

Review Article

Review on the Epidemiology, Public Health Importance and Status of Awareness of camel rearing pastoral communities of Ethiopia on camel tuberculosis

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Abstract

In the pastoral areas of Ethiopia, camel is the spine for their everyday life and extraordinarily adjusted to cruel condition. In Ethiopia, camels are for the most part raised in Afar, Somali, and Oromia (Borena, Kereyu and Guji). The pastoral community utilized camel products, such as milk and meat, and they used camels for various purposes for example, for transportation, draft, ploughing land, festivity and rivalry as in dashing. In the pastoral areas of Ethiopia, camel milk is accepted as treatment for gastritis, asthmatics, stomach inconvenience, HIV, hamot (kar), tuberculosis, fever, urinary issues and hepatitis. Camels have high contribution in Economic development of the country. In spite of having such like various purposes for pastoral areas, a few ailments influence the wellbeing status of camel. From significant illnesses, tuberculosis is one of the principal, which influence the camel Health and have a zoonotic impact. Camel tuberculosis is chronic diseases, which is portrayed by the development of granulomas, essentially in the respiratory tract, and related lymph nodes, from which the mycobacteria are discharged and contaminate other susceptible animals. Camel tuberculosis has general public health implication, especially in pastoral areas of Ethiopia due to the communities have the habit of consuming raw camel milk and its products and they do have consistent or day-by-day contact with their camels. In addition to this, the etiological agents are transmitted to humans through aerogenous route from those animals with active cases in the herd. The infection has been reported from several parts of pastoral areas of the country essentially dependent on tuberculin tests and abattoir inspections. Therefore, attention should be given towards the control of tuberculosis in livestock; public health education on zoonotic importance of the disease or awareness creation and the national tuberculosis control needs to consider the one health approach and further epidemiological studies should be undertaken.

Introduction

Ethiopia is one of the country known by rearing different species of animals and it is believed to have the largest livestock population in Africa [1]. From different species of animals rearing in Ethiopia, Dromedary camel (one-humped *Camelus dromedarius*) is the principal one. Out of the 28 million global population of domesticated large camelids (dromedaries and Bactrian) 4.8 million Dromedary camels are found in Ethiopia [2,3].

Most of camel population in Ethiopia is kept by pastoralists

where nature is cruel and shortage of water and feed resource is there. Camels occupy practically all fringe drier lowland areas that generally fall below 1,500 meters above sea level [4,5]. The pastoral areas of Ethiopia is known by a camel culture, a monoculture that is communicated as an adjustment to dry environment through reliance on the camel dependent on uniform farming strategies and portability [6]. In Ethiopia, camels are mostly raised in Afar, Somali and Oromia (Borena and Kereyu) regions [7]. Guji and west Guji drier areas, pastoral communities are following the tried-and-tested adaptation strategy of camels and goats which one is more resilient more

than cattle and sheep [8]. The kunama and Irob peoples also known by keeping camels [9].

Camels are the backbone of the pastoral economy and resource for greater part of pastoralists. They used camel for ploughing land or for agriculture. The draft power created by camel ranges from 17 to 22 percent of body weight [10]. In food security, the camel utilized the pastoral communities as wellspring of meat, milk, and pay producing, just as for different purposes, for example, transport, amusement, festivity and rivalry as in hustling and magnificence appear in the East Africa, the Middle East and South Asia [11-13].

Currently, in Ethiopia the utilization of camel milk is expanded because of various purposes. Presently days a few people in Ethiopia mindful of that, the camel milk holds distinctive compound parts inside it which make it one of a kind from other dairy animals and help the customer for various medical advantages. As indicated by various authors the camel milk comprises of: finely homogenized fat, various kinds of proteins, for example, casein, whey and insulin, carbohydrate, minerals, vitamins and electrolytes [14-16].

In view of the segments of various synthetic compounds or because of various bioactive segments in camel milk individuals utilized as a treatment for various illnesses. The individuals which live in Babilie and Kebribeyah districts, Jijiga Zone of the Somali Regional State they utilized camel milk as treatment of gastritis, asthmatics, stomach inconvenience, HIV, hamot (kar), tuberculosis, fever, urinary issues and hepatitis. In addition, it is used to treat various diseases such as jaundice, malaria, constipation, to clear the stomach, baby blues care of ladies, to detoxify snake venom and fart, intestinal sickness and blockage for reason that camels peruse on different plant species and dynamic specialists with helpful properties from these plant species are discharged into the Milk. Pastoralists considered camel milk as prepared available medication for various sicknesses [17-19].

The children want to drink camel milk as opposed to other dairy animals' milk. Camel milk have had stunning upgrades in their behaviour and diets [15]. The lactose substance of camel milk (4.8%) is practically like human mother's milk and in this manner can be readily digested by people experiencing lactose prejudice that implies tit fill in as treatment for allergy [20].

In addition to camel milk, camel meat also a significant source of animal protein in many African and Asian countries, especially in areas where the climate adversely affects the production efficiency of other animals. The culinary and cooking practices, as well as the palate for meat, in several African and Arabian countries have evolved toward camel meat to other meat animals' species in light of convictions in restorative advantages, its accessibility as well as moderate cost [21]. Camel meat is more beneficial contains less fat as well as less levels of cholesterol in fat than other meat animals. Compared to beef, camel meat is also comparatively high in polyunsaturated fatty acid giving opportunity for reducing the risk of cardiovascular disease, which is related to saturated fat consumption. Camel meat is also used for remedial purposes

for diseases such as hyperacidity, hypertension, pneumonia, and respiratory disease [22].

