International Journal of Microbiological Research 12 (2): 39-49, 2021
ISSN 2079-2093

DOI: 10.5829/idosi.ijmr.2021.39.49

Camel Mastitis: Prevalence, Risk Factors and Isolation of Major Bacterial Pathogens in Gomole District of Borena Zone, Southern Ethiopia

[1]Shubisa Abera Leliso, [2]Minda Asfaw Geresu and [3]Galma Wako

[1]National Animal Health Diagnostics and Investigation Center (NAHDIC), Sebeta, Ethiopia
[2]Department of Veterinary Science,
College of Agriculture and Environmental Science, Arsi University, Asella, Ethiopia
[3]Gomole District Pastoral Office, Borena Zone, Southern Ethiopia

Abstract: As of other dairy animals, dromedary camel could be affected by udder infection as mastitis, a complex disease occurring worldwide among dairy animals, with heavy economic losses largely due to clinical and subclinical mastitis. Hence, this cross-sectional study was carried out from November 2017 up to March 2018 to determine prevalence, associated risk factors and major bacterial pathogens causing mastitis in traditionally managed camels in Gomole district of Borena Zone, Southern Ethiopia. Consequently, 348 lactating camels were examined clinically and subclinical cases were screened with California mastitis test (CMT). The overall prevalence of mastitis was 22.4% (78/348), including clinical 4.3 % (15/348) and subclinical 18.1% (63/348), respectively. The quarter level prevalence of mastitis was 16.6% (232/1, 392) by excluding the blind teat. Of the total 1, 392 examined teats, the right hind (RHQ) (4.3%, 60/1392) and left hind quarters (LHQ) (4.3%, 60/1392) were the most frequently infected quarter whereas the left front quarter (LFQ) (3.9%, 55/1392) was the least infected quarter. Age, body condition score and lactation stages were significantly associated (p<0.05) with lactating camel mastitis prevalence among the putative risk factors. Amongst 312 quarters milk samples subjected to bacteriological examination, 74.4% (232/312) yielded mastitis causing pathogens, both Gram positive and negative bacterial isolates, while no growth was observed in 25.6% (80/312) quarters sampled. Of the bacterial isolates obtained by culturing, *Streptococcus* species (24.6%, 57/232) and Coagulase negative *Staphylococci* (21.6%, 50/232) were the dominant isolates identified whereas *Streptococcus agalactiae* (3%, 7/232) was the least isolates obtained. The prevalence of camel mastitis in the study area was found to be considerably high. Hence, implementation of integrated approaches has great importance in the study setting for the prevention and control of mastitis in order to improve quality of camel milk, minimize economic loss and prevents significant public health risks.

Key words: Camel · Mastitis · Prevalence · Risk Factors · Gomole District · Borena

INTRODUCTION

Of about 22 million camels in the world, Ethiopia has 4.5 million camels, 89 % are one-humped (*Camelus dromedarius*) camels [1-3]. The camel is a multipurpose animal that has outstanding performance in the arid and semi-arid environments where browse and water are limited and it makes an important contribution to human survival and utilization of these dry and arid lands [3, 4]. In Ethiopia, camels are mostly kept by pastoralists of Borana, Kereyu, Afar, Somali, Beja and Rashaida which cover more than 50% of the pastoralist area in country [2, 5]. With its unique bio-physiological characteristics, the dromedary has become an icon of adaptation to challenging ways of living in these arid and semi-arid regions [6].

Camel plays significant role as 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 semi-arid areas of the African and Asian countries where

Corresponding Author: Shubisa Abera, National Animal Health Diagnostics and Investigation Center (NAHDIC), Sebeta, Ethiopia.

the pastoralists prefer camel milk to other types of milk due to the fact that it is nutritious, thirst quenching, easily digestible and can be preserved much longer [2, 7]. Its 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 [4].

Additionally, the phosphorus contents are also higher in camel milk than that of other livestock. It is, therefore, evident that camel milk is superior to the milk of other domestic animals in many aspects [8]. Moreover, camel milk has been reported to possess medicinal value against various ailments such as dropsy, jaundice, spleen ailments, tuberculosis, asthma, anemia, piles and food allergies [9, 10].

Though its milk has an ample of significance, like other dairy animals, dromedary camel could be affected by udder infection as mastitis, a complex disease occurring worldwide among dairy animals, with heavy economic losses largely due to clinical and subclinical mastitis. The later requires indirect means of diagnosis [11]. Evidence indicates that subclinical mastitis causes suffering of the animal, reduces milk yield, alters milk properties, impairs preservation and processing and is a public health concern for consumers of camel milk [12, 13].

Recently, however, occurrence of mastitis among lactating camel has been reported from different camel rearing countries like Somalia [14], Sudan [15], Kenya [16], Israel [17] and different parts of Ethiopia [4, 5, 18-24]. However, there is paucity of information on the prevalence of camel mastitis and its risk factors in Gomole district of Borena zone, Southern Ethiopia. So as to design appropriate control and prevention program in she-camel dairy herd up to date information on the nature of mastitis and economic impact of the problem need to be identified. Therefore, this study was conducted to determine the prevalence of camel mastitis, isolation of major bacterial pathogens and associated risk factors in traditionally managed lactating camels in the study setting.

MATERIALS AND METHODS

Study Area: The study was conducted from November 2018 to April 2019 in Gomole district of Borana Zone, Oromia Regional state, Southern Ethiopia. Generally, Borena area represents a vast lowland area in Southern Ethiopia covering about 95, 000 km^2. The area is bordering with Kenya to the South, Somali region to the East, Guji zone to the North and Southern People, Nation and Nationalities Region to the West. Gomole district is located at the southern part of Ethiopia in Oromia regional state at about 535 km away from Addis Ababa in southern direction. Borena plateau gently slopes from high mountain massifs, 1650 maslin the North to 1000 maslin the South bordering Kenya, with slight variation due to central mountain ranges and scattered volcanic cones and craters [16].

