EJTAS
ISSN 2786-7447
EUROPEAN JOURNAL OF THEORETICAL AND APPLIED SCIENCES
OPEN ACCESS
PEER REVIEWED

Prevalence of Camel Mastitis and Its Associated Risk Factors in and around Garowe District, Puntland, Somalia

Ahmed Ali Farah, Said Abdirashiid Said ✉, Abdirahman Jama Farah
Faculty of Veterinary and Agricultural, Department of Veterinary Medicine, East Africa University, Puntland, Somalia

Suggested Citation
Farah, A.A., Said, S.A. & Farah, A.J. (2023). Prevalence of Camel Mastitis and Its Associated Risk Factors in and around Garowe District, Puntland, Somalia. *European Journal of Theoretical and Applied Sciences, 1*(6), 1106-1121. DOI: 10.59324/ejtas.2023.1(6).107

Abstract:

Mastitis is one of the main issues that cause economic inefficiencies in dairy farms. It has numerous infectious and non-infectious origins and is divided into clinical and subclinical forms. A cross sectional study of camel mastitis was conducted on 88 lactating camels from Garowe District Puntland between May to August 2023 to estimate the prevalence and causes of mastitis, as well the risk factors involved on disease. Prevalence of mastitis was assessed by using California mastitis test (CMT) and bacterial cultured. The overall prevalence of mastitis at animal level was camels examined for mastitis was found a prevalence of 39.7% (35/88) in the current study. The overall quarter level prevalence was 47.7% (168/352). Among these 10(11.4%) and 25(28.4%) were found to be positive with clinical and sub-clinical mastitis respectively, based on clinical examination and mastitis indicator paper (Table 2). Regarding Result analysis showed that there was a statistically significant association (P<0.05) among four the risk factors (tick infected, wound stage of lactation and poor hygienic). Tick infestation and udder lesions were significantly associated with camel mastitis ($P < 0.05$). Bacteriological examination of CMT along with bacteriological culture methods were used. The study cultured a positive camel milk samples revealed that *Staphylococcus* spp was the major causative agents for both clinical and sub clinical camel mastitis (45.7%) followed by Streptococcus agalactiae (25.7%), E. coli (14.3%), Klebsiella spp. (8.6%) and Micrococcus (5.7%) respectively. The study demonstrated that camel mastitis is a problem which warrants appropriate control measures in order to improve the health of camels and quality of camel milk production in the study area. The isolation of genera of pathogenic bacteria from the camel milk samples suggests the need for strict hygienic measures during the production and handling of camel milk to reduce public health hazards. Furthermore, public education should be given to improve their awareness about the importance of proper herd health management and hygienic milking practices. In order to minimize the adverse effect of mastitis on the yield, quality of milk and zoonotic impact of the pathogen. The prevalence of camel mastitis in the study area was found to be significantly high. Therefore, implementation of integrated approaches has great importance in the study sites for the prevention and control of mastitis hence minimizing economic loss and prevents significant public health risks.

Keywords: *Prevalence, Camel mastitis, Lactating camels, Risk Factor, Bacteria.*

Introduction

Livestock production is a major contributor to economic development, especially among the developing countries, both driving economic growth and benefiting from it (Oselu et al., 2022). According to the Food and Agriculture Organization (FAO), the number of dromedary camels worldwide is estimated to be 39 million in 2020, of which over 80% are in Africa **(**Zhou et al., 2023). In East Africa, where there is the highest density of dromedary camels in the world, Ethiopia, Sudan, Somalia, and Kenya have 1.6, 4.9, 7.3 and 4.7 million camels, respectively, accounting for almost 50% of the global population (Zhou et al., 2023).

The one-humped camels (Camelus dromedaries) adapt very well to arid and semi-arid (ASALs) environments and continue to thrive even during severe droughts when cattle, sheep and goats experience high mortalities. Camels are largely browsers, a tenet that assists them in accessing feed from trees and shrubs during droughts when pastures are scarce. Although camels are raised in harsh environments, they can produce milk consistently and in adequate quantity (Oselu et al., 2022). Camel milk contributes significantly to pastoralists' diet and income generation. These attributes make the dromedaries very vital for the survival of pastoralists, especially in ASALs part of Africa **(**DePuy et al., 2014).

Camel plays a significant role as a source of milk, meat, and draft power in addition to being financial reserve and social security. Camel milk is a key food in arid and semiarid areas of the African and Asian countries where camel pastoralists prefer camel milk to other types of milk due to the fact that it is nutritious, is thirst quenching, is easily digestible, and can be preserved much longer. Camel's milk is rich in protein, fat, minerals, and vitamins, especially in vitamin C. the high vitamin C content has significant importance to human diet particularly in dry areas where green vegetables and fruit are not readily available (Abera et al., 2016).

Mastitis is complex disease that generally involves interplay between management practices and infectious agents, having different degrees of intensity and variations in duration and residual effects. Various infectious agents numbering more than twenty different groups including bacteria, viruses, yeast, fungi, and rickettsia with bacterial being the major cause have been reported (Abera et al., 2016).

In addition, camel Mastitis has both an extreme zoonotic and economic importance. It is the cause of multiple hazardous effects on human health and animal production. Compared to bovine mastitis, few published information is available about the etiological agents associated with camel mastitis. Bacterial infections are considered the primary cause of mastitis in domestic animals.

Raw camel milk may contain microorganisms that are pathogenic for man and their source may lie either within or outside the dam's udder, many microorganisms can get access to milk and milk bi-products among which species, Escherichia coli, Streptococcus spp Staphylococcus aureus, Streptococcus spp (Streptococcus epidermis and Streptococcus agalactia), Escherichia coli, Klebsiella spp, micrococcus spp and others are recognized to be of primary concern (Jilo et al., 2017).

Mastitis is a frequent and important problem among livestock herds in most of countries, the occurrence of mastitis is influenced by risk factors, such as parity of the she camel, presence of tick, age and lactation stage, environmental hygiene, managements, and many different bacterial spp. that have importance, have so far been isolated from mastitis mammary glands in camels either in the form of pure or mixed infection. Many different bacterial spp. that has importance, have so far been isolated from mastitis mammary glands in camels either in the form of pure or mixed infection (Casares et al., 2013).

Mastitis can be distinct as clinical or subclinical which clinical cases of mastitis are characterized by the presence of one or more of symptoms such as udder swelling, heat, redness, pain, or systemic responses, such as elevated temperature, lethargy, and anorexia. However, in sub clinical mastitis there is no visible appearance of changes in the milk or udder, but

milk production decreases, bacteria are present in the milk secretion and composition of milk is altered (Magrino et al., 2023).