In building up the economy of the country the camels has an essential role. As per NBIIA [23]. Ethiopia earned USD 211.1 million during Ethiopian financial year (July 2010-June 2011) by sending out 16,877 tons of meat and 472,041 head of live animals. According to the information accessible with Ethiopian Revenue and Customs Authority, live animals trade contributed 70% of the profit while the parity (30%) was gotten from meat send out. Of the quantity of traded live animals, camel represented 13% and contributed 25% to the income produced. As Mehari, et al. [24], report in Somali area camel milk sale was the main sources of income, and there are various camel milk assortment focuses selling milk in nearby towns and urban areas of the Somali district of Ethiopia, just as traded to the neighbouring nation of Somaliland [25]. In addition, in Meiso (Oromia) lowlands of Ethiopia, the majority of pastoralists (78%) had been selling camel milk [26]. Milk selling is the job of women in Afar, and this is comparative in the Somali district of Ethiopia where it was customarily and predominantly promoted by women and their associations along connection lines [18].

The camel milk and meat, inspite of having such like pleasant segments of various chemical components which is suitable for human being utilization and therapeutic incentive as well as economic advantages it polluted by various pathogenic *enterobacteriae* (*Eschericha coli*, *Salmonella species* and *Shigella species*), *Staphylococcus aureus*, *Pyogenic Streptococci*, *Campylobacter jejuni*, *Listeria monocytogenes*, *Yersinia enterocolitica*, *Bacillus species* and pathogenic shape are distinguished in crude camel milk [27-30].

In addition to the above pathogens, Tuberculosis a genuine rising sickness in camels of various African countries, especially in Ethiopia. As researchers reviled that, in Ethiopian abattoirs a predominance of up to 10% was recorded dependent on the recognizable proof of gross lesion in apparently healthy dromedaries [31]. The other research as of late show that, the prevalence of camel tuberculosis in Akak abattoir in central Ethiopia report that 9.82% [32]. Few researchers also conducted different research in different pastoral areas of Ethiopia, which indicate different prevalence rate of camel tuberculosis [31,33,34-37].

Tuberculosis diseases circulate between human and animals. So that it do have a serious a zoonotic and reverse zoonotic importance. In Ethiopia had also confirmed transmission of *M. tuberculosis* from farmers to their cattle, goat and camel [38,39,34, 40]. The *M. tuberculosis* strain isolated from disseminated TB lesions in a camel belongs to the E-A lineage (SIT 149), a dominant strain in Ethiopia [34,41]. Therefore, in Ethiopia *M. tuberculosis* seems to be more frequently transmitted from humans to livestock than *M. bovis* from cattle to humans.

Therefore, an urgent need to advocate for effective control measures is highly necessary, because in Ethiopia there is largest number of pastoral population in which their life is depend on



livestock and consumed raw animal products such as milk and meat daily. This type of condition predispose the public for transmission of zoonotic diseases such as tuberculosis. So that, determination of prevalence of camel tuberculosis in pastoral area and other animals is first step to appraising the disease transmission risk and burden. Even tuberculosis has long been reported, in different pastoral areas, there is no sufficient information on the prevalence, public health importance and its control measures in Ethiopia at national level.

Therefore, the objectives of this review paper are:

- to show available information on the epidemiology of Camel tuberculosis
- to indicate zoonosis of camel tuberculosis
- To highlight some possible approaches for Camel tuberculosis control and
- To give clue for policy makers on control strategy of camel Tuberculosis.

Camel Tuberculosis (Tb)

Etiology of the diseases: Tuberculosis (TB) is a major infectious disease of mammals caused by infection with bacteria of the *Mycobacterium tuberculosis complex* (MTBC) [42]. Most cases of TB in farm animals are caused by infection with *M. bovis*, the member of the MTBC that causes bovine TB. However, TB in camelids caused by infection with *M. microti* (another member of the MTBC), *M. kansasii* and *M. avium* complex has been reported in Great Britain (GB) and other countries [43,44].

The name “Tuberculosis” comes from the nodules, called ‘tubercles’, which form in the lymph nodes of affected animals [45]. The genus *Mycobacterium* of the family *Mycobacteriaceae* includes non-motile and non-sporing acid-fast rods of various lengths [46]. Mycobacteria are generally not species-specific pathogens [47].

Mycobacteria possess a waxy coat that makes it difficult for the host’s defence mechanisms to destroy them and results in a slow chronic disease [48]. So that Tuberculosis (TB) is, a chronic, reportable granulomatous zoonosis caused by *Mycobacterium tuberculosis complex* and affects many animal species including camels [49,50].

Classification of mycobacterium

The genus *Mycobacterium* includes diverse species ranging from environmental saprophytes and opportunistic invaders to obligate pathogens differing in their nutritional requirement [51].

