Publisher homepage: www.universepg.com, ISSN: 2663-7529 (Online) & 2663-7510 (Print)
https://doi.org/10.34104/ijavs.022.01160129
International Journal of Agriculture and Veterinary Sciences
Journal homepage: www.universepg.com/journal/ijavs

Review on the Epidemiology and Public Health Importance of Camel Tuberculosis

Moges Abate Aklilu[1], Daniel Tamirat WeldeMariam[1]*, Shahana Akter Shanta[2], Md. Samiul Islam[3], and Aklema Akter[4]

[1]Dept. of Veterinary Public Health, Haramaya University College of Veterinary Medicine, Ethiopia; [2]B.Sc in Nursing, Shaheed Tajuddin Ahmad Medical College and Hospital, Bangladesh; [3]Diploma in Pharmacy Technology, Bhawal Gazipur Medical Institute, Bangladesh; [4]Diploma in Nursing, Bhawal Gazipur Medical Institute, Bangladesh.

*Correspondence: danitsehay21@gmail.com (Daniel Tamirat WeldeMariam, Department of Veterinary Public Health, Haramaya University College of Veterinary Medicine, Haramaya, Ethiopia).

ABSTRACT

Camel (*Camelus dromedarius*), Camels are an important livestock in Ethiopia and are raised in Somali, Afar, and Oromia (Kereyu, Borena, and Guji). They are used for various purposes such as transport, drafting power, ploughing land, festivals and rivalry as in dashing. The pastoral community utilizes their products such as milk and meat . However, they are also, susceptible to various diseases which can affect their health. One of the major diseases that affect camels is tuberculosis. Camel tuberculosis is a persistent disease that is characterised by the improvement of granulomas inside the breathing tract and associated lymph nodes. The mycobacteria are discharged from those granulomas and might contaminate different prone animals Camel tuberculosis is a chronic disease that is characterized by the development of granulomas in the respiratory tract and related lymph nodes. The mycobacteria are discharged from these granulomas and can contaminate other susceptible animals. Camel tuberculosis is a chronic disease that affects the respiratory system and the lymph nodes of the infected animals. It can also pose a public health risk in areas where people consume raw camel milk or have close contact with camels. The disease is caused by different types of mycobacteria, such as *Mycobacterium caprae*, *Mycobacterium tuberculosis* and *Mycobacterium bovis* The diagnosis of camel tuberculosis can be based on clinical signs, history, tuberculin skin tests, post-mortem examinations, bacteriological and molecular methods. Public awareness and control measures are needed to reduces the transmission of the disease and its economic impact.

Keywords: Epidemiology, Control, Ethiopia, Public health, Camel tuberculosis, and Zoonosis.

INTRODUCTION:

Camels are an important livestock in Ethiopia and play a significant role in the livelihood of pastoral and agro-pastoral communities. They are known for their resilience to harsh climates and are often used for transportation, draft, ploughing land, festivity and rivalry as in dashing (Yirda *et al.,* 2020). According to the Babege *et al*. (2021), approximately 35 million camels exist worldwide,with the majority of them living in Somalia, Niger, Kenya, Ethiopia,Chad Mali, Pakistan and Mauritania. These five countries that border each other - the Somalia, Kenya, Sudan, Ethiopia, and Djibouti - have 84% of the camels in Africa and more than half of the global camel population (Mwinyihija and Mekonnen, 2016).

Climate change is partly responsible for the expansion of camel rearing areas, especially in Africa (Faye *et al*., 2012). Important domestic animal species that are specifically adapted to arid and

semiarid regions of Asia and Africa include camels (*C. dromedaries*) (Faraz, 2020). According to the Babege *et al.* (2020) 1.42 million heads of the dromedary camels are raised in arid and semi-arid areas of Ethiopia, with the majority of these animals living in the east of the nation regions (Babege *et al.*, 2021). Camels are the main source of income for numerous communities who raise camels in various ecozones around the world (Faraz *et al.*, 2019).

In Ethiopia, different pastoralist communities keep camels for various purposes, producing milk and meat, for instance (Faraz *et al*., 2019). Camel milk is an important source of income and food security for the pastoralists and the traders involved in the camel milk value chain in Ethiopia. Camels are well adapted to the dry and harsh environments where other livestock species struggle to survive (Madalcho *et al.,* 2019; Faraz *et al.,* 2021). The management system of camels in Ethiopia is mainly traditional and extensive, relying on natural pastures and water sources (Woldearegay *et al.,* 2015). The pastoralists move seasonally with their animals to access water and pasture resources (Nori, 2005). The average camel herd size per household varies from a few heads to several hundreds, with females constituting more than 75% of the herd. Male camels are usually sold early for slaughter or as pack animals. Female camels can reproduce up to 25 years of age, producing eight to ten calves in their lifetime. Camels occupy practically all fringe drier lowland areas that generally fall below 1,500 meters above sea level (Bediye *et al.*, 2018). The majority of pastoralists rely on camels as a resource and as the foundation of the pastoral economy. They utilized camels for agriculture or land plows (Bediye *et al.,* 2018). The camel used pastoral communities as a source of meat, milk, and income for food security, as well as for other functions including transportation, entertainment, celebration, and competition as in hustling and splendor arise in East Africa., the Middle East and South Asia (Gader and Alhaider, 2016). In recent years, camels have become one of the national export animals for Ethiopians (Kasaye *et al*., 2013; Saikat *et al*., 2020).

Camel milk has been used as a treatment for various diseases in many cultures. According to a study, people living in Babilie and Kebribeyah districts, Jijiga Zone of the Somali Regional State used camel milk as treatment for gastritis, asthmatics, stomach discomfort, HIV, hamot (kar), tuberculosis, fever, urinary problems and hepatitis. Additionally, camels graze on a variety of plant species, and therapeutic active ingredients from these plant species are released into the milk, which is used to treat a variety of illnesses like jaundice, malaria, constipation, to clear the stomach, postpartum care for women, to detoxify snake venom, and diarrhea (Dibessa, 2020). The pastoralists thought camel milk to be readily available medication for various sicknesses due to the presence of various bioactive components in camel milk. These bioactive components have been found to have antimicrobial, antiviral and anti-inflammatory properties. The milk is also rich in many nutrients that are important for overall health. Camel milk is comparable to full cow's milk in terms of calories, protein, and carbohydrates. Additionally, it has a lot of antioxidants, which guard against cell damage and the development of major illnesses including cancer, the diabetes, and heart disease (Dibessa, 2020). Camel milk has become increasingly popular in many countries due to its nutriational content and potential health benefits. According to (Abrhaley and Leta, 2018). children prefer camel milk over other dairy animals' milk due to its taste and nutritional value. Camel milk has a lactose concentration of 4.8%, which is comparable to that of human mother's milk and is easily assimilated by those who are lactose intolerant.

This makes it a fantastic substitute for those with cow's milk allergies (Gebremichael *et al.*, 2019). In addition, the culinary and cooking practices, as well as the palate for meat, in the several African and Arabian countries have evolved toward camel meat due to its medicinal benefits, the availability and affordability. Camel meat is leaner than beef and contains more protein than chicken. It is also prosperous in vitamins and minerals such as iron, zinc and vitamin B12 (Bekhit and Farouk, 2013). Camel farming is an important source of income for many people in Ethiopia. According to data available from the Ethiopian tax and income authority, live animal trading accounted for 70% of profit, while meat exports accounted for the remaining 30% . During the Ethiopian financial year (July 2010-June 2011), the Ethiopia earned USD 211.1 million by exporting 16,877 tons of meat and 472,041 head of live animals. Camels accounted for 13% of the total number of traded live animals and 25% of the total revenue generated (Mamo, 2019).