Mastitis in camels has been reported from almost all camel rearing countries. Mastitis, besides causing the loss in milk production has hazardous effects on human beings and suckling calves. Since some of the most pathogenic organisms like mycobacterium, brucellas etc. are excreted in the milk. The milk of camel, like that of other dairy animals, contains all the essential nutrients and provides a nutritious food (Suchitra et al., 2013).

Subclinical mastitis is hard to detect and treat because animals don't show any clinical signs. Sub clinical mastitis causes a 70% loss of milk production in infected animals; therefore, Subclinical mastitis is a major problem affecting dairy animals all over the world. It causes enormous losses for dairy animal and consequently influences the national income of the country **(**Mogeh et al, 2019). Economic losses are due to; loss in milk production, discarding abnormal milk and milk withheld from cows treated with antibiotics, degrading of milk quality and price due to high bacterial or somatic cell count (SCC), costs of drugs, veterinary services and increased labor costs, increased risk of subsequent mastitis, herd replacement, and problems related to antibiotics residues in milk and its products (Guarín and Ruegg 2016). There are no written reports about the prevalence of subclinical mastitis in Somalia. Therefore, there is a need to know the prevalence of sub clinical mastitis in the livestock of Somalia. The purpose of this study was to document and determine the prevalence of mastitis in dairy herds and to establish associated factors that may lead to mastitis in lactated Camel (Abera et al., 2016).

Problem Statement

Livestock production accounts for 60-65% of the gross domestic product (GDP). Based on estimates of livestock numbers and past growth rates, Somalia has about 6 million camels, 0.80 million head of cattle, 13.4 million goats and 11.75 million sheep in 2012 (Mohamud et al., 2020). Despite the large number of animals in Somalia, there is shortage of milk, and this leads extensive consumption of imported milk and discouragement to development of dairy sector in Somalia. The shortage of milk and milk products has many causes. However, information on Mastitis which is one of the major causes of reduced milk production in dairy lactating animals in Somalia particularly Garowe district is lacking or inadequate (Husein et al., 2013).

Recently occurrence of mastitis among lactating camel has been reported from different camel rearing countries like Somalia. But there is lack of information on the prevalence of camel mastitis and its risk factors in Somalia. To design appropriate control and prevention program in she-camel dairy herd, up to date information on the nature of mastitis and major bacterial pathogens associated with its occurrence need to be identified (Mohamud et al. However, there is no more information which was done on the camel mastitis in Puntland based on Garowe.

Therefore, this study will be conducted to determine the prevalence of camel mastitis to identify the major bacterial pathogens contributing to mastitis and risk factors associated with mastitis occurrence in traditionally managed practices in lactating camels in Garowe District.

Research Objectives

General objective of the study

This study will be aimed to assess the prevalence and associated risk factor of camel mastitis in and around Garowe district, Puntland state Somalia.

Specific objectives

To determine the prevalence of clinical and subclinical camel mastitis in dairy farms of the study area

To isolate and identified major bacteria pathogens that causes of camel mastitis.

To identify associated risk factors of mastitis.

Significance of the Study

The study will provide information on the extent to which mastitis is present among the dairy

animals in Garowe district. This would be beneficial to both camel dairy farmers, other stakeholders in the dairy value chain to improve on the food security and increase households' income in line with the vision of the ministry of livestock in Puntland. This study is equally important to the future researchers and other community-based organization, business union and NGOs that involves to the health animals and animal productions.

Expected Limitations of the Study

There were limitations that the research my face while conducted the study. These are including when conducted the research is faced in difficulties with the respondents to get because always they are busy for their works, on the other hand it may include Printing expenses and also The time was limited .2 months only have designed and the weather also becomes another challenge due to autumn time due to very hot because we need to go same selected areas in Garowe district and then was likely makes hard to do activities and some of the work such as taking milk samples and preparation of equipment's. Will be mainly about direct tests in the laboratory and finding the result.

The scope of the study covers, prevalence of camel mastitis and its associated risk factors in and around Garowe district, Puntland, Somalia March 2023 to July 2023.

Literature Review

General Overview of Mastitis

Mastitis is a complex and multi-factorial disease, the occurrence and severity of which depends on factors related to the animal, the environment and pathogens involved. Mastitis reduces the quality and quantity of milk and is a disease of great economic and public health importance (Schmidt et al., 2017). Mastitis can be defined as inflammation of the mammary gland regardless of the cause and is characterized by physical, chemical and, usually, bacteriological changes in the milk. It is also characterized by pathological changes in the glandular tissue (Seyoum et al., 2016).

The most important changes in the milk include discoloration, presence of milk clots and presence of a large number of leucocytes (Al–Otaibi et al., 2013). While clinical cases are easy to detect by manual palpation and by visual examination of the milk using a strip cup (there is swelling, heat, pain and in duration in the mammary gland, and the milk is discolored and clotted), a large proportion of mastitis cases are not readily detectable; such cases are referred to as subclinical mastitis. Mastitis is a relatively infrequent disease in camels compared with cattle, but the incidence of mastitis may increase in dairy camels due to hand milking and teat malformation. Acute mastitis has been reported to occur during the first few days following parturition, dystocia, or cesarean section in the dromedary (Srivastava and Kumaresan, 2015).

Prevalence of Clinical and Subclinical Camel Mastitis in Dairy Farms

Based on the severity, the inflammation can be classified into sub- clinical, clinical, and chronic forms, and its degree is dependent on the nature of causative pathogen and on the age, breed, immunological health and lactation state of the animal (Oliveira et al., 2015).

Clinical mastitis is characterized by sudden onset, alterations of milk composition and appearance, decreased milk production, and the presence of the cardinal signs of inflammation in infected mammary quarters. It is readily apparent and easily detected. In contrast, no visible signs are seen either on the udder or in the milk in case of sub-clinical mastitis, but the milk production decreases and the somatic cell count increases. It is more common and has serious impact in older lactating animals than in first lactation heifers. Because of the lack of any overt manifestation, the diagnosis of sub-clinical mastitis is a challenge in dairy animal management and in veterinary practice (FAO, 2014).

Most estimates have shown a 30% reduction in productivity per affected quarter and a 15% reduction in production per cow/lactation,2, 3 making the disease one of the most costly and serious problems affecting the dairy industry worldwide (Cervinkova et al., 2013). Mastitis has been known to cause a great deal of loss or

reduction of productivity, to influence the quality and quantity of milk yield, and to cause culling of animals at an unacceptable age (Abdurrahman et al.,2017).

