easily infected with higher doses of Mycobacteria via colostrum from infected camel in a similar way, as it occurs in cattle (Phillips *et al*., 2003). In connection with this, another report mentioned of vertical transmission of *M. bovis* from an infected dam to her calf through congenital infection in utero (Ozyigit *et al*., 2007). It was observed that lesion was more frequently observed in female camels as compared to male camels. This could be due to the fact that female camels were brought for slaughter at their older age after completion of the reproductive age (Munyeme *et al*., 2008) as cited in Dubie *et al*., (2016).

Also the pathogen risk factor: the causative organism is moderately resistant to heat, desiccation and many disinfectants; the virulence of M. bovis relates to its ability to survive and multiply in host macrophages. The environmental risk factor includes housing, sharing the same shelter with humans and the stocking intensity of animals (Quinn and Markey, 2003).

2.4. Source of Infection and Transmission

There are different modes of spread of tuberculosis between camelid herds. One is the introduction of an infected animal into a non-infected herd (Bush *et al*., 1990). Secondly, animals with pulmonic lesions will excrete the organism in exhaled air, sputum and faeces from sputum that is swallowed (Windsor, 1999). The risk of being infected through aerogenous route is assumed to be high as there is a close association with camels since the livelihood of the over whelming nomadic population depend on camel. Camels in some countries (UAE) are no longer kept under nomadic management system and hence the risk zoonotic tuberculosis is increasing in those camels kept under intensive system of management (Wernery *et al*., 2007).

Tuberculosis is rare among camels kept under nomadic conditions. The disease occurs more frequently when camels are kept in close quarters with other camels or in close contact with cattle, for example in Russia and Egypt (Elmossalami *et al*., 1971; Donchenko *et al*., 1975). Pulmonary form of the TB is more common in camels indicating respiratory route as the major source of exposure in camel herds (Narnaware *et al*., 2015).

There is also other way to acquire the disease; for instance in the areas where dromedaries roam freely in the desert during day and return to their comps in evening; they can easily have contact with excretions of desert gazelles from which they contracted the infection. Several authors have reported tuberculosis in gazelles of the Arabian Peninsula (Ostrowski et al; 1998). It is also worthy of mention that dromedaries are coprophagus animals and this habit can expose them to the infectious agents (Dubie *et al*., 2016).

2.5. Pathogenesis

Tuberculosis spreads in the body by two stages, the primary complex and post primarily dissemination. The primary complex consists of the lesion at the point of entry and in the local lymph node. Post primary dissemination from the primary complex may take the form of acute miliary tuberculosis, discrete nodular lesions in various organs, or chronic organ tuberculosis caused by endogenous or exogenous reinfection of tissues rendered allergic to tuberculoprotein. Depending up on the site of localization of infection, clinical signs vary but, since the disease is always progressive, there is a constant underling toxemia which causes weakness, debility, and eventual death of host (Radostits *et al*., 2007).

Tuberculous lesions of cattle infected with *M. bovis,* most frequently found in the lungs and in the broncho-mediastinal lymph nodes, most probably in association with air-borne infection.

In contrast to human infection, the primary pulmonary lesion in cattle rarely heals spontaneously, but tends to disseminate locally through the natural cavities, such as the bronchi, or more widely via the lymphatic and haematogenous routes. The outcome of the infection, with few exceptions, is a chronic wasting disease of long duration (Cosivi *et al*., 1995). In relation to distribution of the tuberculosis lesions in body organs, camels 57.14% of the tuberculosis lesions were localized in the lungs and associated lymph nodes, 28.57% in the retropharyngeal lymph nodes and 14.29% in the mesenteric lymph nodes (Kasaye *et al*., 2013). Enlarged mesenteric lymph node and caseous granulomatous lesions are indicated in figure 1