In Somali area, camel milk sale was the main source of income. 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 neighboring nation of Soma (Yohannes Mehari and Gebru, 2006). In addition, in Meiso (Oromia) lowlands of Ethiopia, the majority of pastoralists (78%) had been selling camel milk (Tegegne *et al.*, 2013). Tuberculosis affects Old World Camelids (OWC) including Dromedaries and Bactrian camels (Miller *et al.*, 2015). Camel tuberculosis is common (Kinne *et al*., 2006a) reported a higher TB prevalence of 13% in camels in Kazakhstan, while (Kinne *et al.*, 2006b) reported a similar prevalence of 10% in Ethiopian abattoirs based on the diagnosis of macroscopic lesions in otherwise healthy dromedaries (Mamo *et al*., 2011). A bacterial disease that affects both people and animals, tuberculosis is persistent. It is distinguished by the progressive development of particular granulomatous tubercle lesions in the tissues that are afflicted. The disease affects all age groups of susceptible hosts and is accountable for more deaths throughout the world than any other bacterial disease today (Shitaye *et al.*, 2006; Gole and Hamido, 2020).

In this African country, the bacterium that causes TB in humans appears to infect animals more often than the one that affects cattle does humans. Therefore, effective control measures are highly necessary because in Ethiopia there is the largest number of pastoral population in which their life is dependent on livestock and consumed raw animal products such as milk and meat daily. This kind of situation makes people more likely to contract zoonotic illnesses like tuberculosis. To estimate the risk and burden of camel tuberculosis transmission in pastoral area and other animals, the first step is to determine its prevalence. Even though 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 the Ethiopia at the national level (Ayana and Dibessa, 2020).

The aims of this paper are -

1) To discus the zoonotic impotrance of camel tuberculosis
2) To highlight some possible approaches for the Camel tuberculosis control and prevention

Camel Tberoculosis

The genus *Mycobacterium* of the family Mycobacteriaceae includes non-motile and non-sporing acid-fast rods of various lengths (Teshome, 2021). 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 (Thacker *et al.*, 2011). The following species are grouped in the MTC: *M. tuberculosis*, *M. canettii*, *M. africanum*, *M. bovis*, *M. pinnipedii*, *M. caprae* and *M. microti* (Djelouadji *et al*., 2011).

Of these, *M. tuberculosis*, *M. bovis*, *M. pinnipedii*, *M. caprae,* and *M. microti* have been isolated from the camelids (Damene *et al.,* 2020). The name "Tuberculosis" comes from the nodules, called the 'tubercles', which form in the lymph nodes of the affected animals (Pasick *et al*., 2015). So that Tuberculosis (TB) is, a chronic, reportable granulomatous zoonosis caused by *Mycobacterium tuberculosis* complex and affects many animal species including camels (Dibessa, 2020).

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* (Riojas *et al*., 2018). 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 (Mostowy *et al.*, 2005).

Etiology of Tuberculosis in Camel

Two members of *Mycobacterium* are *Mycobacterium bovis* and *Mycobacterium tuberculosis* cause tuberculosis in cattle and other domestic animals (Erler *et al*., 2004). Some of atypical Mycobacteria rarely causing TB in camels are *M. kansasii*, *M. aquae*, *M. aqua var. ureolyticum*, *M. microti*, *M. fortuitum* and *M. smegmatis*. The atypical spices of *Mycobacterium* cause disease in camel when it becomes immunocompromised (Mamo *et al*., 2011). Along with three atypical Mycobacteria (*M. kansasii* and *M. microti*) discovered TB in a small llama herd on the border of England and Wales, the four major Mycobacteria, *M. bovis*, *M. tuberculosis*, *M. avium*, and *M. avium* sups Para tuberculosis, have been isolated from new world Camelids (Kinne *et al.,* 2006).

Source of the contamination and means of the Transmission

Granulomas, which are clumps of immune cells that isolate hazardous substances in the body and are most commonly found in the lungs and accompanying lymph nodes, where the mycobacteria spread and infected additional susceptible people, are what characterize the disease (Dibessa, 2020). In close-contact groups of animals, respiratory spreading is the most important mode of disease transmission. When an infected host coughs or sneezes, releasing *M. bovis* into the air, an uninfected host inhales it directly, resulting in infection or contamination (Francis, 1971). Inhaled air, milk, urine, nasal discharge, vaginal discharge, and discharges from exposed peripheral lymph nodes are all sources of microorganisms. Evident infection disseminators are gross lesions that link with the airways, skin, or intestinal lumen. Animals may have active mycobacterium in their nasal and bronchial mucus prior to the onset of any sickness symptoms. Excretion of the organism starts in experimentally infected animals around ninety days after infection (Teshome, 2021). When an infected animal is put into a herd of camelids that is not already diseased, tuberculosis can spread between the herds (Alvarez *et al.*, 2012). Animals with pulmonary lesions exhale bacteria that non-infected animals may breathe in and become infected as a result (Dubie *et al.*, 2015). Due to their frequent interaction with their domesticated animals, pastoralists are particularly susceptible to zoonotic illnesses, which are diseases that can spread from animals to humans (Desta, 2016). In Ethiopia, the main ways that camels can infect people are by drinking raw milk and eating under oocked meat from sick animals, and by breathing in the air near them. For several underdeveloped nations where pasteurization is uncommon and where people live close to their livestock, these potential risk risks are especially concerning (Gumi *et al.*, 2012).

Epidemiology

Mycobacterium tuberculosis is a chronic and the contagious disease that affects people and animals worldwide. Camelids, such as the dromedaries, are susceptible to TB and can act as reservoirs of the infection for other species (Pesciaroli *et al*., 2014). In Ethiopia, TB is endemic in most regions and poses a serious threat to public health and animal welfare. On the epidemiology of TB specifically relevant to camelids in Ethiopia, there is, however, insufficient available data. The available studies suggest that the distribution of TB in camelids varies greatly between regions and depends on the diagnostic methods used. Members of the tuberculosis bacteria complex are the primary causes of tuberculosis in camelids. Direct or indirect contact with infected items or animals can spread the disease.The lack of the established and trustworthy diagnostics makes camelid TB diagnosis difficult (Alvarez *et al*., 2012). In order to better diagnose and control TB in camelids and comprehend its effects on both human and animal health in the Ethiopia, further study is required (Wernery and Kinne, 2012). Worldwide, people, wild, domesticated, and confined animals are all susceptible to tuberculosis. Since 1888, dromedaries have been associated with tuberculosis (TB). There are significant regional and national variations in the geographic distribution (Kasaye *et al.,* 2013). The incidence of camel tuberculosis is very low in most European countries, as well as in the United States, Canada, Japan, and New Zealand, with less than 0.1% of the animals infected. Some countries, such as Australia, Denmark, Sweden, Norway, and the Finland, have declared themselves free of this disease.