Somalia, camels are important not only for milk production but also for the husbandry system. Camels have been identified as source of milk and meat with the increased human population in the developing countries (Diaz et al.,2022). For these desert countries, camels are the best animals to sustain the hard situation of the desert such as heat, and water and food scarcity. Camels have advantage over other cattle in their ability to provide sustained average milk production over the year (Kula Jilo., 2017). Also, camel's milk is more nutritious than other types due the high presence of proteins, fats, vitamins, and minerals. Another advantage of the camel milk is its medicinal characteristics and helps cure some diseases such as jaundice, asthma, anemia, food allergies, dropsy, spleen diseases and piles (Eyassu et al.,2022).

Isolate and Identified Major Bacteria Pathogens that Causes of Camel Mastitis

Correct milking procedures such as milking mastitis camels last, and proper sanitation of utensils, milker's hands and udder before milking could help to improve the situation. The frequency of isolation of coliforms and other micro-organisms causing environmental mastitis is usually directly influenced by unhygienic housing conditions (Sharma et al., 2012).

Most commonly, mastitis begins as a result of penetration of the teat duct by pathogenic bacteria. Many infective agents have been implicated as causes of mastitis in camels, the commonest being bacterial infection (Kayan-Fadlelmula et al.,2022). The documented common causes of bacterial mastitis in camels are include Staphylococcus aureus, Streptococcus agalactiae, Streptococcus species other than Streptococcus agalactiae, coagulase negative Staphylococci species, Escherichia coli, Micrococcus species, Corynebacterium species, Bacillus species, Pasteurella species, Klebsiella species, Mycoplasma species and Nocardia species (Kayan-Fadlelmula et al.,2022).

Among the bacterial species associated with bovine mastitis, two categories are distinguished. These are major pathogens which are responsible for most severe cases of mastitis and the minor pathogens, which are rarely associated with marked leuckocytosis and clinical manifestations; Streptococcus agalactiae and Staphylococcus aureus have been documented as the two most important mastitis pathogens in camels. Acute or chronic mastitis is one of the important diseases of she-camel in Eastern Sudan. The isolates Staphylococcus aureus, Escherichia coli, Corynebacterium spp. are the main causes of mastitis in camels (Nichols et al.,2022).

Moreover, Environmental mastitis is caused by bacteria living in soil, bedding, water, manure, calving pads. Examples of these bacteria include Streptococcus uberis, Streptococcus dysgalactiae, Coliforms such as E. coli and Klebsiella, while the first can sometimes persist and spread though the milking process, the second does not survive in the udder and does not persist (Kula Jilo., 2017).

Transmission

Transmission mechanisms depend on the bulk of the infection in the environment, including: infected quarters; efficiency of milking personnel; susceptibility of the animal/camel, which is related to the stage of lactation, age of the camel (older animals more susceptible) and level of inherited resistance (possibly related to teat shape and anatomy of the teat canal); lesions on the teat skin especially the orifice; and the immunological status of each mammary gland (Eisa et al.,2022).

Risk Associated Factors

Many factors are involved for development of bovine mastitis most importantly management practice and infectious agents (Biressaw and Deme, 2015). In addition to management and the causative agents, other factors such as udder shape, genetics (Awale et al., 2012), parity, hygiene, age, lesions, milking practice, stage of lactation and tick infestation also play an important role in the development of mastitis (Girma et al., 2012).

Diagnosis of Mastitis

Subclinical mastitis, on the other hand, is difficult to diagnose and depends on various test procedures aimed at detecting the cause or products of inflammation in milk (Fitzgerald, 2012). A camel with subclinical mastitis produces less milk but does not have a swollen udder or abnormal milk. Infection is present but can only be detected with the help of indirect methods (Bal et al., 2016). These include the California mastitis test (CMT), and Direct microscopic somatic cell count (DMSCC) a simple and rapid test that can be applied in the field; it is particularly used to detect subclinical udder infections caused by either one of the two major mastitis pathogens: Streptococcus agalactiae and Staphylococcus aureus (Papadopoulos et al., 2018).

The direct microscopic somatic cell count (DMSCC), which requires only simple laboratory equipment and produces results on the same day (Kula Jilo., 2017). However, there has been a problem in interpretation of results of these tests because the basal levels of cells and their physiological variations in the camel are still not yet established (Smith and Wardyn, 2015).

Clinical mastitis can be diagnosed by visual inspection of milk, palpating udder and physical examination of cow while sub-clinical mastitis can be primarily identified by using some tests e.g., California Mastitis Test (CMT) (FAO, 2014). Sub-clinical mastitis does not only cause economic loss to dairy industry but also act as a carrier and source of infection for other cows at farm Moges et al., 2012). Several cases of clinical mastitis are treated daily but very minimum number gets recovered due to lack of diagnostic facilities in the field (Oliveira et al., 2015).

In the diagnosis and control of mastitis in camels, laboratory procedures are of value in the examination of milk samples for cellular, bacterial, and chemical changes. Much attention has been given to the development of field tests based on physical and chemical changes in milk (Sun et al.,2022).

Research Materials and Methodology

This chapter presents the methods and procedures that were used in sample selection, data collection, analysis, and presentation. It included research design, sampling techniques, data collection methods, study population, sampling procedure and sample size, data analysis methods, ethical consideration, and anticipated limitations of the study.

Study Area

The current study will conduct in Garowe of Nugal region which is in the Northern part of Puntland -Somalia. Garowe is the administrative capital of the province in state of Puntland region in northeastern Somalia. Garowe is in the Nugal region, and is the seat of the Puntland parliament, presidential palace and government ministries. A fast-growing city, it has also evolved into a local media and cultural hub (Adam et al., 2018). Garowe is located about 780 km away from Mogadishu capital of Somalia. Garowe has an estimated total population of 190,000 according to the Yusuf et al. (2019).

The population of Garowe town is estimated to be 485,760 people. Provision of basic social services is fairly good, though the infrastructural support is inadequate. The highway system which connects the towns between northern and southern Somalia traverses Garowe town and supports linkages of trade, local cereal supply and labour migration (Said et al., 2019). Garowe divided into eight local administrations namely Gillab, Qalqalooc, Libaax, Geida Debabo, Bixin, Lugo, Salaxley and War Weytan (Mohamud et al., 2018).

Grower is semi-arid, characterized by tropical desert with hot and dry climate. Coldest average temperatures occur from November to February, when thermometer readings range from 23 to 25 °C (73 to 77 °F). The weather slowly heats up in the spring, as the April rainy season begins. Average temperatures later reach a maximum of around 41°C over the summer period. The mean annual rainfall ranges from 400-500mm in the region is sparse and variable, with no single area receiving more than 400 mm (15.7 in) of rain annually (Desire, 2016).