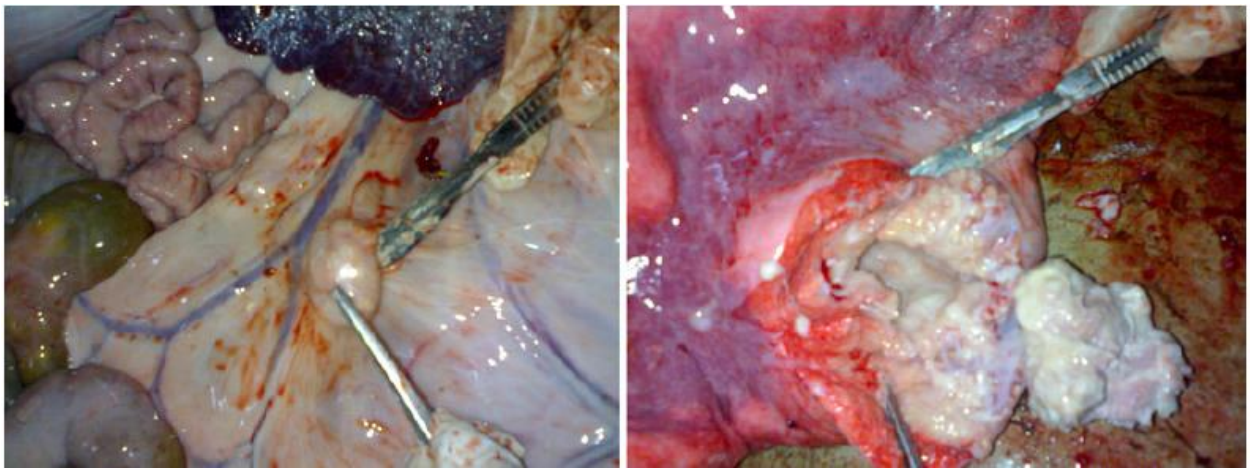

Figure 1: Granulomatous lesions from camel:

enlarged mesenteric lymph node (left) and cross section of a caseous granulomatous lesion in the lung (right). The mycobacterium isolated from this lesion was characterized as M. tuberculosis (Photo: E. Meles). Source: (Gumi *et al*., 2012).

The histopathology of affected organs revealed typical granulomatous lesions where in the giant cells and acid-fast bacilli were occasionally observed in pulmonary form whereas they frequently observed in disseminated form (Narnaware *et al*., 2015).

2.6. Clinical Findings

Development of overt disease is often related to the virulence of the organism, the route of infection, the stage of infection and several host related factors. Regional lymph nodes may be enlarged in advanced cases and, in some instances, may rupture and drain to the surface (Smith, 2009). The general signs are: weakness, erratic appetite, and emaciations as well as low grade fluctuating fever. Enlarged superficial lymph nodes provide a useful diagnostic sign (Thoen *et al*., 1995).

In advanced stages when much lung has been destroyed dyspnea with increased rate of respiration becomes apparent (Hirsh *et al*., 2004). Involvement of the mammary tissue may result in marked induration of affected quarters often accompanied by supra mammary lymph node enlargement (Quinn *et al*., 2002). Bovine TB manifests as a chronic granulomatous caseous necrotizing inflammatory process that primarily affects the lungs and their draining lymph nodes (Domingo *et al*. 2014).

Tuberculosis is a chronic debilitating disease. Clinical signs in camelids include; wasting, anorexia, respiratory distress, enlargement of superficial lymph nodes, recumbencey and eventually death. Clinical signs are often associated with extensive respiratory pathology, and it is surprising that overt respiratory distress is sometimes not observed in animals with severe lung lesions. Animals are occasionally found dead with no previous clinical observations (Wernery and Kinne, 2012).