However, the bovine tuberculosis is widespread in almost all African countries (Dubie *et al.,* 2015). A study conducted in an abattoir in Eastern Ethiopia identified *M. Bovis* as the agent responsible for Tb in the dromedary camels. Out of 398 carcasses examined, 33 (8.3%) were positive for camel Tb according to (Beyi *et al.,* 2014). It was discovered in eastern Ethiopia in order to describe its frequency and isolate *M. bovis* as the causal organism from affected camels. A study which conducted on 276 pastoral camels which slaughtered at abattoir of east of Addis Ababa show that 14 camels with lesions suggestive of tuberculosis infection, indicating a 5% prevalence in this area. A tissue impression smear from a lesioned camel was AFB-positive in only four cases out of 14, and from 14 samples only one samples was confirmed to have MTBC by PCR (Rhodes *et al.,* 2015). In a study conducted on 906 camels from two pastoral regions of Southern and Eastern Ethiopia, 91 camels were suspected tuberculosis lesions, indicating a 10% prevalence. from those which have liesion symptom were 31camels, 31 (34 percent) with acid fast Bacilli (AFB) positive mycobacterial isolates from cultured. A PCR test for *Mycobacterium* detected 21 positive camels out of

31, but only two of them had MTBC and were the identified as *M. bovis* (Dibessa, 2020).

In these two Ethiopian studies, the low recovery rate of a positive causal agent (i.e., *M. bovis*) from the majority of lesioned camels may be attributable to a poor culture for non-MTBC mycobacteria, and it also reveals the range of mycobacteria that cause mycobacterial illnesses in the camels. The *M. terrae* complex, *M. fl avescens*, *M. brasiliensis*, *M. chelonae*, and *M. avium* have been identified as the responsible parties by recent 16S rDNA sequencing of these non-MTBC mycobacteria (Mamo *et al*., 2011). The probable link between non-MTBC and MTBC in camel mycobacterioses in Ethiopia has also been demonstrated in other investigations conducted in slaughterhouses. A thorough post-mortem investigation of 293 OWCs from eastern Ethiopia shows that TB lesions are significantly correlated with female dromedaries, with a probable incidence of 12.3% (36/293). Mycobacteria were found in 61% of the lesions examined in a research on camels with gross lesions. Only three of the isolates were identified as *M. tuberculosis* by molecular characterisation, while the bulk (15/22) were non-MTBC (Gumi *et al*., 2012; Zerom *et al.*, 2013). Camels from Metehara and Borana have been found to have 9.82 percent camel TB at Akaki abattiors. Camels from Metehara and Borana have a high prevalence, with 9.6% and 10.94%, respectively, from Metehara and Borana. According to Jibril *et al.* (2019), out of 387 camels tested with the single intra-dermal comparative the cervical tuberculin (SICCT) test, 38 (9.82 percent) were positive for tuberculin reaction. Similarly, other studies have reported abattoir-based prevalence of camel tuberculosis of 10.4% in Akaki (Jibril *et al.,* 2016), 5.1% in Dire Dawa (Gumi *et al*., 2012a), and 3.1% in Southern Ethiopia (Gumi *et al*., 2012). In addition, some authors have found camel tuberculosis prevalence of 5.1% and 3.1% in Akaki and Eastern Ethiopia, respectively (Beyi *et al*., 2014; Kasaye *et al*., 2013).

In Ethiopia, *M. bovis* and *M. tuberculosis* have been isolated from tissue lesions of dromedary camels (Zerom *et al*., 2013). Moreover, *M. pinnipedi*, *M. caprae*, and *M. microti* have been identified from camelids as the members of the MTBC (García-Bocanegra *et al*., 2010; Manual, 2008). According to *Kinne et al.* (2006) and Zerom *et al.* (2013) non-tuberculous mycobacteria (NTBC) such *M. kansasii*, *M. aquae*, *M. fortuitum*, and *M. smegmatis* are also responsible for causing camel TB. In southern Ethiopia, *M. tuberculosis* strains have also been found in camels (Gumi *et al*., 2012) from camels in Eastern Ethiopia (Zerom *et al.*, 2013) and from goats in Afar and from pigs in Ethiopia (Arega *et al*., 2013).

Risk Factors

In accordance with Mamo *et al.* (2011) the tuberculosis-causing agent is susceptible to all types of animals, including humans, physical conditions, sex, and age groups. In conventional domesticated animal raising systems, The way livestock are kept and managed, such as mixing different animal species and sharing water sources, can increase the risk of *M. bovis* spreading among animals, from animals to humans, from humans to animals, and from humans to humans (Gumi *et al.,* 2012). Camels with TB were more common in the youngest and oldest age groups. Similar findings have been reported in cattle, especially in older animals with TB (Munyeme *et al*., 2009). This might be because older animals have weaker immune systems. Younger camels might have more lesions because their immunity is not fully developed (Menzies and Neill, 2000). Also a pathogen risk factor: the causative organism is heat, desiccation, and many disinfectants resistant; *M. bovis* pathogenicity is related to its capacity to survive and reproduce in the host macrophages. Housing, sharing a shelter with humans, and animal stocking intensity are all environmental risk factors (Quinn *et al.,* 2003). The consumption of raw milk (as opposed to pasteurized milk) is a common practice in the Ethiopia that increases the risk of zoonotic TB transmission from infected animals to humans. *M. bovis* is the main agent of zoonotic TB and it can be found in unpasteurized milk and other dairy products. Moreover, the inhala-tion of aerosols from cattle to humans (or vice versa) can also be a potential source of infection (Romha and Ameni, 2018). Another factor that contributes to the spread of zoonotic TB is the low level of aware-ness among pastoralists. They often value the nutria-tional and medicinal benefits of raw milk and do not boil it before the consumption. They also have limited knowledge about milk-borne diseases (Wako, 2015).

Pathogenesis

Camel tuberculosis (TB) is a persisting infectious disease caused by *Mycobacterium bovis* or *Myco-*

bacterium tuberculosis, which can affect the respiratory system, lymph nodes, and other organs of camels (Mohamed, 2019). The pathogenesis of camel TB is not well understood, but it is believed to involve inhalation or ingestion of the bacteria, followed by multiplication and dissemination within macrophages (Gumi *et al*., 2011). The bacteria can evade the host immune response by inhibiting phagosome-lysosome fusion, modulating cytokine production, and inducing granuloma formation (Abebe, 2019). The clinical signs of camel TB may include weight loss, coughing, dyspnea, lymphadenopathy, and abscesses (Khan *et al.,* 2013).

Camel TB poses a significant threat to the health and productivity of camels in Ethiopia, as well as a potential zoonotic risk to humans who consume camel milk or meat (Gutema *et al.,* 2019). According to the distribution of TB lesions in the bodily organs of camels, lungs and related lymph nodes accounted for 57.14% of lesions, retropharyngeal lymph nodes for 28.57%, and mesenteric lymph nodes for 14.29% (Kasaye *et al*., 2013). By using this process, mycobacteria are able to live, grow, and finally destroy phagocytes. In order to move from cell to cell, M. marinum, a close relative of *M. TB* and *M. bovis*, may break through the phagosomes and enter the cytoplasm (Stamm *et al*., 2003). Then, more phagocytes come in to ingest the growing amount of tubercle bacilli. A granuloma, a tiny collection of cells, forms. Large numbers of phagocytes build up as a result of the disease's cellular reactions, and eventually macroscopic lesions called tubercles appear. After 10-14 days, the host's macrophages acquire cell-mediated immunity (CMI) responses and become more capable of eliminating the intracellular bacteria. T lymphocytes, which are involved in cell-mediated immunity (CMI), secrete lymphokines that are messenger proteins produced by lymphocytes. These lymphokines attract, immobilize, and activate more mononuclear cells from the blood at the locations where harmful mycobacteria or their products are present (Thoen *et al*., 2006).