The Mycobacterium Tuberculosis Complex (MTBC)

The mycobacteria assembled in the MTC are characterized by 99.9% similarity at the nucleotide level and identical 16S rRNA sequences but differ widely in terms of their host tropisms, phenotypes, and pathogenicity. Suggesting that

they all derived from a common ancestor [52-54]. MTBC is defined as a complex of seven distinct bacterial species named *M. tuberculosis*, *M. canettii*, *M. africanum*, *M. pinnipedii*, *M. microti*, *M. caprae* and *M. bovis* [55,56], but, importantly, differ in physiological characteristics, virulence and host range. *Mycobacterium tuberculosis*, *M. africanum* and *M. canettii* are principally pathogenic in humans. *Mycobacterium bovis* and *M. microti* are the causative agents of TB in animals, and can be transmitted to humans. [57-59].

The host range of *M. bovis* is considered the broadest of the complex, causing sickness over an assortment of animals. It could be normal that the major evaluative movements associated with adjustment to various hosts would have involved huge microbiological separation [57,59]. The different bacterial species show a certain host tropism. E.g. *M. bovis* most commonly affects cattle, *M. tuberculosis* affects humans, *M. microti* is most frequently isolated from voles [53]. Nevertheless, spill over to other hosts has been observed for most of the bacteria [55,60,61].

The Non-Tuberculous Mycobacteria (NTM)

Mycobacterium species other than the MTBC that cause TB like diseases in man and animals are commonly called non-tuberculous mycobacteria (NTM) or “atypical mycobacterium” [51,62]. Non-tuberculous mycobacteria are ubiquitous organisms with nearly 100 different species found in soil and water [63]. Some of the species including in this member are *M. avium complex* (*M. avium* and *M. intracellulare*), *M. kansasii*, *M. scrofulaceum*, *M. simiae*, *M. habana*, *M. neoaurum*, *M. vaccae*, *M. palustre*, *M. elephantis*, *M. bohemicam* and *M. septicum* [62]. Atypical mycobacterium are not pathogenic to man and animals except in certain situations such as direct inoculation into wound or introduction into immune compromised hosts due to immune suppressive therapy or due to HIV infection [62]; however, they are important during diagnosis as they sensitize man/animals to tuberculin test [58,62]. In addition, NTM exerts a challenge in microscopic diagnosis of MTBC, it cannot differentiate MTBC from NTM particularly *M. chelonae* as both of them have similar chording feature under microscopy, which can cause a misidentification problem [64].

Etiology of tuberculosis in camel

Two members of *Mycobacterium tuberculosis complex* (MTC) cause tuberculosis in cattle and other domestic animals: *M. bovis* and *M. caprae* [65,66].

Some of atypical Mycobacteria rarely causing TB in camels are *M. kansasii*, *M. aquae*, *M. aquae var. ureolyticum*, *M. microti*, *M. fortuitum* and *M. smegmatis*. The atypical species of Mycobacterium cause disease in camel when it becomes immunocompromised [67]. The four major Mycobacteria, *M. bovis*, *M. tuberculosis*, *M. avium* and *M. avium supsp* paratuberculosis have been isolated from new world Camelids as well as some atypical Mycobacteria (*M. kansasii* and *M. microti*) found tuberculosis in small llama herd near the border of England and Wales [68].



Epidemiology of camel tuberculosis

In Ethiopia, there is little published information on the epidemiology of camel tuberculosis. The ailment influences camels all through the globe, incorporating camels raising in pastoral areas of Ethiopia. In 1991, Abdurahman & Bornstein [69], detailed the malady to be moderately uncommon in Somalia; a nation around then had perhaps the biggest population of OWCs on the world [70]. At that point after hardly any studies have been directed in the epidemiological investigation of Tuberculosis and recognizable proof of the causative agents in camels [31,33,35].

The study, which is done by Beyi, et al. [37], at abattoir of Eastern Ethiopia was to recognize *M. Bovis* in dromedary as causative agent of Tb. The prevalence of camel shows that 33 (8.3%) of the 398 examined carcasses.

The investigation of camel tuberculosis which is led by Mamo, et al. [33] in eastern Ethiopia was in order to describe its prevalence and to isolate *M. bovis* from infected camels as the causative organism. A study on 276 pastoral camels slaughtered at an abattoir east of Addis Ababa showed 14 camels have lesions typical of TB infection, providing an estimate of 5% prevalence in pastoral camels in this area. However, of these 14 lesioned camels, only four had AFB-positive tissue impression smears, and only one of these four samples was PCR-positive for MTBC [33]. Another investigation of 906 apparently healthy camels from two further pastoral regions of Eastern and Southern Ethiopia demonstrated 91 camels to have suspicious TB lesions, giving an expected prevalence of 10%. Acid fast Bacilli (AFB) positive mycobacterial isolates were cultured from 31 (34%) of these lesioned camels, of which 21 provided a positive PCR signal for the genus *Mycobacterium*, but only two were confirmed as MTBC and identified as *M. bovis* [31]). The apparently poor recovery of a positive causative agent (i.e. *M. bovis*) from the majority of lesioned camels in these two studies in Ethiopia could be related to a non-optimal culture for non-MTBC mycobacteria, and also reflect the diversity of mycobacteria causing mycobacterial diseases in camels. More recent 16S rDNA sequencing of these non-MTBC mycobacteria has revealed *M. terrae* complex, *M. flavescens*, *M. brasiliensis*, *M. chelonae* and *M. avium* as causative agents [31].