2.7. Diagnosis

A presumptive diagnosis of TB in cattle and other susceptible species is often made on history, clinical findings, tuberculin skin tests, necropsy findings and other methods (OIE, 2009; Tessema *et al.,* 2011). In vitro lymphocyte assays, including an interferon gamma assay and enzyme linked immunosorbent assays have been developed for the detection of the disease in cattle and so other animals exposed to *M. bovis* (Samuel, 2010). Diagnosis of TB in live camelids faces many difficulties (Wernery and Kaaden, 2002), with none of the currently available tests being able to detect disease with certainty. Schillinger (1987) reported false positive results of the skin test in 10–20% of Australian dromedaries. Culture is still internationally considered as the gold standard for detection of mycobacteria (Ayele *et al*., 2004). Mycobacterium is slow-growing and acid-fast organisms that usually appear on culture media within 2–6 weeks (Wernery and Kaaden, 2002). *Mycobactrium bovis* grows poorly in standard Lowensten-Jensen medium, one of the most widely used culture media (Grange, 2001).

During necropsy examination of the infected lesions varying from firm or hard white, grey, or yellow nodule with a yellow, caseous, necrotic center that was dry and solid to thin walled suppurative abscesses were classified as post mortem positive (Smith, 2009). Post mortem examination should be supported by histopathology and bacteriological examination of lesions for definitive diagnosis of BTB (OIE, 2004).

Microscopic examination using Zihel-Neelsen staining was directly done from tuberculosis suspected lesions. The stained slide were observed under a microscope for the presence of

acid fast bacteria, which appear as red bacillary cells occurring singly or in clumps (Radostits *et al*., 2007).

The gamma interferon test (IFN-γ) and lymphocyte transformation assay are *in vitro* methods for measuring immune responses of circulating lymphocytes. The IFN-γ test is acknowledged by the OIE as an alternative to the TST for internationally traded cattle but the currently used bovine IFN-γ assay (Bovigam, Prionics, Switzerland) is unsuitable for camelids. The lymphocyte transformation assay is not used for routine diagnosis because it is time consuming and complicated to perform (Wernery and Kenni, 2012).

Multi-antigen print immunoassay (MAPIA) and the Vet TB Stat-Pak or 'rapid test' More recent serological tests include the (Waters *et al*., 2006). The MAPIA utilizes a range of antigens printed onto nitrocellulose strips that are incubated with serum samples; the rapid test is a portable lateral-flow chromatographic assay that uses three MTC-specific antigens. These antigens have shown some promise for detecting MTC-infected camelids, but further validation is still required before they can be used reliably for field diagnosis (Wernery *et al*., 2007).

Molecular techniques like polymerase chain reaction (PCR) and spoligotyping is also used. PCR is an in vitro DNA amplification method by enzymatic means at exponential rate that involves a repeated cycling process (Grainanger and Madden, 1993). It is a match faster method and reduces time for diagnosis for mycobacterium infections from 2 to 8 weeks to 2 days under controlled conditions and has shown sensitivity and specificity of nearly 90% in samples from respiratory organs (Pierle *et al*., 1991). Although the procedure is very sensitive when used on tuberculosis culture, similar levels of detection are not observed for clinical samples. It also detects culture negative samples that contained no microscopically visible acid fast organisms (Wards *et al*., 1995). The spoligotyping (spacer oligonucleotide typing) is one of the recently developed techniques, which has been developed to aid the differentiation of isolates belonging of the *M. tuberclosis* complex, including *M. bovis.* It is known for its use in the epidemiological investigation of TB, which improves the traceability of the infection or origin of outbreaks and it is presently considered as promising techniques (Kamerbeek *et al.,* 1997).

2.8. Treatment

First lines of drugs for TB therapy are streptomycin, isonized (INH), ethambutol and rifampin. Second line drugs are phyazinamide, paraminosalicylic acid, kanamycin, cyclosserine,

caperomycin and ethionamide. Because of resistance often develops under single drug regime a combination is commonly used. Because of the public health hazards inherent in the retention of TB animals, anti-tuberculous chemotherapy of animals is discouraged (Hirsh and Zee, 1999). The drug is not advised for animals because of long term treatment, which is uneconomical except for high yielding animals (Radostits *et al.*, 2000).