The presence and enlargement of macrophages in the difficult-to-access channels between the reticular cells of the lymph node assist the growth and development of the granulomatous lesion in the node. In certain cases, the lung and the thoracic nodes are both impacted because some of the mycobacteria that have been engulfed are still in the lung. Primary lesions may grow big and solid and frequently localize in a node or nodes (Thoen *et al*., 2006).

Clinical Findings

Camel Tuberculosis is a serious and contagious disease that affects camelids, such as llamas and alpacas. It is caused by bacteria from the Mycobacterium tuberculosis species, which can infect the respiratory tracks and other organs. Camelids with TB may `not show any signs of illness or may only have mild symptoms, such as changes in behavior, reduced appetite, weight loss, coughing or difficulty breathing. Some camelids may die suddenly without any warning. TB can be transmitted to camelids by contact with infected cattle or wildlife, or through contaminated materials (Crawshaw *et al*., 2013). Therefore, it is important to test camelids for TB regularly and to examine any dead animals for signs of TB lesions. The most common organs affected by TB in camelids are the lungs and the lymph nodes near the lungs. The lesions caused by TB can be very severe and extensive, and may not be detected until the animal is dead. The lesions are white or creamy and caseous.the clinical signs in camelids include wasting, anorexia, and respiratory distress, enlargement of superficial lymph nodes, recumbence and eventually death (Twomey *et al*., 2010). The most common organs affected by tuberculosis are the lungs and their related lymph nodes. The infection can cause multiple or single lesions in the bile ducts or lungs that can merge into large areas of dead tissue, sometimes involving the entire lung lobes. Healthy camelids have small and hard-to-detect lymph nodes. However, tuberculous affected lymph nodes are often very large and have many white, cream or yellowish foci of dead tissue. In severe cases, the whole node may be replaced by one big lesion (Jibril *et al*., 2018). The lung damage may be so extensive that it is surprising that the animal did not die sooner (Crawshaw *et al.,* 2013). In humans, the common symptoms of active lung TB include, cough with sputum and sometimes with blood, chest pains, weakness, weight loss, fever, and night sweats (Bazzano and Yan, 2020).

Pathology

The use of pathology to diagnose camel tuberculosis was unusual in Ethiopia because there were few studies on this disease in camels. Some researchers conducted a tubercle lesion epidemiology assessment using abattoirs in various pastoral districts of

Ethiopia (Dibessa, 2020). A postmortem examination was conducted after the previously mentioned operation (Mamo *et al*., 2011). Under a bright light source, tissues from the lung and lymph nodes including the sub-mandibular lymph node, retropharyngeal lymph node, trachea-bronchial lymph node, cranial and caudal mediastinal lymph node were thoroughly investigated. Externally, the lobes of the left and right lungs were examined and felt. Then, using sterile surgical blades, each lobe is divided into slices that are roughly 2 cm thick to aid in the discovery of lesions. Similar to this, lymph nodes were examined for the existence of visible lesions by cutting them into thin sections (approximately 2 mm thick). Under a bright light source, the sliced surface was inspected for abscess and tubercle lesions (Asseged *et al.*, 2004; Mamo *et al.*, 2011). The prevalence and economic impact of camel TB in Ethiopia are not well studied, but some reports indicate that it is a common and important problem in pastoral regions where camels are kept for milk, meat, and transportation. A cross-sectional study conducted on 906 slaughtered camels in two abattoirs found that 10.04% of them had gross TB lesions, mainly in the abdominal organs(Mamo *et al*., 2011). Another study that examined 31 mycobacterial isolates from camels with TB lesions identified two strains of *Mycobacterium caprae*, one of which was new and designated as SB1953, and 19 strains of non-tuberculous mycobacteria (Dibessa, 2020. These findings suggest that camel TB in Ethiopia is caused by a variety of mycobacteria, some of which may have different sources of infection, transmission routes, and pathogenicity. The diagnosis of camel TB is challenging due to the lack of standardized and validated tests for this species. The intradermal tuberculin test and the P22 ELISA have been used as screening tools, but their sensitivity and specificity are unknown (Infantes *et al.*, 2020). The isolation and identification of the causative agents require sophisticated laboratory techniques that are not widely available.

The pathological prevalence of camel TB was 10.04% based on the presence of gross lesions, which were more common in females and in certain lymph nodes and lung lobes. Out of the camels with visible TB lesions, 34% showed the mycobacterial growth. The mycobacteria were identified as members of the *M. tuberculosis* complex using multiplex PCR, RD4-based PCR, and spoligotyping (Jibril *et al*., 2018). Camels with macroscopic lesions that ranged from hard white, grey, or yellow nodules with a dry and solid necrotic center to thin-walled suppurative abscesses were considered postmortem positive (Kinne *et al*., 2006). Each camel's lymph nodes, including those in the parotid, mandibular, retropharyngeal, tracheobronchial, mediastinal, prescapular, prefemoral, mesenteric, superficial inguinal, and supramammary regions, were carefully inspected for tuberculous diseases and excised. Additionally examined were the lungs, liver, mammary gland, kidneys, and other organs (Beyi *et al*., 2014).

Diagnosis

The process of diagnosing tuberculosis in animals involves two steps: ante-mortem and post-mortem examinations. Ante-mortem tests include the single intradermal comparative tuberculin skin test, which uses purified protein derivatives (PPD) from *M. bovis* and *M. avium* to detect skin reactions, and the interferon-gamma (IFNγ) test, which measures the immune response to mycobacteria. However, these tests have limitations in terms of sensitivity and specificity, especially for camelids. Serological tests, which detect antibodies against mycobacteria, have shown promising results but need further validation . These tests can help identify infected animals before they show clinical signs, which are often nonspecific and may include respiratory distress, weight loss, lymph node enlargement and death. Post-mortem diagnosis is based on the observation of characteristic lesions in the organs, histopathology and bacterial culture . This is the only definitive way to confirm tuberculosis infection in camelids. Camel tuberculosis is a chronic and conta-gious disease that can affect different organs and cause various symptoms depending on where the infection is located. It can be confused with many other diseases, so it is important to use reliable diagnostic methods to confirm it. The most common diagnostic methods for camel tuberculosis are the tuberculin skin test and the identification of the bacteria in samples from infected animals (Kasaye *et al*., 2013).

Other methods that can be used to diagnose camel tuber-culosis are microscopic examination of stained samples, bacterial culture, the molecular techniques, spoilgotyping, histopathology and serological tests. However, none of these methods can provide the accurate diagnosis in all cases, and some of them still need to be the validated (Beyi *et al*., 2014).

Therefore, more research is needed to develop better diagnostic tools for camel tuberculosis.

Treatment

First lines of drugs for TB therapy are streptomycin, isonized (INH), ethambutol and rifampin. Second line drugs are pyrazinamide, 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 discourage (Teshome, 2021). Many countries require reporting of tuberculosis cases in animals and have laws to prevent this disease by killing the infected ones. Giving anti-Tb drugs to sick animals is usually not done, but some captive wild animals have received them. After the detection of Tb in two Bactrian camels kept in a zoo, prophylactic treatment of the remaining 17 camels was attempted using isoniazid incorporated into pelleted feed at a dose of 2.4 mg/kg, fedad libitum (Oevermann *et al.,* 2004).