Other abattoir studies have likewise featured the potential for association of non-MTBC just as MTBC in camel mycobacterioses in Ethiopia. A point by point after post mortem examination of 293 OWCs from eastern Ethiopia shows an expected prevalence of 12.3% (36/293), with the occurrence of TB lesions significantly associated with female dromedaries. Mycobacteria were isolated from 61% (22/36) of those gross lesions investigated, and molecular characterization of the isolates showed just three to be *M. tuberculosis*, and the majority of the isolates from this study (15/22) to be non-MTBC [34,35] examined 694 camels slaughtered at Filtu and Addis Ababa abattoirs (mainly camels from southern Ethiopia) and isolated three AFB-25 positive isolates of which one was *M. tuberculosis* and the other two were non-MTBC. The last gathering of organisms have comparably been distinguished as a critical reason for mycobacterial diseases in Ethiopian cattle's, with one

examination depicting 30% (53/171) of isolates as containing 11 non-MTBC species [38]. These discoveries not just recommend the significance of non-MTBC in OWC TB in Ethiopia, yet in addition feature a potential role for OWCs in the transmission of *M. tuberculosis* in people [2].

As of late Yasmin, et al.[32], reveal 9.82% of camel tuberculosis at Akaki abatoirs and the origin of camels were from Borana and Metehara. The camels which origin from Metehara shows high prevalence which 9.6% and 10.94% from Borana respectively. The single intra-dermal comparative cervical tuberculin (SICCT) test of the 387 camels indicated that overall positive tuberculin reactor prevalence of 9.82% (38/387)

Prevalence of camel tuberculosis recorded by Mamo et al. [31], with abattoir-based prevalence of 10.4% in Akaki and again [46] report the prevalence of 5.1% at Dire Dawa, and Gumi et al.[34], also reports 3.1% for camels in Southern Ethiopia. Similarly, some other authors at different sites in Ethiopia [36,37] for camels at Akaki and Eastern part of Ethiopia. In Ethiopia dromedary camels, *M. bovis* [33] and *M. tuberculosis* from tissue lesions [34,35] have been isolated. Of the MTBC, *M. tuberculosis*, *M. bovis*, *M. pinnipedi*, *M. caprae*, and *M. microti* have been isolated from camelids [71-73].

Non-tuberculous mycobacteria (NTBC) such as *M. kansasii*, *M. aquae*, *M. fortuitum* and *M. smegmatis* have also been isolated from OWCs as causative agents of camel TB [31,35,67,68]. Strains of *M. tuberculosis* have also been identified from camels in southern Ethiopia [34], from camels in Eastern Ethiopia [35], from goats in Afar by Mulugeta, et al. [74], from pigs in central Ethiopia.

Source of infection and mode of transmission

The ailment is described by the development of granulomas, basically in the respiratory system and related lymph nodes, from which the mycobacteria are discharged and contaminate other susceptible individuals [2].

There are a few courses of transmission of disease. Respiratory transmission by means of the inward breath of sullied mist concentrates or fomites is the most productive type of transmission, requiring a low number of organisms' beings as an infective dose. Under most conditions, an infected host creates a vaporized containing *M. bovis* when the animals coughs or sniffles, and the vaporized is breathed directly by an uninfected host, bringing about contamination or infection. Respiratory transmission is the most significant course of disease in groups of Animals that stay in close contact [75].

Organisms are discharged in the breathed out air, nasal discharge, milk, urine, vaginal and uterine discharges and discharges from open peripheral lymph nodes. Animals with gross lesions that communicate with airways, skin or intestinal lumen are obvious disseminators of infection. In the early stages of the disease before any lesions are visible, animal may also exert viable *mycobacterium* in nasal and tracheal mucus. In experimentally infected animal excretion of the organism commences about 90 days after infection [76].



There are various methods of spread of tuberculosis between Camelid herds under intensive management system. This is mainly occurred when infected animal is introduced into non-infected herd [77]. Animal with pulmonary lesions will discharge the organisms in breathed out air that can act as source of infection in those non-infected animals [78].

Camels under nomadic environment, they can get the disease by various systems. Camels under migrant condition, they can get the disease by various systems. A portion of the animals can secure the contamination when they interact with infected animals (camels or cattle). There is likewise other approach to get the sickness; for example in the areas where dromedaries meander uninhibitedly in the desert during day and come back to their camps in night; they can without much of a stretch have contact with discharges of desert gazelles from which they gotten the disease. Several authors have announced tuberculosis in gazelles of the Arabian Peninsula [79]. It is likewise deserving of notice that dromedaries are coprophagous animals and this habit can expose them to the infectious agents.

Zoonotic infections, transmissible between humans and animals, are closely associated with pastoralists, because of their close contacts with their domesticated animals [80,81]. In Ethiopia, the significant routes of transmission from camel to individuals are probably going to be through utilization untreated milk and meat items from infected animals, but also via aerosol in the proximity to livestock. These conceivable hazard factors are of specific worry for some developing countries where pasteurization is limited and where individuals are living close to their animals [34,40].