The climate is generally semi-arid with annual average rainfalls ranging from 300 mm in the south to >700 mm in the north. The rain pattern is of a bimodal type with the main rainy season called *Ganna* extending from mid-March to May and the small rainy season (*Hagayya)* from mid-September to mid-November. The other two seasons are the cool dry season (*Adolessa*) extending from June to August and the major dry season (*Bonna*) extending from December to February whereas annual mean daily temperature varies from 19 to 24 with moderate seasonal variation [26].

Animal husbandry in the Zone is characterized by extensive pastoral productions system and seasonal mobility. Cattle are the dominant animal species followed by goats, camels and sheep.

According to Borana zone department of planning and economic development bureau, the total camel population of Borena zone was estimated to be about 450, 570, of which about 30, 113 camel population were found in the Gomole district [27]. Seasons affect herding strategies due to its effect on forage and water resource availability. As aridity increases, the principal stock shifts gradually from cattle combined with small stock to camels combined with small stock, with a relative degree of the social and cultural values accounting for differences. Camel herd movement may move the whole herd to water points and to relatively better areas where green fodder is available, or by herd splitting where lactating and young animals are kept around homesteads and moving the rest to distant located forage areas [28, 29].

Study Population: The study animals consisted of indigenous breeds of one humped camel (*Camels dromedaries*) reared under pastoral management system which allows free grazing, usually mixed with livestock from other villages, the animals move from feed shortage area to feed abundant areas especially during drought season.The population consists of lactating camels residing in Gomole district that were managed under pastoral production systems. The study animals selected from the population at Satellite livestock camps (‘*Fora’*) and Base livestock camps (‘*Warra*’).

Study Design: A cross sectional study supported by questionnaire survey was conducted to determine bacteriological prevalence of camel mastitis and its associated putative risk factors in Gomole district of Borena Zone.

A Questionnaire survey was conducted to assess the management aspects and its possible risk factors and milk handling method with each selected lactating camel owners/herders. Individual lactating camel from livestock satellite and base camps was selected and other relevant information was recorded. Questionnaires were prepared, pre-tested and adjusted by translating in to local language (Afan Oromo) and administered by the interviewer after carefully explaining the purpose of the work to the interviewees. The potential risk factors such as age, parity and lactation stage, presence of tick infestation, udder/teat lesions, teat handling techniques and history of treatment were given due attention while interviewing camel owners/herders.

Sample Size Determination and Sampling Strategy: The number of animals sampled was calculated according to considering a minimum expected prevalence of 50%, the desired absolute precision level of 5%and a confidence level of 95%. A previous study conducted by Wubishet *et al.* [24] revealed an overall prevalence of 37.4% camel mastitis in Borena zone. Hence, the sample size for the study animals in the study area was determined using the standard formula indicated below by considering 37.4% as expected prevalence.

$$n = \frac{1.96^2 P\exp\ (1 - P\exp)}{d^2}$$

where, n= the required sample size, 1.96^2 = the value of Z at confidence level, Pexp = expected prevalence (50%) and d = the desired absolute precision level at 95% confidence interval (0.05). Accordingly, 348 lactating camels in the study site were considered in this study.

Gomole district was purposely selected for the study by considering its largest camel population, camel milk marketing and accessibility of infrastructures. In the district, there were 14 '*Kebeles*' (the smallest administrative unit in Ethiopia). Of these4 '*Kebeles*', Dase-Gora, Buya, Bildim and Kella-Kufa, were selected purposely by their proximity to roads, accessibility of infrastructure and camel holdings of each '*Kebele*'. From each '*Kebele*', households who have 10 or more lactating camels and voluntary were identified.

From each household proportional number of lactating camels were selected by simple random sampling for collection of milk sample and physical examination. Prior to commencement of the study, list of HHs of those kebeles (sampling frame) was obtained from the district Agricultural and Rural development office. The sample size of HHs was determined using the formula recommended by Arsham [31] for survey studies.

$$N = 0.25/(SE)^2$$

where: N = sample size and SE= standard error of the proportion.

Assuming the standard error of 7.9% at a precision level of 5% and the confidence interval of 95%, 40 HHs owning lactating camel were selected by a simple random sampling technique for interview. The numbers of HHs selected per kebeles were fixed based on the proportion of HHs owning lactating camel in each kebele.

Clinical Examination of Udder and Milk Sampling: Animals were individually identified and clinical examination of udder was performed by visualization and palpation. During examination, palpation of udder and visual observation of udder lesion, clinical mastitis, udder symmetry and size as well as observation of milk consistency, color changes and presence of grossly visible substances were performed. Clinical mastitis was recognized by some disorders of udder, such as swelling, redness, hardened udder which was painful upon palpation, heat in case of acute mastitis and there could be alteration in the color and consistency of milk [4, 32].

Contrarily, subclinical mastitis was characterized by apparently normal milk and increased leukocyte counts. Moreover, blind teats were also considered as one abnormality and high tick infestation load as the blockage of the teat is the chronic stage of mastitis. Tick infestations and use of anti-suckling devices (materials put on teats to protect the continuous calf suckling) were also noted [50].

About 25 ml of fresh whole milk samples were collected directly from the udder of lactating camels early in the morning before the herds were released for grazing and late in the afternoon at time of milking by using sterile screw caped universal bottle if the pathological symptom revealed as the case, was clinical mastitis. Before milking, all quarters and udder were carefully examined by visual observation and palpation. The teat ends were disinfected with water and cotton moistened with 70% alcohol.