Study Design

A cross-sectional study supported by questionnaire survey will be conducted to determine the prevalence of camel mastitis, to identify the major bacterial pathogens contributing to mastitis and its associated risk factors. The study will be conducted from May 2023 to August 2023 with the objectives of investigating prevalence of camel mastitis and its associated risk factors in and around Grower district, Punt land, Somalia. This study had two parts (survey and laboratory experiment). Twenty camel dairy farms that were selected during study period has been distributed into four sub areas proportionally (Boxing, Sun if, jibagale/2aadAwrculus and Jibagale, Abaaray)

where high sample size was allocated based on camel population and accessibility.

Study Animal Population

The study animals are lactating camels that were kept under traditional management from different areas of in and around Grower town. A total of 20 lactating camels destined for inspection of prevalence of clinical and subclinical mastitis accordingly. Area selection was purposive due to the nature and reproductive systems used while the Farm selection will be based on randomly method.

Inclusion and Exclusion Criteria

Inclusion criteria

The inclusion criteria were all camel dairy farms that in and around Grower district those was willing to participate volunteer in the study, ready to give the required information through questionnaires and availability during the survey.

Exclusion criteria

All camel dairy farms who were refused to participate this study was exclusion criteria.

Sample Size Determination

Raosoft sample size determination was adopted with assuming confidence level of 95%, marginal error of 5%, the target population of 100 and response distribution 50% was used, therefore 80 was the sample size. Nonresponse rate of 10% was used so the total sample size was 88 since there was no previous study on prevalence of lactating camels Grower district. Taking 10% nonresponse rate was used primary related questionnaire respond rate = 88 × 10% = 8; The final sample size was: 80+8 = 88 was the finalize sample size.

Administration Questionnaire and Observation Survey

Before the formal survey, preliminary visits were made to get the consent of the farmers, locate of camel dairy farms and to give a brief description to each respondent on research objectives and potential benefit of involving in the study. The revised version of the questionnaire that will be used in the pilot study was translated into 'Somalia', the National language that is clearly understood by the most of Somali communities. Semi-structural Questionnaire survey will be conducted to assess the management aspects and possible risk factors contributing to mastitis occurrence and milk handling method with each selected lactating camel owners/herders.

Additionally, a general questionnaire survey will be carried out in which of age of camel, parity number, housing, feeding, source of water, economic importance of mastitis, milking order of lactating, camel's traditional husbandry system used by camel owners, stage of lactation, pre milking udder preparation and hygiene were included in questionnaire.

While administering questionnaires, direct observation on general cleanliness, hygienic conditions and practices concerning milk will be also done and noted at the same time. Upon finishing of the administration of questionnaires, milk samples were collected for laboratory analyses. Sometimes milk will be sampled first before administering questionnaires because some farmers wanted to transport and sell to the milk vendors.

Collection of Samples and Handling Procedures

A total of 107 from different dairy camel farms will be collected from selected dairy camel farms based on availability, voluntary basis to provide milk, transportation, and accessibility of time for sampling and laboratory work. Based on the

information gained camel owners/herders will be interviewed to select the infected lactated camel.

The infected lactated camels will be selected simple randomly method based on the presence of lactating camel in the farm. Almost all lactating cows of the selected herds will be included to take milk samples and considered to select the individual apparently clinical and sub-clinical lactated camels. 15 out zones 5 villages of Grower were randomly selected by lottery method which were (Boxing, Sun if, Brita deer, Awrculus and Jibagale, Rabable) and 107 respondents was purposively selected regarding animal attendants and farm owners.

Milk samples were directly collected from the udder of the animal at the early morning during ongoing milking process and late in the afternoon at time of milking. The milk collection was conducted according to the national mastitis council (NMC, 2004). Aseptic procedure will be followed while collecting milk samples in order to reduce or prevent contamination with microorganisms (Quinn et al., 2004). Before collecting the sample from each quarter, teats were disinfected and cleaned teats with 70% alcohol and given time to dry.

About 10 ml of milk was aseptically collected from each clinically and sub clinically mastitis non-blind quarters by using sterile test tube and California Mastitis Test (CMT) was used for sub clinical mastitis and close physical examination with careful palpation of the udder was done to determine the clinical mastitis. Then all CMT positive samples were transported by an icebox to Grower General Veterinary Laboratory at Ministry of Livestock for microbiological examination. The samples will be kept in the refrigerator at 4°C and culture will be conducted within 24 hours (Kebede, 2005). The samples will be prepared according to the technique recommended by the International Organization for Standardization (ISO 8261:2001).

Bacterial Isolation and Identification from Milk Sample

Bacteriological culturing and identification was done to the standard method (ICMSF, 1985) at Ministry of Livestock Animal Husbandry laboratory (MoLAH) of Microbiology laboratory. Both clinical and CMT positive milk samples from each sample were cultured (Preethirani et al., 2015). The all presumptive positive of California Mastitis Test (CMT) were used further for Microbiological investigation of cultured. Primary culture was performed in Nutrient Agar media. The Primary cultures were considered to be positive when bacterial growth was observed on the inoculated plates and negative when no bacterial growth was observed. The representative isolates colonies were performed by Gram staining according to the methods described by Merchant and Packer (1967) to determine the size, shape, and arrangement of bacteria. Stained slides were examined under light microscope at 100X magnification microscope with immersion oil to enhance visible of colony morphology. Then Pure culture was further obtained by sub-culturing part of typical colony and well isolated colony on a corresponding medium (MacConkey Agar, MSA, and Agar) and incubated further at 37 ºC aerobically for 24 hours according to the Bergey's manual of determinative bacteriology (1994). The isolated organisms with supporting growth characteristics on various media were subjected to different biochemical tests included catalase test, oxidase test, triple sugar iron (TSI) agar slant reaction, methyl red-Voges Proskauer (MR-VP) test, indole reaction, and motility indole urease (MIU) test as procedure mentioned by Cheesbrough (1985) and Jahan et al. (2015). Identification of bacterial isolates was done based on colony morphological features and hemolytic reactions (primary cultures), gram staining reactions and biochemical tests on pure cultures (Quinn et al.,1994). To differentiate Staphylococcus and Streptococcus spp, catalase reaction was performed on all Gram- positive isolates employing the rapid slide technique as described by Cheesburgh (1985). The culture to be tested for catalase test was picked with sterile inoculating loop from the nutrient agar plate and mixed with a drop of 3% H2O2 on a clean glass slide and the formation of oxygen bubbles was observed within a few seconds. Tube coagulase test was performed by adding 0.5 ml of horse

plasma to 0.5ml BHI culture broth then mixed and incubated for 24 h at 37 °C according to the method described by (Quinn et al., 2004).