Risk factors

In conventional domesticated animals raising system, the different species of animals are often herded together and watering points are common. Such livestock husbandry and management systems can be an important risk factor for animal-to-animal, animal-to-human, human-to-animal, and human-to-human *M. bovis* transmission [82,76].

All species of animals including human beings, body conditions, sex and age groups are susceptible to *tuberculosis causing agent* [33]. The prevalence of TB in camels were relatively higher in the younger and older camels than other age groups. Different authors have likewise announced in dairy cattle especially that more seasoned animals are influenced by TB [83], which could be due to the fact that older animals have weaker immune system. The higher recurrence of lesion in younger camels could be due to the less developed immunity [84]. The [32] likewise report of high prevalence in old camels. Young camels can also be easily infected with higher doses of *Mycobacteria* via colostrum's from infected camel in a similar way, as it occurs in cattle [85]. With the goal that the age is one of the most risk factor in camel tuberculosis.

In addition, the pathogen act as risk factor for tuberculosis in camels and other animals. 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 [86].

In Ethiopian transmission of tuberculosis from diseased animal to man is the conduct of preference of raw milk (as compared to pasteurized milk) consumption. The zoonotic risk of tuberculosis frequently connected with utilization (ingestion) of unpasteurized milk and other dairy items infected with *M. bovis*. Additionally, airborne transmission from cows to-human (or the other way around) ought to be considered as a potential risk factor [87].

The other risk factor is absence of awareness of Zoonotic diseases in the pastoral areas of Ethiopia. The pastoralists demonstrated low familiarity with milk-borne infections. Then again, the members frequently underlined the healthful and restorative benefit of devouring milk. From pastoralist areas, the Borana people group accept that milk in the udder has no damage and if people don't make it terrible, milk can't be awful "Healthy animal" is "healthy" and most contamination and subsequent lowering of the quality of milk happens after milking. The other thought from Borana pastoralist is, at times, it was likewise noticed that udder wellbeing is a contributing variable for low quality of milk. The milk has 'sickness', when the udder is diseased and they said, "We want raw milk, Boiled milk is dead". Raw milk is good. Only educated people boil milk [88].

Pathogenesis

The animals presented to causative agents of tuberculosis through various courses of vaporized presentation, by ingestion of nourishment and water with *M. bovis* regularly create essential foci in lymph tissues related with the intestinal tract. Other mycobacteria including *Mycobacterium* subsp. *avium*, *Mycobacterium avium* subsp. *paratuberculosis*, *Mycobacterium intracellulare*, *Mycobacterium scrofulaceum*, *Mycobacterium kansasii*, *Mycobacterium fortuitum*, and *M. tuberculosis* may induce tuberculin skin sensitivity. Aerosol exposure leads to the involvement of the lung and associated lymph nodes. The mucociliary clearance by mucus and epithelial cilia in the upper respiratory passages provides a defence against infection by inhalation of mycobacteria. However, microorganisms on small particles such as dust and water droplets that do not impinge against the mucociliary layer can pass through terminal bronchioles, thus gaining access to alveolar spaces. The estimated size of terminal endings of bronchioles is about 20 μm as compared to 1–4 μm for an acid-fast bacillus. Following aerosol exposure, *M. bovis* is carried to the small air passages, where phagocytes ingest it. The phagocytes pass through the lining of the bronchioles, enter the circulation, and are carried to lymph nodes, parenchyma of lungs, or other sites. After ingestion of the bacillus, the mononuclear macrophages attempt to kill the organism; however, virulent tubercle bacilli possess the ability to escape killing. Ingestion of the tubercle bacilli by the phagocytes into phagosomes or intracytoplasmic vacuoles protects the organisms from bactericidal components in serum. Following ingestion into phagocytes, mycobacteria effectively prevent phagolysosome fusion and acidification [89]. Mycobacterial lipids such as lipoarabinomannan (LAM)

and phosphatidyl inositol mannoside have been shown to intercalate within endosomal membranes and contribute to the arrest in phagosome maturation [90]. In addition, mycobacterial proteins of the antigen complex have been shown to localize within cytoplasmic vacuoles free of mycobacteria [91]. By this mechanism, mycobacteria survive and multiply within the phagosomes and eventually destroy the phagocytes. *Mycobacterium marinum*, a close relative of *M. tuberculosis* and *M. bovis*, may lyse the phagosome and enter into the cytoplasm and use actin polymerization to spread from cell to cell [92], a phenomenon that has not been observed with *M. tuberculosis* or *M. bovis*. Nonetheless, phagosomes containing *M. tuberculosis* or *M. bovis* BCG display certain degree of permeability, allowing entrance of cytosol components of up to 70 kDa in size. These findings led to the hypothesis that these membrane-permeable phagosomes may allow a bidirectional transfer of mycobacterial products such as peptides, cord factor, or other toxic products from the phagosomes into the cytoplasm. This process may have implications for the role of cytotoxic T cells and class II mediated antigen presentation in the pathogenesis of mycobacterial infections [93]. On the basis of these findings, pathogenic mycobacteria may even gain access to the cytoplasm [94]. Then other phagocytes then enter the area and ingest the increasing numbers of tubercle bacilli. A small cluster of cells referred to as a granuloma develops. Cellular responses attempting to control the disease result in the accumulation of large numbers of phagocytes, and finally the formation of macroscopic lesions, denominated tubercles. After 10–14 days, cell-mediated immunity (CMI) responses develop, and macrophages of the host have an increased capacity to kill the intracellular bacilli. The CMI responses are mediated by T lymphocytes, which release lymphokines (messenger proteins secreted by lymphocytes) that attract, immobilize, and activate additional blood-borne mononuclear cells at the sites where virulent mycobacteria or their products exist. The enlargement and presence of macrophages in impenetrable passageways between reticular cell fibers of the lymph node provide an environment for mycobacterial growth and development of the granulomatous lesion in the node. On occasion, some phagocytized mycobacteria remain in the lung, and both lung and thoracic nodes are affected. Primary lesions often become localized in a node or nodes and may become large and firm [47].