Pertaining to the subclinical mastitis, milk let-down was initiated by allowing the calf to suckle for a short time, prior to milking and then, quarter milk was screened

for inflammation using the California Mastitis Test (CMT) [19]. This test was conducted after discarding the first streaks of milk, the following approximately 10 mL of milk per quarter were milked into the CMT paddle and then, visual assessment of the milk was performed, with respect to consistency, color and clots. The milk was then mixed with an equal amount of 3%CMT fluid and blended using a circular motion. Scores represented four categories: 0, negative (-) or trace (±); 1, positive (+); 2, positive (++) and 3, positive (+++). Negative (-) and trace (±) reactions were considered as "negatives" and different intensities of positive reactions (+, ++, +++) were considered as "positives" [20]. Subsequently, the milk samples positive for subclinical mastitis were collected in sterile test tubes by discarding the first few streams of milk from each quarter for bacteriology.

Bacterial Isolation and Identification: California mastitis test (CMT) positive milk samples and milk samples collected from clinical quarters were cultured on sheep blood agar and MacConkey agar for bacteriological analysis at Yabello Regional Veterinary Laboratory. Inoculated plates were incubated aerobically at 37°C for 24 hours. Presumptive identification of bacterial isolates was carried out based on colony morphological features, Gram staining reactions, hemolytic reactions, catalase test and other biochemical tests [34].

Then, bacterial isolates were transferred to available selective media for further characterizations and species identifications. Gram-positive cocci were tested for catalase and catalase-positive isolates were further tested for coagulase production. Briefly, Staphylococci species were identified based on their growth characteristics on mannitol salt agar, coagulase, catalase and oxidase tests.

Staphylococcus aureus was differentiated from other Staphylococcus species by coagulase test and maltose fermentation test. Streptococci isolates were evaluated based on CAMP reaction, hydrolysis of esculin and sodium hippurate, catalase production and sugar fermentation tests. Specifically, *Streptococcus agalactiae* was differentiated from other mastitis-causing streptococci by using CAMP test, esculin hydrolysis on Edwards medium and growth on MacConkey agar. Gram negative isolates were further tested using triple sugar iron (TSI), IMViC, motility, urea and oxidase test [51].

Data Storage and Analysis: Biological data generated from questionnaire survey and laboratory investigations were recorded and coded using Microsoft Excel spreadsheet (Microsoft Corporation) and analyzed using SPSS version 24.0. An overall prevalence of mastitis was calculated as the number of CMT positive milk samples and milk samples collected from clinical quarters divided by the total number of samples tested. Association of prevalence with the potential risk factors (age, body condition, parity number, origin ('*Kebele*'s), lactation stage and teat problems) was computed by Chi-square (χ^2) test. A p-value <0.05 was considered statistically significant for χ^2.

RESULTS

Animal and Kebele Level Prevalence of Clinical and Subclinical Mastitis in Lactating Camels: Out of 348 traditionally managed lactating camels examined for mastitis, clinical as well as sub-clinical cases, an overall prevalence of 22.4% (Table 1) was recorded of which 4.3% and 18.1% camels were found to be affected with clinical and sub-clinical mastitis, respectively as depicted in Table 2. Among the '*Kebeles*' selected from Gomole district, Buya *Kebele* had relatively the highest prevalence of lactating camel mastitis (11.2%) whereas Kela kufa and Bildim '*Kebeles*' (3.4%) had the lowest prevalence of clinical and subclinical mastitis amid the 4 selected '*Kebeles*' (Table 3).

Quarter Level Prevalence of Mastitis in Traditionally Managed Lactating Camels: Of 1392 examined teats, 232 (16.6%) teats were found positive using CMT for subclinical mastitis and by physical examination for the clinical mastitis through excluding the blind teat from which the milk sample was not collected. The result further revealed that the right hind (RHQ) and left hind quarters (LHQ) were the most frequently infected quarter (4.3%) whereas the left front quarters (LFQ) was the least infected quarter (3.9%) as indicated in Table 4.

Putative Risk Factors Associated with the Occurrence of Mastitis in Lactating Camels: A chi-square analysis revealed that age, body condition score and lactation stages were significantly associated ($p< 0.05$) with lactating camel mastitis prevalence among the putative risk factors considered during the study as depicted in Table 5.

Household's Questionnaire Survey Result: Locally, udder health problem is known as '*dhukkuba muchaa*', which literally means 'disease of teats'. Though the name implies "disease of teat", the term is understood to

Table 1: Prevalence of mastitis at the animal and quarter level based on the CMT in Gomole district of Borena zone

Status	Number of examined animals	Number of positives	Prevalence (%)
Camel level	348	78	22.4
Quarter level	1392	232	16.6

Table 2: Prevalence of clinical and sub-clinical form of mastitis at animal level in the selected study setting

Form of mastitis	Number of positive	Prevalence (%)
Clinical	15	4.3
Sub-clinical	63	18.1
Total	78	22.4

Table 3: Prevalence of clinical and sub-clinical mastitis at *Kebele* level in the selected study district

Kebele's	Number of animals examined	Number of positive	Prevalence (%)
Dase-Gora	56	15	4.3
Buya	187	39	11.2
Kela-Kufa	57	12	3.4
Bildim	48	12	3.4
Total	348	78	22.4

Table 4: Quarter level prevalence of mastitis in traditionally managed lactating camels in the study site

Quarter	Number of blind teat	Number of positive	Prevalence (%)
Right front	15	57	4.1
Right hind	8	60	4.3
Left front	7	55	3.9
Left hind	11	60	4.3
Total	41	232	16.6