Data Analysis Tools

Data obtained from a questionnaire survey and observational studies of bacteriological quality analysis were entered into a Microsoft Excel spreadsheet and analyzed will be entered into a Microsoft Excel spreadsheet. Data will be analyzed using Statistical Package for Social Sciences (SPSS) software, version 25. 0. Descriptive statistics was employed to summarize the data and expressed in terms of frequency and percentage. For statistical inference, the level of significance will be taken as 0.05 will be considering as a significant association at 95% level of confidence. Additionally, Chi-square test was used to see the presence and strength of association of the potential risk factors with occurrence of mastitis using SPSS.

Research Ethics

Ethical Consideration

The research done in the way that no one can harm or suffer adverse consequences from research activities. A permission access from letter East Africa university faculty of Veterinary Medicine to the concerned bodies included security roads, camel dairy farms and other communities. The research was conducted with respect to ethical values, confidentiality, & moral expectation. East Africa university faculty of Veterinary Medicine. Informed consent was Informants gave their informed consents to take part in the study after receiving detailed information regarding the voluntary nature of participants and about confidentiality. Ethics are norms of standards of behavior that guides moral choices about behavior and our relationship with others.

Study Limitations

Security issues and poor transportation to the field survey is far from the city were challenges sometimes, so we to hire a rent car to reach our destination. The data were collected from camel dairy farms with variations in the level of completeness of documentation of the demographic and sample collection described, however some of the camel dairy farms lactated camels were already milked and that was challenge.

Results and Discussion

Questionnaire Survey and Observation

Overall, out of 88 samples, 35 (39.7%) were tested positive for camel level, whereas 168 (47.7%) out of 352 quarter-level milk samples were positive (Table 1). The proportion of mastitis positives in relation with camel and quarter level were presented in (Table 1). Accordingly, a total of 35 clinical and sub-clinical cases of lactating camels were examined for mastitis using mastitis indicator paper California Mastitis (CMT) during the study period. Concerning that 10(11.4%) and 25(28.4%) were found to be positive with clinical and sub-clinical mastitis respectively (Table 2).

Table 1. Prevalence of Mastitis Both at the Animal and Quarter Level Based on the On-Mastitis

Observation level	No of examined animals	No of positive	Prevalence (%)
Camel level	88	35	39.7%
Quarter level	352	168	47.7%

Table 2. Prevalence of Mastitis at the Animal and Quarter Level Based on the CMT

Form of Mastitis	No of positive	Prevalence (%)
Clinical	10	14.4%
Sub-clinica	25	28.4%

Among the "site village" selected from Grower district, Abaaray 12 (13.5%), Kalabayr 5 (5.7%), Owrculus 7 (7.9%), Boxing 3 (3.4%), Jibagale/2aad 6 (6.8%) and Sunjif 2 (2.3%) respectively. When compared the prevalence of the villages/sites Abaaray 12 (13.5%), had relatively the highest prevalence of lactating camel mastitis followed by Owrculus 7 (7.9%), whereas Sunjif 2 (2.3%)

had the lowest prevalence of clinical and subclinical mastitis among six sites (Table 3).

Table 3. Prevalence of Clinical and Subclinical Mastitis at Site Level in the Selected Study District

Site	No of examined animals	No of positive	Prevalence (%)
Abaaray	22	12	13.6%
Kalabayr	18	5	5.7%
Owrculus	13	7	7.9
Boxin	15	3	3.4%
Jibagale/22aad	11	6	6.8%
Sunjif	9	2	2.3%
Total	**88**	**35**	**39.7**

Hygienic Condition and Camel Management Practices

Despite having a good understanding of mastitis' symptoms and treatments, farmers and pastoralists lack the preventive measures necessary to control the condition. Among them, the majority of farmers do not call and rely on a veterinarian to treat their animals and offer guidance on mastitis management measures; this demonstrated how little trust farmers have in veterinarians. The interviewers' responses and observations indicated that 12(13.6%), 46(52.3%), 21(23.9%), and 9(10.2%) Call veterinarian, Treated own self, Veterinary no important, and Veterinary assistant important, respectively. Among most farmers don't call and rely on a veterinarian to treat their animals and offer guidance on mastitis management measures, demonstrating the lack of trust that farmers have in veterinarians (Table 4).

Table 4. Knowledge of Mastitis and Its Prevention Measures

Variable	Frequency	Percentage
Call veterinarian	12	13.6%
Treated own self	46	52.3%
Veterinary no important	21	23.9%
Veterinary assistant important	9	23.9%

Concerning the usage of antibiotics by farmers and pastoralists to treat mastitis Oxytetracycline 62(72%) and pen strep 25(28%) are the two most often used antibiotics. Regarding the understanding that drugs have no effect on humans 39(44%), have an effect on humans 23(26%), and they were used to treat lactated animals and subsequently sold (26(30%) as treated milk to the general population (Table 5).

According to this study, mastitis was found in 21 (23.9%), 11 (12.5%), and 19 (21.6%) of lactating camels with tick-infested udders, wounds, and poor hygiene respectively (Table 6). The results from the (Table 2) below revealed that there were associations between the risk factors (tick-infested udders, wounds, and poor hygiene) and the occurrence of mastitis in camels at $p<0.05$.

Table 5. Antibiotics' Effects on Consumers after Treating Animals

Variable	Frequency	Percentage
Oxytetracycline	63	72%
Pen strip	25	28%
Sell to the public	26	30%
Have impact on human	23	26%
No impact on human (antibiotic milk)	39	44%

Among potential risk factors for the occurrence of sub-clinical mastitis in this study was also considered stage of lactation of middle lactation and late above seven month 10(11.4%) and 3(3.4%) respectively. Regarding Result analysis showed that there was a statistically significant association ($P<0.05$) among four the risk factors (tick infected, wound stage of lactation and poor hygienic). Regarding that the early lactating and old aged camels are highly chance to get mastitis than and adult aged as shown (Table 6).