Clinical finding

Clinical signs in infected camelids tend to be vague or non-existent. Observant owners may detect subtle changes in behaviour. In some, there is a short period of illness terminating with respiratory symptoms. Other signs such as weight loss, loss of appetite, exercise intolerance or an intermittent dry cough are not consistent. Some camelids remain in good body condition until sudden death. As there is no routine surveillance for camelids, it is for the owner or their veterinary surgeon to arrange a post-mortem examination for any dead or moribund animals. The respiratory system and associated lymph nodes are most frequently affected. The lung lesions may be so extensive that it is surprising that severe pathology did not prove fatal earlier. The lesions are white or

creamy and caseous. There may be miliary lesions or multiple foci in the lungs, and in more advanced cases, these lesions coalesce to give large areas of caseous necrosis, often involving whole lobes. The lymph nodes of healthy camelids can be small and difficult to find. By contrast, tuberculous lymph nodes are often massively enlarged and contain multiple white, cream or yellow-tinged caseous foci and in severe cases, the whole node may be replaced by one large caseous lesion [2].

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Pathology

In Ethiopia determination of camel tuberculosis relying upon pathology was exceptionally, uncommon as a result of not many research was led on prevalence and epidemiology of this diseases in camel. Abattoir based epidemiological survey of tubercle lesion were performed by some researchers in different pastoral areas of Ethiopia. As Yasmin [96], the overall lesion prevalence of 7.54% was recorded. Other researchers such as Gumi, et al. [34], revealed 12.3% (36/293) for camels in Eastern Ethiopia. Kassaye et al. [36], also conduct research at Akaki slaughtered abattoir on camels that reveal 21(4.52%) based on gross tuberculosis lesion detection. The lesions were more conspicuous in cranial mediastinal and retropharyngeal lymph nodes. Miliary lesions were observed in the lung and mesentery in two of the 19 (10.53%) positive cases.

According to Mamo, et al. [31], the prevalence of camel TB was 10% (91/906) On the basis of gross pathology. The Lung lesions were highest in the retropharyngeal lymph node and mesenteric lymph node. Conversely, isolation from mandibular and parotid lymph nodes were less frequently mycobacterial culture positive Figure 1.

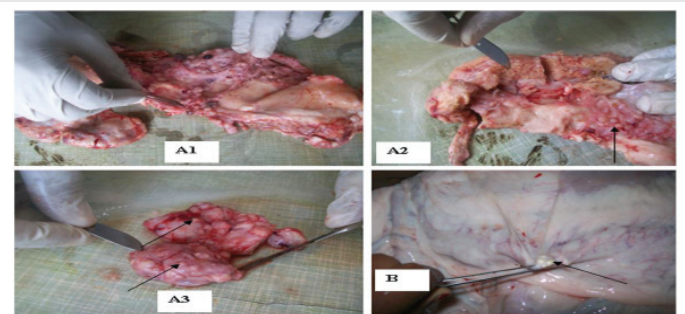


Figure 1: Pathological lesion of camel TB in different organs.

Source: Mamo et al. [31] A1) lesions in mediastinal parts of the lung. (A2) lesion in mediastinal lymph node and nodules on other parts as indicated by arrows. (A3) lesions in hepatic lymph node. (B) lesion in mesenteric lymph nodes.

As Beyi et al. [37], revealed that 33 (8.3%) out of the 398 examined carcasses showed tuberculosis compatible Lesions (TCL) at Dire Dawa municipal abattoir. Enormous extents of the lesions were found in the thoracic lymph nodes and the lungs followed by the lymph nodes of the head and the complement in mesenteric lymph nodes. Out of 33 camels



with TCL, 4/33 (12%) showed growth on Lowenstein-Jensen (LJ) media supplemented with pyruvate and 6/33 (18%) on LJ media supplemented with glycerol. Ziehl-Neelsen staining of centrifuged sediments of the 33 lesions smears demonstrated only 11 acid fast bacteria (AFB) positive slides. Out of these 11 AFB positive smears, only six proved positive upon bacteriological examination culture.

For pathological Lesion In the detail abattoir inspection, lymph nodes including parotid, mandibular, retropharyngeal, tracheobronchial, mediastinal, prescapular, prefemoral, mesenteric, superficial inguinal and supramammary lymph node from each camel were examined thoroughly and were incised for the presence of tuberculous lesions. In addition, organs such as lungs, liver, mammary gland and kidneys were also inspected [31,37,34].