Table 5: Prevalence of mastitis in association with different putative risk factors in lactating camels in the study site

Risk Factors		Number of camels examined	Number of positives	p-value
Kebeles	Dase-Gora	56	15	.772
	Buya	187	39	
	Kela-Kufa	57	12	
	Bildim	48	12	
Age	Adult (5-10 years)	248	69	.000
	Old (≥ 11 years)	100	9	
Body condition	Good	138	33	.001
	Medium	168	45	
	Poor	42	0	
Lactation stage	Early	102	54	.000
	Mid	98	3	
	Late	148	21	

Table 6: Bacterial species isolated from quarter milk samples obtained from traditionally managed lactating camels in the selected study area

Bacterial species	Number of isolates	% of total isolates
Escherichia coli	23	9.9
Staphylococcus aureus	26	11.2
Streptococcus agalactiae	7	3.0
Bacillus spp.	8	3.4
Coagulase negative *Staphylococci*	50	21.6
Streptococcus spp.	57	24.6
Micrococcus spp.	16	6.9
Corynebacterial spp.	20	8.6
Actinomyces pyogenes	11	4.7
Total	232	100.0

be general udder health problems. Pastoralists associated the problems of udder health with different factors and grouped based on the perceived causes and clinical signs into different categories. The main categories identified were: '*diraandisa*' (tick infestation), '*nyaqarsa*' (chronic swelling in the form of a boil) and '*Buda*' (which means evil eye and is characterized by bloody milk).

Of the 40 house holds owning camels interviewed, 85 %(34/40) of them responded that as clinical mastitis is the major problem and a disease they were aware of while all of them were not aware of sub-clinical mastitis. All the households interviewed in the study setting responded that as milk ejection was initiated by letting the calves to suckle their dams before milking, washing the udder/teats of camels is not practiced prior to milking and milking utensils were washed and smoked before milking camels. As animal health delivery to their camels is so poor, all respondents responded as they treat mastitis cases by a combination of phytotherapeutics and modern drugs. Particularly, experienced (elder) camel owners indicated that they know traditional ways of treating camel mastitis using traditional remedies and drugs. Of the respondents, majority (95%) of them were using local herbal medicine known as "*Aloe vera*" to treat the disease by topical application on swollen udder. Pertaining to season of the occurrence of the disease, majority of the respondents (85%) stated as the disease was mostly occurring during wet major rainy season ('*Ganna*') and early lactation stage while only 12.5 % of the respondents were responding as it occurs during short rainy season ('*Hagayya*'). Whereas none of the respondents indicated as if the disease was occurring during cold dry season ('*Adolessa*') and the major dry season ('*Bona*').

Bacterial Isolation and Identification: Among the 312 quarters milk samples subjected to bacteriological examination, 232 (74.4%) yielded mastitis pathogens, both Gram positive and negative bacteria isolates, while no growth was observed in 80 (25.6%) quarters samples. Of the bacterial isolates obtained by bacteriological culturing, Streptococcus species (24.6%) and Coagulase negative Staphylococci (21.6%) were the dominant isolates identified whereas the least one was *Streptococcus agalactiae* (3%) as illustrated in Table 6.

DISCUSSION

Mastitis is an important constraint to milk production in pastoralist camel (*Camelus dromedarius*) herds in arid and semi-arid parts of Ethiopia and a number of reports revealed that as mastitis in traditionally managed camels is increasing and likely continues to rise as the milk production per individual camel gradually increases. Accordingly, the overall prevalence of mastitis in camel herds (animal level) in the current study was 22.4% as determined by the CMT and clinical examinations of the udder and the milk samples and the quarter level prevalence was 16.6%using CMT screening test result. This finding, 22.4%, is lower than the prevalence report of 59.8% in Afar Region of Ethiopia [19], 76% in selected pastoral areas of eastern Ethiopia [22], 18.5% in Abu Dhabi, United Arab Emirates [35], 30.2% in Jijiga town of eastern Ethiopia [5], 44.8% in Yabello district of Borena Zone [23], 34.7% in Borena zone of Oromia Regional State [24] and 31% in Gursum district of Hararghe Zone [36]. Besides this, the prevalence of mastitis at quarter level (16.6%) observed in this study is also lower than the reports of [5, 18, 37] whom reported 25.8%, 20.5% and 25.6% at the quarter level using CMT, respectively. Nevertheless, Abera *et al.* [4] reported a relatively lower (15.8%) of subclinical mastitis from Eastern Ethiopia compared to the present study.

On top of this, the current study result also revealed that the hind quarters, right hind (RH, 4.3%) and Left hind (LH, 4.3%), were infected more compared to the front quarters, the right (RF, 41%) and left front (LF, 3.9%), which contradicts the finding of Mogeh *et al.* [38] who recorded that the right quarters, right (RF, 15.6% and RH, 7.8%), were highly infected compared to the left quarters (LF, 5.2% and LH, 4.6%). A lower prevalence in the current study could be due to variation in the sensitivity of diagnostic CMT screening techniques used, season of study and encroachment of bush clearing performed in study area which facilitates the grass to grow that hosts more ticks whereas a higher risk of infections in hind quarters compared to the front ones could be due to the unfavorable hygienic condition; greater exposure to dung and urine. In addition, due to the shorter length of the hind teats with a corresponding shorter teat canal, the defense potential in the hind quarter could be decreased [35].