Control and Prevention

Ethiopian pastoralists rely on Dromedary camels for milk, meat, and profit since they can tolerate the harsh climate of the country's several regions. Tuberculosis (TB) affects dromedary camels causing morbidity and mortality in these animals (Jibril *et al*., 2018). National control programs are frequently focused on intradermal tuberculin testing, but these programs are unlikely to be successful because to the limits of this test in camelids; therefore, a combination of ante mortem assays could improve the sensitivity of herd testing. The infection can be controlled by eliminating infected animals and preventing further spread in the herd, but it will not be eliminated until the infection is controlled in wildlife hosts, which are reservoirs of the disease (Thoen *et al.,* 2006). To control the disease effectively, it is necessary to understand how the infection spreads within the ecological system that includes both domestic and wild animals (Renwick *et al*., 2007). Some preventative measures include pasteurizing milk, culling sick animals and organs during meat inspections, and employing efficient disease management techniques (Dibessa, 2020). It also helps to regularly clean and sanitize polluted locations, food troughs, and water sources. Poorly managed cattle are more susceptible to tuberculosis than well-managed cattle (Kiros, 1998). With hot 5% phenol or an equivalent cresol as phenols (2-5%), hypochlorite (1-5%), alcohol (often 70% ethanol), formaldehydes and iodophores (3-5%), and glutaraldehyde (Zahra), food and water troughs should be thoroughly cleaned and disinfected.

Public Health importance of Camel Tuberculosis

One of the most dangerous infectious diseases for humans in the globe is tuberculosis (TB). In 2010, Tb was estimated to have caused an estimated 8.8 million new cases, a 128 population/year global incidence rate, and 1.5 million fatalities (WHO, 2012). The current increasing incidence of this infection in humans, particular in immune compromised human, has given renewed interest in the public health importance of *M. bovis*, especially in developing countries like Ethiopia (Radostitis *et al.*, 2007). Camel tuberculosis (TB) is a zoonotic disease caused by *Mycobacterium bovis* and *Mycobacterium tuberculosis*, which can infect humans and animals. Camel TB is a major public health concern in the Ethiopia, where camels are widely used for milk production, transportation, and meat consumption. Camel TB poses a serious threat to the health and livelihoods of camel keepers and consumers, as well as to the national economy and food security.

According to the World Health Organization (WHO), the Ethiopia ranks among the 30 high TB burden countries in the world, with an estimated incidence of 164 cases per 100,000 population in 2019 (WHO, 2012). The prevalence of camel TB in Ethiopia is not well known, but some studies have reported rates ranging from 1.4% to 15.6% based on bacteriological and molecular methods. Camel TB can be transmitted to humans through direct contact with infected animals or their products, such as milk and meat. However, the extent of human exposure and infection by camel TB in the Ethiopia is largely unknown (Teshome, 2021). Camel TB is also a potential threat to wildlife conservation, as camels share habitats and water sources with wild animals, such as antelopes, gazelles, and hyenas. Camel TB could spill over to these species and cause outbreaks that could affect their population dynamics and biodiversity. Moreover, camel TB could compromise the efforts to control bovine TB in cattle and other domestic animals, as camels can act as reservoirs and sources of infection (Mamo *et al.*, 2009). Dromedary camels are important livestock animals that provide

meat and milk for human consumption. They are found mainly in the Middle East and Africa, where they number around 30 million. Camels are well adapted to harsh and dry environments, but they also face various health risks. They can be infected by and transmit pathogens that cause diseases in humans and other animals, such as MERS, brucellosis, camelpox, and Rift Valley fever (Zhu *et al.,* 2019). The transmission of infectious zoonotic illnesses between animals and humans is generally facilitated by intimate contact between them. "Those diseases and infections that are naturally communicated between vertebrate animals and man," according to the World Health Organization (WHO). People who live close to animals, especially in developing countries, are at risk of getting zoonotic TB, which is a type of TB caused by *Mycobacterium bovis*. This bacterium can infect many animals, but cattle are the main source of human infection. People can get zoonotic TB by drinking raw milk or eating raw meat from infected animals, or by breathing in the bacteria from animal droppings or carcasses. Zoonotic TB is hard to diagnose and treat because it needs special tests and drugs that are often not available. Zoonotic TB can affect the lungs and other organs of the body. It is a serious public health problem for people who depend on livestock for their livelihood (WHO, 2017). Camel tuberculosis, like bovine tuberculosis, has a major zoonotic impact, particularly in nomadic populations who consume raw camel milk and animal products. Prevalences of 5-10% were recorded in slaughtered camels based on gross pathology (Mamo *et al.*, 2009).

Current Status of the infection in Ethiopia

Animals in Ethiopia are afflicted with BTB, a condition brought on by bacteria from the Mycobacterium tuberculosis complex. In Ethiopia, meat inspection at the slaughterhouses, tuberculin skin testing, and occasionally bacterial culture are the major means for detecting BTB (Shitaye *et al.,* 2007). According to a cross sectional study conducted on 906 camels slaughtered at Akaki and Metehara abattoirs, the prevalence of camel TB was 10.04% based on pathology and 2.2% based on molecular characterization of the causative agents (Ashenafi *et al.,* 2013). Another study on 276 camels slaughtered at the Dire Dawa abattoir reported a prevalence of 5.07% based on postmortem examination and 1.45% based on culture isolation of *M. bovis*. Camel TB has public health implications, especially in pastoral areas of Ethiopia where people consume raw camel milk and its products and have close contact with their camels (Zerom *et al.*, 2013) as summarized in (**Table 1**).

Table 1: Summary of current Status of the infection in Ethiopia.

No	Site of the study	Reported Prevalence	Study
1	At the Dire Dawa abattoir in Ethiopia, a cross-sectional study of camel tuberculosis was conducted.	5.07% based on postmortem examination	(Ethiopie, 2009)
2	Infection with *Mycobacterium tuberculosis* complex in animal and humans in the Afar region's Amibara District	34% (31/91) of camels with grossly suspicious TB lesion	(Ashenafi *et al.,* 2013)
3	Pathology of camel tuberculosis and molecular characterization of its causative agents in pastoral regions of Ethiopia at Akaki and Metehara abattoir	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.*, 2013)
5	Prevalence of camel tuberculosis at Akaki abattoir in Addis Ababa, Ethiopia.	4.52 % based on tuberculosis lesion detection	(Kasaye *et al.*, 2013)
6	Prevalence of bovine tuberculosis in dromedary camels and pastoralists' understanding of the disease's zoonotic significance in Eastern Ethiopia's Dire Dawa City Administrative Council (DDAC) and Somali pastoral region.	8.3% based on the post mortem examination and 6.0% based on the tuberculin test.	(Beyi *et al.*, 2014)

CONCLUSION AND RECOMMENDATIONS:

Camel tuberculosis is a zoonotic disease caused by the *Mycobacterium bovis* and *M. tuberculosis* that affects the health and productivity of camels and poses a public health risk to humans who consume camel milk and meat. The epidemiology and public health importance of camel tuberculosis in Ethiopia are poorly understood due to the lack of reliable data and diagnostic tools. However, some studies have indicated that the prevalence of camel tuberculosis is

high in some regions of the Ethiopia, especially in pastoral areas where camels are kept in close contact with other livestock and humans. The transmission of camel tuberculosis is likely to occur through inhalation, ingestion, or direct contact with infected animals or their products. The risk factors for camel tuberculosis include poor husbandry practices, lack of biosecurity measures, co-infection with other diseases, and genetic susceptibility of camels. The clinical signs of camel tuberculosis are nonspecific and may include weight loss, coughing, lymphadenitis, mastitis, and abscesses. The diagnosis of camel tuberculosis is challenging due to the limitations of the available tests, such as tuberculin skin test, interferon-gamma assay, bacteriological culture, and molecular techniques. The control and prevention of the camel tuberculosis require a coordinated and collaborative approach involving multiple stakeholders, such as camel owners, veterinarians, public health officials, researchers, and policymakers.