Diagnosis of tuberculosis

The Diagnosis of tuberculosis disease in animals is embraced into two stages. The first one is antemortem and the second is post-mortem examination. At ante mortem diagnosis different types of diagnosis can be undertake, such as The single intradermal comparative tuberculin skin test, using tuberculin purified protein derivatives (PPD) extracted from *M. bovis* (PPDB) and *M. avium* (PPDA), remains the primary official TB test for camelids [97].

The camelid Interferon-gamma (IFN γ) test detects MTBC and is not *M. bovis*-specific. The results showed that the IFN γ assay, as a test for *M. bovis* per se, had a low specificity of between 80% and 98%, with the highest (most desirable) specificity (98%) giving a disappointingly low sensitivity (~35%) and the highest sensitivity (80%) giving the lowest specificity. The other is evaluation of gamma interferon and antibody tuberculosis tests in apacas [98].

The serological tests did not appear to suffer from the low specificity seen in the IFN γ test. Two of the tests, having a quantitative read-out (IDEXX ELISA and DPP rapid antibody test), were amenable to ROC analysis to set appropriate cut-offs for the data, while both the STAT-PAK rapid antibody test and the ENFERplex multispot ELISA provided qualitative positive/negative readouts not amenable to ROC analysis. Infected animals can be detected before onset of clinical signs [43]. The other method of diagnosis of camel TB is clinical signs, necropsy findings and specific immune response. In camelids, this strategy is difficult to conduct because of the lack of adequate tests for live animals [97].

A definitive diagnosis can be made only at post-mortem examination by demonstration of typical gross lesions, followed by histopathology and confirmatory bacterial culture. Because of the chronic nature of the disease and the multiplicity of signs caused by the variable localization of the infection, the disease occurs in a particular area it must be considered in the differential diagnosis of many other diseases. The diagnosis of tuberculosis in live animals is mainly based on the tuberculin skin test and demonstration of the organism in exudates or excretions from lesions of slaughtered animals [76].

The other diagnostic method of camel tuberculosis are : Identification of the agent by , according to OIE standards, Microscopic examination by the use of the procedure of acid- fast stain takes suspicious organ sample from camel that died due to tuberculosis and stain with Ziehl-Neelsen (ZN), Mycobacteriological Culture, Culture from lung and lymph node using Lowenstein-Jensen (LJ), Nucleic acid recognition methods (Molecular techniques), *Spacer oligotyping* (*Spoligotyping*), Methods for molecular epidemiological investigations and Microscopic Lesions (*Histopathology*) Post-mortem examination was carried out on the slaughtered camels. Tissues specimens are taken from the inspected tubercles and fixed in 10% neutral formalin [99,100-102].

From Different techniques of diagnosis of camel tuberculosis, the methods which are used by different researchers in Ethiopia are Mycobacterial genus typing(PCR), Post mortem inspection and pathology scoring, Mycobacterial isolation from tissue lesions, Spoligotyping, single intradermal comparative cervical tuberculin (SICCT) test, Ziehl-Neelsen (Z-N) staining and Mycobacteriological culture are the most diagnostic techniques used [31,33,34,37,36].

Distribution of camel tuberculosis in Ethiopia

Ethiopia has high frequency rate of TB infection and the diseases is one of significant general medical issues in the country. The country is one among the universes 22 countries with high TB trouble [103]. Ethiopia, pastoralist territories are notable for high TB prevalence where the pastoralists keep huge number of animals as a method for occupation and endurance technique in the arid and semi-arid regions of the country [2].

Even though, the number of researchers who conduct on camel tuberculosis is limited, the origin of camels on which the researches done are from different pastoral areas of Ethiopia. Table 1 shows that the distribution of camel tuberculosis in different pastoral area of Ethiopia.

Control and Prevention of camel tuberculosis

Effective control requires an understanding of epidemiology of infection within the ecological system that can include domestic as well as wild animal species [104]. *Condemnation of carcass and organs during meat inspection, culling of infected animals and pasteurization of milk, effective disease control strategies.*

The test and slaughter policy is the only one assuring of eradicating TB and relies on the slaughter policy of reactors to the tuberculin test. In affected herd, testing every three months is recommended to rid the herd of individuals that can disseminate infection [105].

Routine hygienic measures aimed at cleaning and disinfection of contaminated premises, food and water troughs are useful. Cattles under poor management were more likely to develop tuberculosis than cattle under good management system [105,106]. Feed troughs should be cleaned and thoroughly disinfected with hot 5% phenol or equivalent cresol as phenols (2-5%), hypochlorites (1-5%), alcohol (usually 70% ethanol), formaldehydes and iodophores (3-5%), and glutaraldehyde [107].