Thus, the finding of clinical mastitis (4.3%) in the current study is higher than the prevalence report of 2.1% from Borena lowland pastoral area, Southwestern Ethiopia [20]. Conversely, the current finding is relatively lower than the report of 4.9%in Jijiga town of eastern Ethiopia [5], 5.4% in Borena zone of Oromia Regional State [23], 5.7% in pastoral area of Borena lowland [37], 6.3% in Gursum district of eastern Hararghe zone [36], 8.3% in Jijiga, Eastern Ethiopia [4], 12.5% in Afar region [19],

12.5% in Borena Zone [24] and 19.5% in Eastern Sudan [39]. Pertaining to the sub-clinical mastitis, a prevalence rate of 18.1% at animal level, the present work result is relatively higher than the report of Osman [40] who reported a prevalence rate of 15.8% from Jijiga zone of Somali Regional State of Ethiopia compared to the present study. Nevertheless, the current study result is lower than reports of Abera *et al.* [4], Husein *et al.* [5], Almaw and Molla [18], Bekele and Molla [19], Regassa *et al.* [23], Wubishet *et al.* [24] and Mehamud *et al.* [36] whom reported 20.7%, 25.3%, 24.1%, 47.3%, 25.4%, 22.2% and 24.7% at camel levels using CMT from Jijiga Zone of Somali Regional State, around Jijiga in eastern part of Ethiopia, eastern Ethiopia, Afar region, Borena zone and Gursum district of eastern Hararghe zone, respectively. This difference might be due to the season of the study period, tick infestation load related to season of study, risk factors like age, lactation stage and parity numbers.

The current study revealed that the selected '*Kebeles*' from Gomole district of Borena Zone was negatively associated with lactating camel mastitis ($p>0.05$). Of the 4 selected '*Kebeles*', the highest prevalence of lactating camel mastitis was observed in Buya '*Kebele*' (11.2%) whereas Kela kufa and Bildim '*Kebeles*' (3.4%) had the lowest prevalence of lactating camel mastitis among the selected study sites. This variation might be due to differences in management system (feed, health care etc.) and hygiene during milking, risk factors and awareness level of owners for mastitis disease.

Age was considerably associated with the prevalence of mastitis as detected by CMT and microbiological culturing, which corroborates with the finding of Zeryehun *et al.* [37] and Aqib *et al.* [41] who reported that adult age (5-10) was found significantly ($p<0.05$) associated with the occurrence of lactating camel mastitis in pastoral area of Borena lowland of South-western Ethiopia and in Cholistan desert of Pakistan, respectively. This finding is inconsistent with the studies conducted in Jijiga town of eastern Ethiopia [4, 5] and Thal area of Jhang, Pakistan [9] which revealed that old age was positively associated ($p<0.05$) with the prevalence of lactating camel mastitis. This contrast might be because of higher milk production in the current study during middle (adult) age which is a predisposing risk factor for mastitis [32].

The non-parametric statistical analysis revealed that medium body condition score of the animals was positively associated ($p<0.05$) with the occurrence of lactating camel mastitis in the current study in which there was no mastitis case in poor (thin) body condition score. This finding is inconsistent with the report of Zeryehun *et al.* [37], Aqib *et al.* [41] and Ali *et al.* [42] whom reported a significant association of thin body condition score with the occurrence of mastitis in dromedary camel in Cholistan desert of Pakistan, pastoral area of Borena lowland of Southern Ethiopia and Cholistan desert and Suleiman mountain range of Pakistan, respectively. Hence, this area needs an indebt study to unveil the factors responsible for this difference.

Likewise, stage of lactation significantly affected ($p<0.05$) and was found to be associated with the prevalence of mastitis being the highest (52.9%; 54/102) during the early stage of lactation. This finding corroborates with the findings of Husein *et al.* [5], Ahmad *et al.* [9], Regassa *et al.* [23] and Mogeh *et al.* [38] whom revealed a positive association of early lactation stage with the incidence of camel mastitis in desert environment of Jhang (Pakistan), Jijiga town, Eastern part of Ethiopia, Borena zone and Hargeisa district, western part of Somaliland, respectively. This was sometimes due to the fact that most new infection occurs during the early part of dry period and in the first two month of lactation, especially with environmental pathogens [43].

About 85% (34/40) of interviewed respondents (pastoralists) stated as camel clinical mastitis is the major problem and the disease, they are aware of. This finding relatively corroborates with the finding of Husein *et al.* [5] who stated that about 70% of the respondents were aware of clinical mastitis and as they know it by different names in Jijiga, eastern Ethiopia whereas all of them were not aware of sub-clinical mastitis which agrees with the reports of Abera *et al.* [4] and Husein *et al.* [5] from Jijiga town, eastern Ethiopia. On top of this, all the households interviewed in the study setting responded that as milk ejection was initiated by letting the calves to suckle their dams before milking which agrees with the work of Seligsohn *et al.* [44] who stated that calves were released one by one and allowed to suckle their mothers to initiate milk let-down. Moreover, as all the interviewed respondents responded that milk ejection was initiated by letting the calves to suckle their dams before milking and milking utensils were washed and smoked before milking camels which is consistent with the reports of [5, 22] in selected pastoral areas of eastern Ethiopia.

Almost all (95%) of the respondents interviewed stated that as they were using local herbal medicine plant known as "*Aloe vera*", applied topically on the swollen udder and modern drugs to treat the diseases of udder in the present study. Our finding corroborates with the report of Abera *et al.* [4] who reported as clinical mastitis

was treated by a combination of phytotherapeutics and modern drugs in Jijiga town. In contrast to this, Seifu and Tafesse [22] reported as camel owners were using various extracts from the roots, leaves, seeds and exudates of different plant and branding with hot iron in selected pastoral areas of eastern Ethiopia. Pertaining to season of the occurrence of the disease, the majority of respondents (85%) stated as the disease was mostly occurring during wet major rainy season ('*Ganna*') and early lactation stage while only 12.5 % of the respondents were responding as it occurs during short rainy season ('*Hagayya*') whereas none of the respondents indicated as if the disease was occurring during cold dry season ('*Adolessa*') and the major dry season ('*Bona*').