Some of the recommended strategies for controlling camel tuberculosis are:

1) Improving the awareness and knowledge of the camel owners and consumers about the zoonotic potential and economic impact of camel tuberculosis.
2) Implementing regular screening and surveillance programs for camel tuberculosis using appropriate diagnostic methods and reporting systems.
3) Applying quarantine and isolation measures for suspected or confirmed cases of camel tuberculosis and restricting the movement and trade of infected animals and their products.
4) Enhancing the biosecurity and hygiene practices in camel farms and slaughterhouses to prevent the introduction and spread of camel tuberculosis.
5) Promoting the use of pasteurization or boiling of camel milk and proper cooking of camel meat before consumption to reduce the risk of human infection.
6) Supporting the development and evaluation of effective vaccines and therapeutics for camel tuberculosis.
7) Conducting further research on the epidemiology, pathogenesis, diagnosis, treatment, & prevention of camel tuberculosis in Ethiopia.

ACKNOWLEDGEMENT:

We would like to thanks Dr. Adem Abdella from ours deep heart for his advice and holistic mentoring. One thing that has not been forgotten is our deepest gratitude and thankfulness to all the providers of literature that spent their time to supply us with the necessary information.

CONFLICTS OF INTEREST:

The authors have no conflict of interest.

REFERENCES:

1) Abebe, F., (2019). Synergy between Th1 and Th2 responses during *Mycobacterium tuberculosis* infection: A review of current understanding: The paper discusses the importance of simultaneous induction of Th1/Th2 responses to design and develop vaccine against TB. *Inter. ReviewsofImmunology*, **38**(4), pp.172-179. https://doi.org/10.1080/08830185.2019.1632842
2) Abrhaley, A. and Leta, S. (2018). Medicinal value of Camel milk and meat. *J. of Applied Animal Research,* **46**, 552-558.
3) Alvarez, J., Mateos, A. and Dominguez, L. (2012). Diagnosis of tuberculosis in camelids: old problems, current solutions & future challenges. *Transboundary and Emerging Diseases,* **59**, 1-10.
4) Arega, S. M., Conraths, F. J. and Ameni, G. (2013). Prevalence of tuberculosis in pigs slaughtered at two abattoirs in Ethiopia and molecular characterization of *Mycobacterium tuberculosis* isolated from tuberculous-like lesions in pigs. *BMC Vet. Res.,* **9**, 1-9. https://bmcvetres.biomedcentral.com/articles/10.1186/1746-6148-9-97
5) Ashenafi, D., Mamo, G., and Simenew, K. (2013). Epidemiology and Molecular characterization of causative agents of bovine tuberculosis in ruminants. *J. of Bacteriology and Parasitology,* **4**.
6) Asseged, B., Yimer, E. and Lemma, E. (2004). Evaluation of abattoir inspection for the diagnosis of *Mycobacterium bovis* infection in Cattle at Addis Ababa abattoir. *Tropical Animal Health and Production,* **36**, 537-546.
7) Ayana Dibessa, Z. (2020). Review on epidemiology and public health importance of Goat Tuberculosis in Ethiopia. *Veterinary Medicine International,* 2020.

8) Babege K., Wandara, S. and Lameso, L. (2021). Potential of Camel production and man-agement Practices in Ethiopia. *J. of Dryland Agriculture,* **7**, 67-76. https://doi.org/10.5897/JODA2020.0070
9) Bazzano, A. N. and Yan, S. D. (2020). Design for global health. Design for Health. *Elsevier*.
10) Bediye, S., Tilahun, S. and Kirub, A. (2018). Engaging opportunities for Camel production. *Ethiopian Somali Region Pastoral and Agro-pastoral Research Institute (EsoRPARI), Jig-jiga*, 1-105.
11) Bekhit, A. E.-D. and Farouk, M. M. (2013). 13 Nutritive and health value of Camel meat. *Camel Meat and Meat Products*, **205**.
12) Beyi, A. F., Ameni, G. and Ali, M. S. (2014). Prevalence of bovine tuberculosis in dromedary Camels and awareness of pastoralists about its zoonotic importance in Eastern Ethiopia. *J. of Veterinary Medicine & Animal Health,* **6**, 109-115. https://doi.org/10.5897/JVMAH2014.0284
13) Crawshaw, T., De La Rua-Domenech, R. and Brown, E. (2013). Recognising the gross pathology of tuberculosis in South American Camelids, Deer, Goats, Pigs and Sheep. *In Practice,* **35**, 490-502.
14) Damene H., Sahraoui N. and Rigouts L. (2020). Broad diversity of *Mycobacterium tuberculosis* complex strains isolated from Humans & Cattle in Northern Algeria suggests a zoonotic trans-mission cycle. *Plos Neglected Tropical Dis-eases,* **14**, e0008894.
15) Desta, A. H. (2016). Pastoralism and the Issue of Zoonoses in Ethiopia. *J. of Biology, Agri-culture and Healthcare,* **6**, 21-27.
16) Dibessa, Z. (2020a). Review on the epide-miology. *public health importance and status of awareness of Camel rearing pastoral com-munities of Ethiopia on Camel tuberculosis. Inter. J. of Vet. Scinse Resarch,* **6**, 068-079. https://www.peertechzpublications.org/abstracts/IJVSR-6-157
17) Dibessa, Z. A. (2020b). Review on the epide-miology, public health importance and status of awareness of Camel rearing pastoral communi-ties of Ethiopia on Camel tuberculosis. *Inter J. of Veterinary Science and Research,* **6**, 068-079.
18) Djelouadji, Z., Raoult, D. and Drancourt, M. (2011). Palaeogenomics of *Mycobacterium tub-erculosis*: epidemic bursts with a degrading genome. *The Lancet Infectious Diseases,* 11,
19) Dubie, T., Sisay, T., and Negash, W. (2015). Preliminary assessesment on the epidemiology and public health implication of Camel tuber-culosis in pastoral area of Ethiopia. https://www.researchgate.net/publication/313389379_PRELIMINARY
20) Erler, W., Cvetnic, Z. and Zolnir-Dovc, M. (2004). Molecular fingerprinting of *Mycobac-terium bovis subsp. caprae* isolates from Cen-tral Europe. *J. of Clinical Microbiology,* **42**, 2234-2238.
21) Ethiopie, C. (2009). A cross sectional study of camel tuberculosis in Ethiopia. *Bullettin Ani-mal Health Prodaction African,* **57**, 13-20.
22) Faraz, A. (2020). Food security and socio-economic uplift of camel herders in Southern Punjab, Pakistan. *Land Science,* **2**, p8-p8.
23) Faraz, A., Mirza, R. and Ishaq, H. (2019a). The Camel-a short communication on classification and attributes. *J. of Fisheries and Livestock Production,* **7**, 289.
24) Faraz, A., Ishaq, H. and Tariq, M. (2019b). Socio economic status and associated cons-traints of Camel production in desert Thal Punjab. *Pakistan. J. of Fish. Livestock. Pro-daction,* **7**, 288.
25) Faraz, A., Bilal, R. M. and Muhammad, S. N. (2021). Milk production potential of Marecha Camel (*Camelus dromedarius*) in extensive and semi-intensive management systems. *Pakistan J. of Zoology,* **53**, 273. https://dx.doi.org/10.17582/journal.pjz/20200227090212
26) Faye, B., Chaibou, M. and Vias, G. (2012). Integrated impact of climate change and socio-economic development on the evolution of Camel farming systems. *British J. of Environ-ment and Climate Change,* **2**, 227-244.
27) Francis, J. (1971). Susceptibility to tuberculosis and the route of infection. *Australian Vete-rinary J.,* **47**, 414-414.
28) Gader, A. G. M. A. and Alhaider, A. A. (2016). The unique medicinal properties of Camel products: A review of the scientific evidence. *J. Of Taibah University Medical Sciences,* **11**, 98-103.
29) García-Bocanegra, I., Ruiz-Villamayor, E. and Perea, A. (2010). Tuberculosis in alpacas