**Table 1:** Prevalence of some camel tuberculosis in different regions of Ethiopia.

S. No	Study areas	Origin of the camels	Sample Size	Over all prevalence	Reference
1	Pastoral area of Somali and Oromia	Shinillae Babile Melka Jebdu Dawe Gursum, and Wahil of Somali	276	5.1%	[33]
2	Pastoral area of Afar & Oromiya	Awash-Fentale (Kereyu and Afar) and Borena pastoral area		10.4%	[31]
3	Pastoral area Oromiya & Somali	Filtu	181	3.1%	[34]
		Negelle	513		
4	Pastoral area of eastern Ethiopia.	Dire Dawa	92	(12.3)%	[35]
		in Harar,	11		
		in Aweday	18		
		in Jijiga abattoirs	172		
5	Pastoral area Oromia and Somali	Borena,	376	4.52%	[36]
		Kereyu and	5		
		Minijar	39		
6	Pastoral area Oromia and Somali	Dire Dawa	118	(8.3%)	[37]
		Shinile	208		
		Jijiga	154		
7	Pastoral area Oromia (Southern and Eastern)	Borena	323	9.82%	[96]
		Metehara	64		
8	Pastoral area Oromia (Southern and Eastern)	Borena	1739	7.54%	[32]
		Metehara	331		

Tuberculosis is a reportable disease in many countries and, where this is the case, control is the subject of statutory regulation, with culling of infected animals. Treatment of infected animals is not usually attempted, although there are some reports of anti-Tb drugs being used in captive wild animals. Control depends on the removal of infected animals and prevention of further introduction of infection into the herd, but the disease will not be eradicated until infection is controlled in reservoir hosts, such as in wildlife [49].

Public health significance of camel tuberculosis

In Ethiopia, pastoralist areas are well known for high TB prevalence where the pastoralists keep large number of livestock as a means of livelihood and survival strategy in the arid and semi-arid regions of the country. Camels are the backbone of majority of pastoralists in the country where the habit of sharing the same dwelling and consumption of raw camel products that may favour the transmission of zoonotic diseases like TB [2].

A close interaction between animals and humans primarily contributes to the transmission of infectious zoonotic diseases between them. World Health Organization (WHO) defines zoonosis as “those diseases and infections which are naturally transmitted between vertebrate animals and man.” Human population encounters animal disease with varying frequency depending on their occupation, geographical location and the prevailing culture of the country. Weather living in urban or rural environment, animals constantly may have close contact with human on farm (food producing animals), at area of

residence (dogs, cats, cage birds), through leisure activities (horse, wild life) or by virtue of the occupation of individual as veterinarians or animal nurses. This close contact can result in the occurrence and transmission of zoonotic disease, which is naturally transmitted between vertebrate animal and man. Zoonotic tuberculosis is an infectious disease of domestic animals that can be transmitted from animal to human through consumption of raw milk and meat from infected animals and directly through erogenous route. These possible risk factors are of particular concern for many developing countries where pasteurization is limited and where people are living close to their [34,108].

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. TB caused by *M. bovis* is clinically indistinguishable from TB caused by *M. tuberculosis* and can only be differentiated by laboratory methods [109].

Tuberculosis as a zoonosis plays an important role among nomadic people where milk and milk products are consumed in raw state. This is true for camel milk. Aerosol transmission may also occur as professional hazard in agriculture and workers as well as to butchers man, which may develop typical pulmonary tuberculosis. The incidence of pulmonary tuberculosis caused by *M. bovis* in man is significant in occupational groups in contact with infected animals or their carcass particularly in countries where animals kept in barns. The close contact between the owners and their animal could facilitate the transmission of the disease to man [110].

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. Based on gross pathology, prevalence's of 5–10% were reported in camels' slaughtered [33]. 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 especially in countries like Ethiopia. The poor, especially in developing countries, are thought to be at highest risk to contract zoonotic tuberculosis [111] and the observed higher susceptibility of HIV-infected persons to *M. bovis* infections is of major concern [112].

Conclusions and Recommendations

In Ethiopia, the prevalence recorded on camel tuberculosis and public Health importance or zoonotic importance is rare when we compare to bovine tuberculosis and the economic impacts of camel Tuberculosis was not studied yet.

Studies, which have been conducted in different pastoral areas of the Ethiopia, indicated that the disease has significant effect both in animals and in humans as the result of consumption of uncooked products of camel such as milk and meat.

Pastoral people who was closely tied with rearing of camels are at risk of being infected with zoonotic disease such as camel



tuberculosis. In Ethiopia, the status of the disease was not known and people have little or no awareness on the potential risk of the disease as zoonosis. In addition to contracting the infection by consumption of raw infected camel milk, people having close association with infected animals have high probability of being acquiring the infection. In the different pastoral areas of Ethiopia, many peoples only think the medicinal value of camel meat and milk rather than thinking potential source of different pathogens.

Based on the above conclusive remarks, the following recommendations are forwarded:

- In Ethiopia where camel tuberculosis is, not well-studied priority should be given towards researches that help in understanding of its epidemiological status to design a control strategy.
- Awareness creation and educating of pastoral people or community awareness about the risk of animal tuberculosis transmission through sharing common shelters, consumption of animal products; and route of zoonosis are of extreme importance for effective implementation of TB control measures.
- Raising awareness of the people about advantageous of milk pasteurization and well cooking of meat in control measure of camel tuberculosis and zoonotic significance of Tuberculosis in camels where the habit of consuming raw camel milk is very common in the pastoral communities.
- Regular monitoring of camel TB in the herds should be practiced to reduce the potential source of infection from infected camels to human.
- One health concept into practical method should be doing integrated diseases surveillance, joint animal-human epidemiological studies and health services development for mutually agreed practical cooperation between human and animal health with special emphasis on developing countries.

Author's contributions

The author read and approved the final manuscript.

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