The commonly isolated genera of bacteria Staphylococcus, Streptococcus, Corynebacterium, Bacillus and Escherichia in this study agree with Abera *et al.* [4], Younan *et al.* [16], Bekele and Molla [19], Abdurahman [45] , Kalla *et al.* [46], Matofari *et al.* [47] and Sena *et al.* [48] whom isolated Staphylococcus, Streptococcus and Escherichia as major mastitogens. Gram-positive cocci were the main cause of mastitis in the camels and constituted 90.1% of the total isolates. This finding is in line with the report of Woubit *et al.* [20] and Seifu and Tafesse [22] from Borena lowland pastoral areas and selected pastoral areas of eastern Ethiopia, respectively. Among the bacterial isolates, Streptococci species were identified as the predominant mastitis causing organisms in the camels studied. This agrees with the report of Saleh and Faye [49] that revealed as Streptococci spp. were the dominant bacterial isolates in Bactrian camel of Al-Jouf, Saudi Arabia whereas coagulase negative staphylococci (21.6%) were the second most common cause of mastitis in the camel herds examined in this study. This finding corroborates with the report of Husein *et al.* [5] and Seifu and Tafesse [22] from selected pastoral areas of eastern Ethiopia and Jijiga Town, respectively.

CONCLUSION

The current study result revealed that the prevalence of camel mastitis in the study area was found to be considerably high. Buya '*Kebele*' had relatively the highest prevalence of lactating camel mastitis amid the 4 '*Kebeles*' selected in the study setting. The study also indicated a relatively higher teat quarter subclinical and clinical mastitis, of which the right and left hind quarters were the most frequently infected. Age, body condition score and lactation stages were significantly associated with lactating camel mastitis prevalence among the putative risk factors considered in the study. *Streptococcus* species (24.6%) and Coagulase negative *Staphylococci* (21.6%) were among the dominant major bacterial isolates identified, whereas *Streptococcus agalactiae* was the least isolates obtained in this study. The bacteria isolated from camel milk samples in the present study are types that cause both contagious and environmental mastitis. Proper and worthy milking techniques are essential in the prevention of both environmental and contagious mastitis. Therefore, in order to reduce a relatively high prevalence of mastitis in the area, following fortnight mastitis control program, improved milking hygiene, cleaning of individual teat with clothes dipped in hot water, prevention of skin lesions, culling of chronic mastitis carriers and treating of clinically infected she-camels should be practiced.

Data Availability: The data that support the findings of this study are available from the corresponding author upon reasonable request

Competing Interests: The authors declare that they have no competing interests.

Authors' Contribution: Shubisa Abera Leliso and Minda Asfaw Geresu designed the study. Shubisa Abera Leliso supervised the laboratory examinations. Galma Wako performed bacteriological culturing and CMT screening test. Manuscript preparation and the statistical analysis were conducted by Shubisa Abera Leliso and Minda Asfaw Geresu. All authors read and approved the final manuscript.

ACKNOWLEDGMENTS

This study was supported by Gomole district pastoral office and Gayo pastoral Development Initiative (GPDI) for the cooperation and financial management. The authors would like to thank staff members of Yabello Regional Veterinary Laboratory (YRVL) staff members for their provision of laboratory equipment's, reagents and genuine encouragement while conducting bacteriological culturing. We would also like to extend our appreciation to Gomole district camel owner's communities for their devotion of time in letting us to access information, sharing their experience and practices and for their hostility during sample collection.