(Lama pacos) caused by *Mycobacterium bovis*. *J. Of Clinical Microbiology,* **48**, 1960-1964.

30) Gebremichael, B., Girmay, S. and Gebru, M. U. (2019). Camel milk production and marketing: Pastoral areas of Afar, Ethiopia. *Pastoralism,* **9**, 1-11. https://pastoralismjournal.springeropen.com/articles/10.1186/s13570-019-0147-7
31) Gole FA, and Hamido AJ. (2020). Review on health benefits of camel urine: therapeutics effects and potential impact on public health around east Hararghe district. *Am. J. Pure Appl. Sci*., **2**(6), 183-191. https://doi.org/10.34104/ajpab.020.018300191
32) Gumi, B., Aseffa, A. and Zinsstag, J. (2012a). Zoonotic transmission of tuberculosis between pastoralists and their livestock in South-East Ethiopia. *Ecohealth,* **9**, 139-49.
33) Gumi, B., Young, D. and Zinsstag, J., (2011). Prevalence of bovine tuberculosis in pastoral cattle herds in the Oromia region, southern Ethiopia. *Tropical animal health and production*, **43**, pp.1081-1087.
34) Gutema, F. and Tesfaye, J., (2019). Review on camel brucellosis: public health importance and status in Ethiopia. *Academic Research J. of Agricultural Science and Research*, **7**, pp.513-529.
35) Harris, N. (2006). Molecular techniques: applications in epidemiologic studies. *Mycobacterium bovis Infection in Animals & Humans*, **54**.
36) Infantes-Lorenzo JA, Roy A, and Ortega J. (2020) Tuberculosis caused by *Mycobacterium caprae* in a camel (*Camelus dromedarius*). *BMC Veterinary Research*, **16**(435). https://doi.org/10.1186/s12917-020-02665-0
37) Jibril, Y., Mamo, G. and Ameni, G. (2019). Abattoir based study on the pathology of tuberculosis in dromedary Camels, Ethiopia. *Biomedical J. of Scientific and Technical Research,* **19**, 14151-14158.
38) Jibril, Y., Zewude, A. and Ameni, G. (2016). Prevalence of Camel tuberculosis and associated risk factors in Camels slaughtered at Akaki Abattoir, Ethiopia. *Ethiopian Veterinary J.,* **20**, 23-38.
39) jibril, y., zewude, a. and ameni, g. (2018). Appraisal of interpretation criteria for the single intra-dermal comparative cervical tuberculin test for the diagnosis of tuberculosis in dromedary camels in Ethiopia. *Tropical Animal Health and Prodaction,* **50**, 1665-1670.
40) Kasaye, S., Molla, W. and Amini, G. (2013). Prevalence of camel tuberculosis at Akaki abattoir in Addis Ababa, Ethiopia. *African J. of Microbiology Research,* **7**, 2184-2189.
41) Khan, I., Neubauer, H. and Saqib, M., (2013). Glanders in animals: a review on epidemiology, clinical presentation, diagnosis and countermeasures. *Transboundary and emerging diseases*, **60**(3), pp.204-221.
42) Kinne, J., Ul-Haq, A. and Wernery, U. (2006a). Camel tuberculosis–a case report. *Tropical Animal Health and Production,* **38**, 207-213.
43) Kinne, J., Ul-Haq, A. and Wernery, U. (2006b). Camel tuberculosis-a case report. *Tropical Animal Health and Prodaction,* **38**, 207-13.
44) Kiros, T. (1998). Epidemiology and zoonotic importance of bovine tuberculosis in selected sites of Eastern Shoa, Ethiopia. http://etd.aau.edu.et/handle/123456789/28268
45) Lyashchenko, K., Burri, I. H. and Zanolari, P. (2007). Antibody responses in New World camelids with tuberculosis caused by *Mycobacterium microti*. *Veterinary Microbiology,* **125**, 265-273.
46) Madalcho, A. B., Tadesse, B. A., and Gebresilassie, G. (2019). Camel feed characterization of Ethiopian Somali region rangelands through traditional knowledge. *J. of Agriculture and Ecology Research International*, 1-15.
47) Mamo, G., Abebe, F. and Ameni, G. (2011). Pathology of camel tuberculosis and molecular characterization of its causative agents in pastoral regions of Ethiopia. *P*ublic Library of Science *One,* **6**, e15862. https://doi.org/10.1371/journal.pone.0015862
48) Mamo, G., Sanni, M. and Ameni, G. (2009). A cross sectional study of camel tuberculosis in Ethiopia. *Bulletin of Animal Health and Production in Africa,* **57**.
49) Mamo, G.D., (2019). Assessment on impact of live animal export on meat export performance in Ethiopia; Policy implications. *Business and Management Studies*, **5**(3), pp.21-28.
50) Manual, O. (2008). Manual of diagnostic tests and vaccines for terrestrial animals. *Chapter,* **2**, 304-323.