Table 6. Association between Tick Infested, Wounded Udder and Hygienic Condition with Occurrence of Mastitis in the Study

Risk factors Categories	No of examined animals	No of positive	Prevalence (%)	P-value
Tick infected				
Yes	32	21	23.9%	0.06
No	56	14	15.9%	
Wound				
Yes	41	11	12.5%	0.000
No	47	24	68.8%	
Poor hygiene				
Yes	35	19	21.6%	0.03
No	53	16	18.2	
Age				
Young (2-5 yrs)	9	7	8%	
Adult (6-7 yrs)	12	5	5.7%	
Old (>8 yrs)	12	11	12.5%	
Lactation stage				
Early (< 3)	23	10	11.4%	0.04
Middle lactation (3-7)	7	4	4.5%	0.11
Late (above 7)	5	3	3.4%	0.001

The Bacteria Major Bacteria Isolated from Camel Milk

Among the California Mastitis (CMT) positive milk samples (35) were further processed for bacteriological examination used differential and selective media and for further biochemical tests. During this study, out of 88 samples tested, only 35 were positive for bacteria belonging to the four genera, including E. coli, Staphylococcus aurous Micrococcus, and Streptococcus agalactiae, during the investigation. Accordingly, different bacterial species with their respective prevalence rate were recorded. The type of bacteria isolated from raw milk were both Gram negative and Gram-positive organisms. Mostly, Gram-positive bacteria were isolated in raw milk sample including *Staphylococcus aureus*, *Micrococcus*, and *Streptococcus agalactiae*. While Gram negative bacteria isolated E. coli and Klebsiella.

Gram-positive cocci were tested for catalase, and catalase-positive isolates further tested with coagulase test. Streptococci were identified by performing CAMP, mannitol, and inulin tests. Gram-negative rods were further differentiated

by testing for motility, lactose fermentation (growth on MacConkey, EMB agar). The prevalence of *Staphylococcus* aureus (45.7%), *Streptococcus agalactiae* (25.7%), *E. coli* (14.3%), *Klebsiella spp.* (8.6%) and *Micrococcus* (5.7%) accordingly. *Staphylococcus aureus* (35.7%) showed the highest prevalence of bacteria isolated follow by *Streptococcus agalactiae* (25.7%). Subsequently, different bacterial species with their respective prevalence rate were recorded (Table 7).

Table 7. Frequency Distribution of Bacterial Isolates from Mastitis Milk in Sample (N=35)

Bacteria Species	No of isolated	Prevalence (%)
Staphylococcus aureus	16	45.7%
Streptococcus agalactiae	9	25.7%
Micrococcus	2	5.7%
E. coli	5	14.3%
Klebsiella	3	8.6%

Discussion

Mastitis is an important constraint to milk production in pastoralist camel (*Camelus dromedarius*) herds in arid and semiarid parts of Somalia and several reports revealed that mastitis in traditionally managed camels is increasing and likely continues to rise as the milk production per individual camel gradually increases to infected mastitis. Among 88 traditionally managed lactating camels examined for mastitis, an overall prevalence of (39.7%) was found in the current study. This finding lower than the report of Geresu et al. (2021), who found an overall prevalence of 76% among traditionally managed camels (*Camelus dromedarius*) in selected pastoral areas in Jijiga Zone, Somali Regional State of Ethiopia. However, the finding of the present study is comparable with that of Mohamud et al. (2020) who found an overall prevalence of (23.4%) in Banadir Region of Somalia.

On the other hand, the finding of clinical (14.4%) and sub-clinical mastitis (28.4%) reported in this study disagrees with the finding of Mogeh et al. (2019) those reported the prevalence of sub-clinical mastitis and sub-clinical ranged from (6.3%) and (24.7%) respectively in Hargeisa areas of Somaliland. In contrast prevalence of sub-clinical mastitis obtained in the current study is higher than that of (13.5%) and (10.8%) reported by Sharma et al. (2026). The variation in prevalence with those observed in other areas might be due to difference in management systems and the agro-ecological zone/region.

According to the interviewers' observations and responses, 12 (13.6%), 46 (52.3%), 21 (23.9%), and 9 (10.2%) called a veterinarian, self-treated, veterinary no important, and important for veterinary assistant, respectively. The lack of faith farmers has in veterinarians is evident in the fact that the majority of farmers do not call and rely on a veterinarian to treat their animals and provide advice on mastitis control methods (Table 4). Regarding the usage of antibiotics by farmers and pastoralists to treat mastitis Oxytetracycline 62(72%) and pen strep 25(28%) are the two most often used antibiotics. Regarding the understanding that drugs have no effect on humans 39(44%), have an effect on humans 23(26%), and they were used to treat lactated animals and subsequently sold (26(30%) as treated milk to the general population (Table 5). This is in agreement with Mohamud et al. (2020) those reported that about the administration of antibiotics to cure mastitis by farmers and pastoralists Oxytetracycline (62.8%) and pen strep (25%) are the two antibiotics that are most commonly used to treat mastitis and other diseases and disorders.

Concerning the udder wound, penetrating superficial skin lesions of the teat and udder were observed on 21 (23.9%), 11 (12.5%), and 19 (21.6%) of lactating camels with tick-infested udders, wounds, and poor hygiene of lactating camels respectively were mastitis positive

compared to the prevalence of those camel without udder lesions. Higher prevalence of mastitis (72.2%) in camels with udder lesions were also reported by Tigabu et al. (2015) in which the udder/ teat skin scratches can be caused by thorn plant of the desert. Tilahun et al. (2016) also recorded that the udder or teat skin scratches can be caused by thorny plant of the desert. Generally, trauma might be directly responsible for mastitis because the injury could predispose the udder to bacterial invasion. This is one of the factors that predispose camels to mastitis, since lesions caused by ticks facilitate bacterial entry and cause permanent tissue damage and influenced by poor udder hygiene and poor management as mentioned earlier by many of the researchers this could be since poor hygiene environment can predispose the udder area by creating a conducive situation for the entrance of majority of mastitis causing microorganisms. However, the findings form this study was consistent with the findings of Silva et al. (2014) who reported high (24.1%, 12.9%, 20.6%) and of mastitis in dromedary camels in afar region-Ethiopia.

Among potential risk factors for the occurrence of sub-clinical mastitis in this study was also considered stage of lactation of middle lactation and late above seven month 10(11.4%) and 3(3.4%) respectively. Based on the result analysis showed that there was a statistically significant association ($P<0.05$) among middle and late lactated were party of risk factors associated with mastitis occurrence. The risk of developing Clinical mastitis is greatest in early lactation and increases with lactated and level of milk production. Similar observations have been reported by Das et al. (2016) those stated that most dairy farms in Bangladesh were used manual milking instead of machine milking. About early lactating and old aged camels are highly chance to get mastitis than and adult aged as shown (Table 6). The present finding is comparable with the result reported by Geresu et al. (2021) who reported (12.4%) the stage of lactation period was statistically significant at ($P>0.05$) that late gestation period was significantly associated with occurrence of mastitis due to prolonged exposure to unhygienic environment and lack of dry therapy was highly access chance to infected mastitis.