REFERENCES

1. Shapiro, B.I., G. Gebru, S. Desta, A. Negassa, K. Nigussie, G. Aboset and H. Mechal, 2015. Ethiopia Livestock Master Plan: Roadmaps for Growth and Transformation Plan II (2015-2020). International Livestock Research Institute (ILRI) Project Report. Nairobi, Kenya.
2. Abera, T., Y. Legesse, B. Mummed and B. Urga, 2016. Bacteriological quality of raw camel milk along the market value chain in Fafen zone, Ethiopian Somali regional state. BMC Research Notes, 9: 285.
3. Mohammed, Y.K., A. Seid and M. Urge, 2017. Camel (*Camelus dromedaries*) meat production potentials and associated constraints in Eastern Ethiopia. East African Journal of Veterinary and Animal Science, 2: 77-86.
4. Abera, M., O. Abdi, F. Abunna and B. Megersa., 2010. Udder health problems and major bacterial causes of camel mastitis in Jigjiga, Eastern Ethiopia: Implication for impacting food security. Tropical Animal Health and Production, 42: 341-347.
5. Husein, A., B. Haftu, A. Hunde and A. Tesfaye, 2013. Prevalence of camel (*Camelus dromedaries*) mastitis in Jigjiga Town, Ethiopia. African Journal of Agricultural Research, 24: 3113-3120.
6. El-Agamy, E.I., 2006. Camel milk. In. Park Y, Haenlein G.F.W, editors. Handbook of milk of non-bovine mammals. Hoboken: Blackwell Publishing, pp: 297-344.
7. Mohammed, A.H., 1993. Conceptual classification of camels in: The multipurpose camel: Interdisciplinary study on pastoral production in Somalia. E.P.O.S, M.O, prints, Upsala, Sweden, pp: 155-158.
8. Kouniba, A., M. Berrada, M. Zahar and M. Bengoumi, 2005. Composition and heat stability of Moroccan camel milk. Journal of Camel Practices and Research, 12: 105-110.
9. Ahmad, S., M. Yaqoob, Muhammad, Qamar, M.Q. Bilal, G. Muhammad, L.G. Yang M.K. Khan and M. Tariq, 2011. Risk factors associated with prevalence and major bacterial causes of mastitis in dromedary camels (*Camelus dromedarius*) under different production systems. Tropical Animal Health and Production, 1: 107-112.
10. Shabo, Y., R. Barzel, M. Margoulis and R. Yagil., 2005. Camel milk for food allergies in children, Immunology and Allergy, 7: 796 -798.
11. Matofari, J.W., Y. Mario, E.W. Mwatha and P.O. Okemo, 2003. Microorganisms associated with subclinical mastitis in Kenyan camels (*Camelus dromedarius*). Journal of Tropical Microbiology and Biotechnology, 1: 11-16.
12. Tibary, A. and A. Anouassi, 2000. Reproductive disorders in the female camelids. In: Skidmore, L., Adams, G.P. (Eds.), Recent Advances in Camelid Reproduction. International Veterinary Information Service, Ithaca, NY (www.ivis.org), pp: 1-11, last updated: 12-December, 2020.
13. Gramay, S. and M. Ftiwi, 2018. Camel milk production, prevalence and associated risk factors of camel mastitis in Asaita Woreda, Afar Regional State, North East Ethiopia. A.R.C. Journal of Animal and Veterinary Sciences, 3: 17-37.
14. Abdurahman, O., H. Agab, B. Abbas and G. Aston, 1998. Relation between udder infection and somatic cells in camel (*Camelus dromedarius*) milk. Acta Veterinaria. Scandinavica, 36: 424-431.
15. Obied, A.I.M., H.O. Begadi and M.M. Mukhtar, 1996. Mastitis in camel (*Camelus dromedaries*) and the somatic cell count of camel milk. Research in Veterinary Science, 16: 55-58.
16. Younan, M., Z. Ali, S. Bornestein and W. Muller, 2001. Application of the California mastitis test in intramammary Streptococcus agalactiae and Staphylococcus aureus infections of camels (*Camelus dromedarius*) in Kenya. Preventive Veterinary Medicine, 51: 307-316.
17. Guliye, A.Y., C. Vancrevald and R. Yagil, 2002. Detection of sub-clinical mastitis in dromedary camels using somatic cell count and the N-acetyl beta-D-Glucosominidase test. Tropical Animal Health and Production, 34: 95-104.
18. Almaw, G. and B. Molla., 2000. Prevalence and etiology of mastitis in camels (*Camelus dromedaries*) in eastern Ethiopia. Journal of Camel Practices and Research, 7: 97-100.
19. Quinn, P.J., M.E. Carter B. Markey and G.R. Carter, 1999. Clinical veterinary microbiology. 1st ed. Mosby Publishing, London, pp: 327-344.
20. Woubit, S., M. Bayleyegn, P. Bonnct and S. Jeanbaptiste, 2001. Camels (*Camelus dromedarius*) mastitis in Borana lowland pastoral, south western Ethiopia. Revued Elevage et De Veterinary Des Pays Tropicaux, 54: 207-212.