2.9. Control and Prevention

Effective control requires an understanding of epidemiology of infection within the ecological system that can include domestic as well as wild animal species (Cousins, 2001). Control of bovine TB in livestock and wildlife species relies on timely detection and removal or slaughter of infected animals and/or herds. In camelids, this strategy is difficult to conduct because of the lack of adequate tests for live animals (Wernery *et al*., 2007).

The basic strategies required for control and elimination of bovine tuberculosis are well known and well defined. However, because of financial constraints, scarcity of trend professionals, lack of political will, as well as the underestimation of the importance of zoonotic TB in both the animal and public health sectors by national governments and donor agencies, control majors are not applied or are applied inadequately in most developing countries. Measures to prevent transmission of infection should be the primary objective to be achieved with trained public health personnel, public education and proper hygienic practices (Cosivi *et al.,* 1998).

Eradication is common in herds and areas which have low incidence of the disease. When the incidence of the tuberculosis is high, a routine test and slaughter program may be economically impossible. Alternatively, vaccination may be used as temporary measure (Radostits *et al*., 2007).

In developing countries, however, BTB remains a major animal health problem, mainly because these countries cannot shoulder the financial burden required to implement a control programme and compensate for slaughtered animals. Limited access to education, poor information network and lack of disease surveillance are other factors that limit the implementation of any such programmes (Ayele *et al*., 2004). Vaccine is not yet available for camels (Wernery and kinne, 2012).

2.10. Zoonotic Importance of Camel Tuberculosis

Tuberculosis (TB) is among the most devastating human infectious diseases worldwide. An estimated 8.8 million new cases, a global average incidence rate of 128/100,000

population/year, and 1.5 million deaths were attributed to TB in 2010 (WHO, 2011). The current increasing incidence of tuberculosis in humans, particular in immune compromised human, has given renewed interest in the zoonotic importance of *M. bovis*, especially in developing countries (Radostits *et al.*, 2007).

Human TB is caused principally by *M. tuberculosis*. The main causative agents of bovine TB are *M. bovis* and, to a lesser extent, *M. caprae*; however, zoonotic transmission of these pathogens is well described and occurs primarily through close contact with infected cattle or consumption of contaminated animal products such as unpasteurized milk (Ayele *et al*., 2004). In pastoral communities of Afar, Somali and Borana, camels are kept almost entirely for milk production. In these communities, camel milk is consumed raw, and this habit combined with close physical contact with their animals create a potential public health concern for transmission of zoonotic diseases such as TB from animals to the pastoralist (Mamo *et al*., 2011).

In general camel tuberculosis similar to bovine tuberculosis results a serious zoonotic impact especially in nomadic population where consumption of raw camel milk and animal products remain the common practice (Mamo *et al*., 2011). Tuberculosis, as a zoonosis from camel to human also plays an important role among nomadic people where milk and milk products are consumed raw (Seifert, 1992).

The presence of multiple additional risk factors can affect the zoonotic aspects of *M. bovis* in Africa. Risk factors such as human behavior, close physical contact between humans and potentially infected animals, habit of consumption of raw milk, which is widely practiced and increasing incidence of HIV infection which is closely linked with tuberculosis (Michel *et al*., 2010; Muller *et al*., 2013). HIV/AIDS is thought to facilitate transmission and progression to active disease of any form of TB (LoBue *et al*., 2003).

Ethiopia ranks seventh among the world's 22 countries with high tuberculosis (TB) disease burden and had an estimated incidence rate of 379 cases per 100,000 people per year (WHO, 2008). In Ethiopia, *M. bovis* was found to be a cause for tuberculous lymphadenitis in 17.1% of 29 human tuberculosis cases (Kidane *et al*., 2002). Also in Ethiopia, Shitaye *et al.,* (2007) reported that 16.7% of 42 human isolates were identified as *M. bovis.* These findings show that the role of *M. bovis* in causing human tuberculosis seemed to be significantly important.