The most predominant bacterium isolated from this study was *Staphylococcus aureus* with prevalence of (45.7%), followed by *Streptococcus agalactiae* (25.7%), E. coli (14.3%), *Klebsiella spp.* (8.6%) and *Micrococcus* (5.7%) respectively. *Staphylococcus aureus* (45.7%) showed the highest prevalence of bacteria isolated along with *Streptococcus agalactiae* (25.7%). The bacteria isolated from cultures like *Staphylococcus aureus* and other coagulase positive *Staphylococcus were* mainly responsible for clinical mastitis but some agents like S*treptococcus agalactiae*, were found in both clinical and sub-clinical mastitis. This finding agrees with the report from Mogeh et al. (2019) who reported the prevalence of (35%) and (28%) respectively.

Conclusion

The fact that the pathogens is isolated from camel milk samples in this study were bacteria that cause both environmental and contagious mastitis indicated that proper management of lactating camels and adequate hygienic condition of the environment are required in order to minimize occurrence of mastitis in the study areas. This study revealed high prevalence of mastitis in camel herds in the sampled area. The high prevalence of mastitis was attributed to inadequate hygienic condition of the dairy environment and tick infestation Additionally, it was observed that the occurrence of camel mastitis significantly vary with stage of lactation indicating a higher prevalence during early stage of lactation. Finally, among the important mastitis causing bacteria, coagulase negative *Staphylococci, Streptococcus agalactia. E. coli, Klebsiella and Micrococcus* were found the most common. Therefore, good management practices with proper sanitation and tick control measures are required to prevent the incidence of mammary infection in camels in the study areas. The isolation of genera of pathogenic bacteria from the camel milk samples suggests the need for strict hygienic measures during the production and handling of camel milk to reduce public health hazards. Furthermore, public education

should be given to improve their awareness about the importance of proper herd health management and hygienic milking practices. In order to minimize the adverse effect of mastitis on the yield, quality of milk and zoonotic impact of the pathogen.

Recommendations

Therefore, in light with the above conclusion, the following recommendations are forwarded:

1. Government should encourage livestock sector by establishing monitoring and emergency teams.

2. Giving trainings and workshops for the camel owners, Camel producers and any other camel milk consumers should avoid consuming raw camel milk but instead boil the milk before consuming.

3. Treatment of camels with mastitis infections using the conventional drugs should be promoted while avoiding non-conventional treatment.

4. There is need to create awareness on camel mastitis among camel keepers. Now there is low level of aware-ness among pastoralists.

5. Puntland Ministry of livestock should have several mastitis control strategies which needed be put in place such as milking procedures, milking order, strict hygiene, post milking teat disinfection, use of antibiotic dry-off therapy and the culling of persistently infected camels.

6. In order to control and prevent mastitis in camels, it is highly advisable to avoid risk factors such as use of antibiotic dry off therapy during dry period, tick infestation, udder lesions and culling persistently the infected camels.

7. California Mastitis Test and somatic cell count should be done at least once a Month for monitoring udder health status of dairy animals.

8. Further studies are needed to determine complete microbiological analysis of dairy animals and sensitivity test of these pathogens.

References

Abbott, R., Abbott, T. D., Acernese, F., Ackley, K., Adams, C., Adhikari, N., ... & Bose, N. (2023). Population of merging compact binaries inferred using gravitational waves through GWTC-3. *Physical Review X*, *13*(1), 011048. https://doi.org/10.1103/PhysRevX.13.011048

Abd-Allah, G. M., Ismail, A., El-Mahdy, H. A., Elsakka, E. G. E., El-Husseiny, A. A., Abdelmaksoud, N. M., Salman, A., Elkhawaga, S. Y., & Doghish, A. S. (2023). miRNAs as potential game-changers in melanoma: A comprehensive review. *Pathology, research and practice*, *244*, 154424. https://doi.org/10.1016/j.prp.2023.154424

Abdella ME. (2014). Clinical study on camel mastitis (Camelus dromedarius) at Butana Region, Sudan. *SUST Journal of Agricultural and Veterinary Sciences (SJAVS).* https://doi.org/10.15406/mojes.2017.02.00034

Abera, T., Legesse, Y., Mummed, B., & Urga, B. (2016). Bacteriological quality of raw camel milk along the market value chain in Fafen zone, Ethiopian Somali regional state. *BMC research notes*, *9*, 285. https://doi.org/10.1186/s13104-016-2088-1

Al-Otaibi & El-Demerdash. (2013). Nutritive value and characterization properties of fermented camel milk fortified with some date palm products chemical, bacteriological and sensory properties. *International Journal of Nutrition and Food Sciences, 2*(4), 174-180.

Al-Ruwaili, M. A., Khalil, O. M., & Selim, S. A. (2012). Viral and bacterial infections associated with camel (Camelus dromedarius) calf diarrhea in North Province, Saudi Arabia. *Saudi Journal of biological sciences*, *19*(1), 35-41.

Al-Sahlany, S. T. G., Khassaf, W. H., Niamah, A. K., & Abd Al-Manhel, A. J. (2023). Date juice addition to bio-yogurt: The effects on physicochemical and microbiological properties during storage, as well as blood parameters in vivo. *Journal of the Saudi Society of Agricultural Sciences*, *22*(2), 71-77. https://doi.org/10.1016/j.jssas.2022.06.005

Carter, G.R. (1979). *Diagnostic Procedures in Veterinary Bacteriology and Mycoplasma.* 3rd edn. Charles C. Thomas Publisher U. S. A. pp. 398-417.

Cheesebrough, L. M. (1985). *Identification of bacteria.* Medical Laboratory manual for tropical countries. Vol II.

Cowan ST. (1985). *Cowan and steel's manual for identification of bacteria* (2nd editon). Cambridge University Press. Cambridge, London.

Del Rio, C., Malani, P. N., & Omer, S. B. (2021). Confronting the Delta Variant of SARS-CoV-2, Summer 2021. *JAMA*, *326*(11), 1001–1002. https://doi.org/10.1001/jama.2021.14811

DePuy, W., Benka, V., Massey, A., Deem, S. L., Kinnaird, M., O'Brien, T., Wanyoike, S., Njoka, J., Butt, B., Foufopoulos, J., Eisenberg, J. N., & Hardin, R. (2014). Q fever risk across a dynamic, heterogeneous landscape in Laikipia County, Kenya. *EcoHealth*, *11*(3), 429–433. https://doi.org/10.1007/s10393-014-0924-0

Fadlelmula, F. K. (2016). March). Practicing Flipped Classroom in Undergraduate Mathematics Courses: A Case Study in Qatar. In *Qatar Foundation Annual Research Conference Proceedings*, Qatar: HBKU Press.