21. Abdul-Gadir, A.E., G. Hildebrand, J.N. Kleer, B. Molla, M.N. Kyule and M.P. Baumann, 2006. Comparison of California mastitis test, somatic cell and bacteriological examinations for detection of camel (*Camelus dromedaries*), mastitis in Ethiopia. Berlin Munch Tierarzil Woshenschr, 119: 5-49.
22. Sear, P.M., R.N. Gonzalez, D.J. Wilson and H.R. Han, 1993. Procedure for mastitis diagnosis and control. Vet. Clin. North Am. Food Anim. Prod., 9: 445-467.
23. Regassa, A., G. Golicha, D. Tesfaye, F. Abunna and B. Megersa, 2013. Prevalence, risk factors and major bacterial causes of camel mastitis in Borana Zone, Oromia Regional State, Ethiopia. Tropical Animal Health and Production, 45: 1589-1595.
24. Wubishet, Z., A. Dabaso and G. Getachew, 2016. Prevalence, associated risk factors and bacterial pathogens of camel mastitis in Borena Zone Oromia Regional State, Ethiopia. International Journal of Veterinary Science, 4: 280-284.
25. YWAPHB, 2014. (Yabello Woreda Animal Production and Health Bureau). Agro-climatic condition of Yabello Woreda.
26. Megersa, B., 2010. An epidemiological study of major camel diseases in the Borana lowland, Southern Ethiopia. The Drylands Coordination Group (DCG), 58: 4-5.
27. Jara, R., M. Alemayehu, Z. Wubishet, T. Mesfin and M. Araya, 2020. Sero-prevalence and associated risk factors of camel brucellosis in Southern lowland of Ethiopia. Journal of Veterinary Medicine and Research, 1: 1180.
28. Demeke, G., 1998. Prevalence of camel trypanosomes and factors associated with the disease occurrence in Liben district, Borana zone of Oromia region, Ethiopia. MSc Thesis. Free University of Berlin, Addis Ababa University, F.V.M. Debre Zeit.
29. Wario, S., Z. Wubishet and M. Alemayehu, 2020. Prevalence and associated risk factors of major prevalent gastrointestinal nematodes in camels of Borena Zone, Southern Ethiopia. Journal of Veterinary Medicine and Research, 1: 1179.
30. Thrusfield, M., 2008. Sampling in Veterinary Epidemiology. 3rd Edition., Black well Science Ltd, London, 46-65, 228-242.
31. Arsham, H., 2007. Questionnaire design and survey sampling. http//www.mirror.service. Org/site/ hom. Ubaltedu/ ntsbarsh/Business-stat. Acessed December, 2020.
32. Radostits, O., C. Gay, K. Hinchcliff and P. Constable, 2007. Veterinary Medicine: A Text Book of Disease of Cattle, Horses, Sheep, Pigs and Goats, 10th ed. Baillière Tindall, London, 631-635; 603-700.
33. Schalm, O.W. and D.O. Noorlander, 1957. Experiments and observations leading to development of the California Mastitis Test. Journal of American Veterinary Medicine Association, 130: 199-204.
34. National Mastitis Council (NMC), 1990. Microbiological procedures for the diagnosis of bovine udder infection, 3rd Ed, Arlington VA, National Mastitis Council. Inc.
35. Al-Juboori, A., N. Kamat and J. Sindhu, 2013. Prevalence of some mastitis causes in dromedary camels in Abu Dhabi, United Arab Emirates. Iraqi Journal of Veterinary Science, 27: 9-14.
36. Mehamud, J., M. Megersa, Y. Abebe and M. Ahmed, 2017. Prevalence, risk factors and major bacterial causes of camel mastitis in Gursum district, Eastern Hararghe, Ethiopia. Global Veterinaria, 3: 203-208.
37. Zeryehun, T., G. Haro and B. Adane, 2017. A cross sectional study on the prevalence of mastitis and associated bacterial pathogens in one-humped camels (*Camelus dromedarius*) in pastoral area of Borena lowland, Southern Ethiopia. Global Veterinaria, 2: 108-115.
38. Mogeh, A.O., A. Teklu and M.D. Ogleh, 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, 4: 201-211.
39. Wanjohi, M., C.G. Gitao and L. Bebora, 2013. Subclinical mastitis affecting hygienic quality of marketed camel milk from North Eastern Province, Kenya. Microbiology Research International, 1: 6-15.
40. Osman, A., 2008. Prevalence of camel mastitis and major bacterial causes in Jigjiga Zone, Somalia region, DVM thesis, Hawassa University, Faculty of Veterinary Medicine.
41. Aqib, A.I., M. Ijaz, A.Z. Durrani, A.A. Anjum, R. Hussain, S. Sana, S.H. Farooqi, K. Hussain and S.S. Ahmad, 2017. Prevalence and antibiogram of *Staphylococcus aureus*, a camel mastitogen from Pakistan. Pakistan Journal of Zoology, 49(3): 861-867.

42. Ali, M., M. Avais, M. Ijaz, M. Chaudhary, R. Hussain, A.I. Aqib, N.U. Khan, M.L. Sohail, M. Khan, M.A. Khan, M. Ahmad, M.S. Hasni, I. Qaiser, G. Rashid, I. Haq and I. Khan, 2019. Epidemiology of subclinical mastitis in Dromedary camels (*Camelus dromedarius*) of two distinct agro-ecological zones of Pakistan. Pakistan Journal of Zoology, 2: 527-532.
43. Radostits, O.M., C.C. Gay, D.C. Blood and K.W. Hinchliff, 2000. Veterinary Medicine: A Textbook of the Diseases of Cattle, Sheep, Pigs, Goats and Horses, 9th edition Philadelphia: WB Saunders, pp: 563-613.
44. Seligsohn, D., A.K. Nyman, M. Younan, W. Sake, Y. Persson, S. Bornstein, M. Maichomo, K. De Verdier, J.M. Morrell and E. Chenais, 2020. Subclinical mastitis in pastoralist dairy camel herds in Isiolo, Kenya: Prevalence, risk factors and antimicrobial susceptibility. Journal of Dairy Science, 103: 4717-4731.
45. Abdurahman, O.A., 2006. Udder health and milk quality among camels in the Errer valley of eastern Ethiopia. Livestock Research Rural Development, 18: 1-9.
46. Kalla, D.J.U., I.S.R. Butswat, S.T. Mbap, A.M. Abdussamad, M.S. Ahmed and I. Okonkwo, 2008. Microbiological examination of camel (*Camelus dromedarius*) milk and sensitivity of milk microflora to commonly available antibiotics in Kano, Nigeria. Savannah Journal of Agriculture, 3: 1-8.
47. Matofari, J.W., M. Younan, J.N. Nanua and M.E.W. Watha, 2005. Microorganisms associated with sub-clinical mastitis and their impact on milk production in camels (*Camelus dromedarius*) in semi-arid lands of Northern Kenya. International Journal Agriculture and Rural Development, 17: 182-187.
48. Sena, D.S., G. Mal, R. Kumar and M.S. Sahani, 2001. A preliminary study of prevalence of mastitis in camel. Journal of Applied Animal Research, 20: 27-31.
49. Saleh, S.K. and B. Faye, 2011. Detection of subclinical mastitis in dromedary camels (*Camelus dromedaries*) using somatic cell counts, california mastitis test and udder pathogen. Emiratus Journal of Food and Agriculture, 1: 48-58.
50. Higgins, A.J., W.R. Allen, I.G. Mayhew, D.H. Snow and J.F. Wade, 1992. An introduction to the camel in health and disease. In the Proceedings of the International Camel Conference. R/W Publications Ltd: New Market, (London), pp: 17-19. Make references like this style.
51. Younan, M., Z. Ali, S. Bornestein and W. Muller, 2001. Application of California Mastitis test in intramammary Streptococcus agalactiae and Staphylococcus aureas infection of camels (*Camelus dromedarius*) in Kenya. Prev. Vet. Med., 51: 307-316.