2.11. Status of Camel Tuberculosis in Ethiopia

Ethiopia is one of the African countries where BTB is considered as protruding disease in animals. Detection of BTB in Ethiopia is carried out most commonly on the basis of tuberculin skin testing, abattoir meat inspection and rarely on bacteriological techniques (Shitaye *et al*., 2007). In general, there is scanty information on TB in camels. Nonetheless, there are few reports published on camel TB in Ethiopia as well as in other countries. The prevalence of camel TB currently recorded at Akaka and Metehara abattoirs was 10.04% (91/906) on the basis of pathology and it was significantly higher in females .The tropism of TB lesions was significantly different among the lymph nodes and lung lobes. Mycobacterium growth was observed in 34% (31/91) of camels with grossly suspicious TB lesions (Hussein, 2009).

Although, the extent of TB has been well documented in humans and most domestic animals, very little is known about the pathology and cause of camel TB in pastoral areas of the world. In Ethiopia, there are some studies indicating the existence of camel TB with a prevalence of camel TB ranges from 5.07% in Dire Dawa abattoir (Mamo *et al*., 2009) to 12.3% in Eastern Etiopia abattoir based (Zerom et al., 2012) as summarized in (Table 1).

Table 1: Summary of Status of Camel Dromedary Tuberculosis in Ethiopia.

Title and site of the study	Reported Prevalence	Authors
A cross sectional study of camel tuberculosis in Ethiopia at Dire Dawa abattoir	5.07% based on postmortem examination	Mamo *et al*., 2009
Study on *Mycobacterium tuberculosis* complex infection in livestock and humans in Amibara District of Afar Region	34% (31/91) of camels with grossly suspicious TB lesions	Hussein, 2009
Pathology of camel tuberculosis and molecular characterization of its causative agents in pastoral regions of Ethiopia at Akaki and Metehara abattoirs	10.04% (91/906) on the basis of pathology	Mamo *et al*., 2011
Tuberculosis in dromedaries in Eastern Ethiopia: Abattoir-based prevalence and molecular typing of its causative agents	12.3% based on post mortem	Zerom *et al*., 2012
Prevalence of camel tuberculosis at Akaki abattoir in Addis Ababa, Ethiopia	4.52 % based on tuberculosis lesion detection	Kasaye *et al*., 2013

Prevalence of bovine tuberculosis in dromedary camels and awareness of pastoralists about its zoonotic importance in Eastern Ethiopia in in Dire Dawa City Administrative Council (DDAC) and Somali pastoral region from	8.3% based on the post mortem examination and 6.0% based on the tuberculin test	Beyi *et al*., 2014

3. CONCLUSION AND RECOMMENDATIONS

This review revealed that different finding of conducted research on camel tuberculosis and its public health implications indicated the role of the disease is significantly important. Camel Tuberculosis has significant effect both in animals and humans in areas where control of the disease is not implemented and consumption of uncooked products of camel is adopted. The status of the disease is not well known and people have little or no awareness on the potential risk of the disease as zoonosis. Pastoralists who are closely tied with rearing of camels are at risk of being infected with zoonotic disease such as camel tuberculosis. Peoples consuming of raw infected camel milk, having close association with infected animals have high probability of being acquiring the infection. Conventional cost intensive test-and-slaughter schemes do not appear to be appropriate control measures for animal tuberculosis in developing countries. Based on the above conclusive remarks, the following recommendations are forwarded:

- In Camel rearing countries future research should be promoted on further investigating camel tuberculosis in mostly affected areas for understanding of its epidemiological status so as to design a control strategy.
- Feasible control strategies for camel tuberculosis in developing countries need to be designed.
- Awareness creation about camel Tuberculosis, transmission path way, prevention and control methods, as well as its zoonotic importance for peoples in camel rearing areas to reduce the risk of transmission and infection of humans by *M. bovis*.
- Public awareness on implementation of pasteurization of milk before consumption and detailed meat inspection in abattoir.
- Implementation of one health approach for Zoonotic camel tuberculosis control.

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