Geresu, M. A., Abera Leliso, S., & Liben, G. W. (2021). Camel Mastitis: Prevalence, Risk Factors, and Isolation of Major Bacterial Pathogens in Gomole District of Borena Zone, Southern Ethiopia. *Veterinary medicine international*, *2021*, 9993571. https://doi.org/10.1155/2021/9993571

Geresu, M.A. (2021). *Camel Mastitis: Prevalence, Risk Factors, and Isolation of Major Bacterial Pathogens in Gomole District of Borena Zone, Southern Ethiopia.* https://doi.org/10.1155/2021/9993571

Girmay, W., Gugsa, G., Taddele, H., Tsegaye, Y., Awol, N., Ahmed, M., & Feleke, A. (2020). Isolation and Identification of Methicillin-Resistant *Staphylococcus aureus* (MRSA) from Milk in Shire Dairy Farms, Tigray, Ethiopia. *Veterinary medicine international*, *2020*, 8833973. https://doi.org/10.1155/2020/8833973

Hussein Abdurahman, M., Zuhairi Abdullah, A., Da Oh, W., Fazliani Shopware, N., Faisal Gasim, M., Okoye, P., Ul-Hamid, A., & Rahman Mohamed, A. (2023). Tunable band structure of synthesized carbon dots modified graphitic carbon nitride/bismuth oxychlorobromide heterojunction for photocatalytic degradation of tetracycline in water. *Journal of colloid and interface science*, *629*(Pt A), 189–205. https://doi.org/10.1016/j.jcis.2022.08.172

ICMSF. (1985). *Microorganism in foods; samples for Microbiological Analysis: Principles and specific applications. Recommendation of the International Commission on Microbiological Specification for Foods. Association of Microbiological Societies.* Toronto, University of Toronto Press.

Jahan, M., Rahman M, Parvej MS, Chowdhury SMZH, Haque ME, Talukder MAK, Ahmed S. (2015). Isolation and characterization of Staphylococcus aureus from raw cow milk in Bangladesh. *Journal of Advanced Veterinary and Animal Research, 2,* 49-5. https://doi.org/10.5455/JAVAR.2015.B47

Jilo, K., Galgalo, W., & Mata, W. (2017). Camel mastitis: a review. *MOJ Ecology & Environmental Sciences*, *2*(5). https://doi.org/10.15406/mojes.2017.02.00034

Magrino, J., Munford, V., Martins, D. J., Homma, T. K., Page, B., Gaubitz, C., Freire, B. L., Lerario, A. M., Vilar, J. B., Amorin, A., Leão, E. K. E., Kok, F., Menck, C. F., Jorge, A. A., & Kelch, B. A. (2023). A thermosensitive PCNA allele underlies an ataxia-telangiectasia-like disorder. *The Journal of biological chemistry*, *299*(5), 104656. https://doi.org/10.1016/j.jbc.2023.104656

Merchant, I A. & Packer, R. A. (1967). *Veterinary Bacteriology and Virology.* Seventh edi. The Iowa University Press, Ames, Iowa, USA.

Mogeh, A. O., Teklu, A., & Ogleh, M. D. (2019). The prevalence of mastitis and its associated risk factors in lactating dromedary camels in and around Hargesa, Somaliland. *International Journal of Scienctific and Engineering Research*, *10*(4), 201-211.

Mohamud, A. I., Mohamed, Y. A., Jama, O. S. A., Mishra, P., & Mohamed, M. I. (2020).

Prevalence and major pathogens associated with clinical and subclinical mastitis in dairy camel (Camelus dromedarius) in Benadir Region of Somalia. *Veterinary Sciences: Research Review*, *6*(2), 132-137. http://dx.doi.org/10.17582/journal.vsrr/2020.6.2.132.137

Oselu, S., Ebere, R., & Arimi, J. M. (2022). Camels, Camel Milk, and Camel Milk Product Situation in Kenya in Relation to the World. *International journal of food science*, *2022*, 1237423. https://doi.org/10.1155/2022/1237423

Oviedo-Boyso, J., Valdez-Alarcón, J. J., Cajero-Juárez, M., Ochoa-Zarzosa, A., López-Meza, J. E., Bravo-Patiño, A., & Baizabal-Aguirre, V. M. (2007). Innate immune response of bovine mammary gland to pathogenic bacteria responsible for mastitis. *The Journal of infection*, *54*(4), 399–409. https://doi.org/10.1016/j.jinf.2006.06.010

Pallathadka, H., Mustafa, M., Sanchez, D. T., Sajja, G. S., Gour, S., & Naved, M. (2023). Impact of machine learning on management, healthcare and agriculture. *Materials Today: Proceedings*, *80*, 2803-2806. https://doi.org/10.1016/j.matpr.2021.07.042

Quinn, Carter M.E., Markey B. Carter G.R. (1994). *Clinical veterinary microbiology*. London Wolfe publishing.

Silva, E.R., Pereira, A.M.G., Moraes, W.S., & Santoro, K.R. (2012). Perfil de sensibilidade antimicrobiana in vitro de Staphylococcus aureus isolado de mastite subclínica bovina. *Rev. Bras. Saúde Prod. Anim. 13,* 701–711. http://dx.doi.org/10.21727/rs.v7i1.82

Tigabu, E., Kassa, T., Asrat, D., Alemayehu, H. Sinmegn, T., Adkins, P.R.F., & Gebreyes, W. (2015). Phenotypic and genotypic characterization of Staphylococcus aureus isolates recovered from bovine milk in central highlands of Ethiopia. *Afr. J. Microbiol. Res. 9,* 2209–2217.

Toroitich, C. K. (2013). *Prevalence of mastitis and associated risk factors in lactating one-humped camels in West Pokot County, Kenya* (Doctoral dissertation, University of Nairobi).

Zhou, Z., Ali, A., Walelign, E., Demissie, G. F., El Masry, I., Abayneh, T., ... & Peiris, M. (2023). Genetic diversity and molecular epidemiology of Middle East Respiratory Syndrome Coronavirus in dromedaries in Ethiopia, 2017–2020. *Emerging microbes & infections*, *12*(1), e2164218. https://doi.org/10.1080/22221751.2022.2164218