51) Menzies, F. and Neill, S. (2000). Cattle-to-Cattle transmission of bovine tuberculosis. *The Veterinary J.,* **160**, 92-106.
52) Miller, M., Waters, W. and Larsen, M. (2015). Tuberculosis, leprosy & mycobacterial diseases of Man and Animals: The many hosts of mycobacteria.
53) Mohamed A. (2019). Bovine tuberculosis at the human-livestock-wildlife interface and its control through one health approach in the Ethiopian Somali Pastoralists: A review. *One Health*, **9**(9), 100113. https://doi.org/10.1016/j.onehlt.2019.100113
54) Mostowy, S., Cousins, D. and Behr, M. A. (2005). Revisiting the evolution of *Mycobacterium bovis*. *J. of Bacteriology,* **187**, 6386-6395.
55) Munyeme, M., Rigouts, L. and Tryland, M. (2009). Prevalence of bovine tuberculosis and animal level risk factors for indigenous Cattle under different grazing strategies in the livestock/wildlife interface areas of Zambia. *Tropical Animal Health & Prod.,* **41**, 345-352.
56) Mwinyihija, M. and Mekonnen, H. (2016). Preview of Camel (*Camelus dromedarius*) hides marketing and challenges in Eastern Africa. *J. of Africa Leather and Leather Products Advances,* **3**, 18-27.
57) Nori, M. (2005). Sustainable Camel milk production and commercialization in Somalia. *Future Livestock Systems American Physiological Society, Course, Wageningen-4*.
58) Oevermann, A., Meylan, M. and Robert, N. (2004). Generalized tuberculosis in llamas (*Lama glama*) due to *Mycobacterium microti*. *J. of Clinical Microbiology,* **42**, 1818-21. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC387549/
59) Pasick, J., Berhane, Y., and Alexandersen, S. (2015). Reassortant highly pathogenic influenza *A H5N2* virus containing gene segments related to Eurasian H5N8 in British Columbia, Canada, 2014. *Scientific Reports,* **5**, 1-4.
60) Pesciaroli, M., Pacciarini, M. and Pasquali, P., (2014). Tuberculosis in the domestic animal species. *Research in Veterinary Science*, **97**, pp.S78-S85
61) Quinn, P. J., García Sánchez, J. and Markey, B. (2003). Elementos de microbiologia veterinaria/Concise review of *Veterinal of Microbiology*.
62) Radostitis, O., Gay, C., and Hinchliff, K. (2007). Vetrenary Medicine. *A Text Book of The Deseases of Catlle, Sheep, Pig And Horse. Ninth Edition, Bailliere Tindal, Lodon, O\Pp,* 1308. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2857440/
63) Renwick, A., White, P. and Bengis, R. (2007). Bovine tuberculosis in southern African wildlife: a multi-species host–pathogen system. *Epidemiology and Infection,* **135**, 529-540.
64) Rhodes, S., Gillgan, S. and Lyashchenko, K. (2012). Evaluation of gamma interferon and antibody tuberculosis tests in alpacas. *Clinical and Vaccine Immunology,* **19**, 1677-1683.
65) Rhodes. S., Wernery, U. and Zanolari, P., (2015). Mycobacterial infections in camelids. In *Tuberculosis, leprosy and mycobacterial diseases of man and animals: the many hosts of mycobacteria* (pp. 216-234). Wallingford UK: CABI.)
66) Riojas, M. A., Rastogi, N. and Hazbón, M. H. (2018). Phylogenomic analysis of the species of the *Mycobacterium tuberculosis* complex demonstrates that *Mycobacterium africanum*, *Mycobacterium bovis*, *Mycobacterium caprae*, *Mycobacterium microti* and *Mycobacterium pinnipedii* are later heterotypic synonyms of *Mycobacterium tuberculosis*. *International J. of Systematic and Evolutionary Microbiology,* **68**, 324-332.
67) Romha, G. and Ameni, G. (2014). Assessment of bovine tuberculosis and its risk factors in Cattle and Humans, at and around Dilla town, southern Ethiopia. *Animal and Veterinary Sciences,* **2**, 94. https://www.sciencepublishinggroup.com/journal/paperinfo.aspx?journalid=212&doi=10.11648/j.avs.20140204.12
68) Saikat, A.S.M.; Mahmud, S.; Uddin, M.E. (2020). Structural and Functional Anno-tation of Uncharacterized Protein NCGM-946K2_146 of *M. Tuberculosis*: An In-Silico *Approach. Proceedings (MDPI), 1st International Electronic Conference on Microbiology*, **66**(1), 13. https://www.mdpi.com/2504-3900/66/1/13
69) Shitaye, J., Tsegaye, W. and Pavlik, I. (2007). Bovine tuberculosis infection in animal and human populations in Ethiopia: a review. *Veterinarni Medicina,* **52**, 317.

70) Shitaye, J., 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. *Veterinarni Medicina-Praha-,* **51**, 512.
71) Stamm, L. M., Welch, M. D. and Brown, E. J. (2003). *Mycobacterium marinum* escapes from phagosomes and is propelled by actin-based motility. *The J. of Experimental Medicine,* **198**, 1361-1368. https://doi.org/10.1084/jem.20031072
72) Tegegne A., Belay B. and Mekasha Y. (2013). Smallholder dairy production and marketing systems in Ethiopia: IPMS experiences & opp-ortunities for market-oriented develop-ment.
73) Teshome, D. (2021a). Camel dromedary tuber-culosis: a review.
74) Teshome, D. (2021b). Camel dromedary tuber-culosis: a review. *SCIREA J. of Animal Husbandry and Veterinary Medicine*.
75) Thacker, T. C., Harris, B., and Waters, W. R. (2011). Improved specificity for detection of *Mycobacterium bovis* in fresh tissues using IS 6110 real-time PCR. *J. of BioMed Centeral and veterinary research,* **7**, 1-5. https://doi.org/10.1186/1746-6148-7-50
76) Thoen, C., Lobue, P. and De Kantor, I. (2006). The importance of *Mycobacterium bovis* as a zoonosis. *Veterinary Microbiology,* **112**, 339-345.
77) Thoen, C. O., Lobue, P. A., and De Kantor, I. N. (2009). Tuberculosis: a re-emerging disease in animals and humans. *Veterinary Italic,* **45**, 135-81.
78) Thomas, R. J. (2013). Particle size and patho-genicity in the respiratory tract. *Virulence,* **4**, 847-858.
79) Twomey, D. F., Crawshaw, T. R., and De La Rua-Domenech, R. (2010). Assessment of ante-mortem tests used in the control of an outbreak of tuberculosis in llamas (Lama glama). *Veterinary Reciserch,* **167**, 475-80. https://doi.org/10.1136/vr.c4192
80) W. H. O. (2012). Global tuberculosis control. WHO report. Geneva. *World Health Organization*.
81) Wako, G. (2015). Economic value of camel milk in pastoralist communities in Ethiopia.
82) Wernery, U. and Kinne, J. (2012). Tuberculosis in camelids: a review. *Revue Scintifique Technique,* **31**, 899-906.
83) Woldearegay, Y. H., Berhanu, M. and Mebratu, A. T. (2015). Study on management practices and production constraints of camel in Raya-Azebo district, Tigray, Northern Ethiopia. *European J. of Biological Sciences,* **7**, 01-06. https://doi.org/10.5829/idosi.ejbs.2015.7.01.91168
84) Yirda, A., Eshetu, M. and Babege, K. (2020). Current status of camel dairy processing and technologies: a review. *Open Journal of Animal Sciences,* **10**, 362-377.
85) Yohannes Mehari, Z. M. and Gebru, G. (2006). Camel and camel product marketing in Babilie and Kebribeyah woredas of the Jijiga Zone, Somali Region, Ethiopia.
86) Zahra, O. Basic Principle of Disinfectant.
87) Zerom, K., Bayu, Y. and Ameni, G. (2013). Tuberculosis in dromedaries in eastern Ethio-pia: Abattoir-based prevalence and mole-cular typing of its causative agents. *Small Ruminant Research,* **109**, 188-192.
88) Zhu, S., Zimmerman, D. and Deem, S. L. (2019). A Review of zoonotic pathogens of Dromedary Camels. *Ecohealth,* **16**, 356-377. https://link.springer.com/article/10.1007/s10393-019-01413-7

Citation: Aklilu MA, Mariam MTW, Shanta SA, Islam MS, and Akter A. (2023). Review on the epidemiology and public health importance of camel tuberculosis. *Int. J. Agric. Vet. Sci.*, **5**(5), 116-129.
https://doi.org/10.34104/ijavs.023.01160129