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Prevalence of Mastitis and Associated Risk Factors in Lactating Camels (*Camelus Dromedarius*) on Dairy Farms in Benadir Region, Somalia

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Abstract

The study took a comprehensive approach to understanding mastitis in lactating camels, a disease that significantly impacts milk quantity and quality. This complex and multifactorial disease poses a significant challenge to dairy camel farming, particularly in Somalia. The study's objective was to determine the prevalence of mastitis and the risk factors associated with it among lactating camels on dairy farms in Benadir, Somalia. To achieve this, a cross-sectional study was conducted from May to September 2022 in the Benadir region of Somalia. A total of 96 lactating camels underwent examination using the California Mastitis Test (CMT) to identify clinical and subclinical mastitis cases. Additionally, a questionnaire survey was conducted among 20 farm employees/owners to gather information on hygiene practices, parity, lactation stage, tick infestation, and the presence of udder/teat lesions. Data regarding parity and lactation stage were obtained through owner interviews. The data collected on specifically designed forms were recorded and entered into a Microsoft Excel spreadsheet for analysis using SPSS version 20 statistical software, ensuring a comprehensive and reliable analysis of the data. The study's findings revealed a significant prevalence of camel mastitis, with 34.4% (33/96) of lactating camels affected and clinical and subclinical cases constituting 5.2% and 29.2%, respectively. Quarter-level prevalence was 46.3%, with clinical and subclinical mastitis at 4.7% and 41.6%, respectively.

The study also identified significant associations ($P < 0.05$) among risk factors such as stage of lactation, parity, and age, indicating a higher susceptibility to mastitis in older camels during early lactation compared to those in late lactation and younger camels. These findings underscore the crucial role of inadequate hygienic conditions on camel farms and udder tick infestations in driving the elevated prevalence of mastitis, highlighting the need for improved management practices in dairy farming in Benadir, Somalia. Effective interventions, including improved management practices and extension services, are essential to reduce the burden of mastitis in dairy camels.

Keywords

Mastitis, Camel, Prevalence, Risk Factors, Somalia

1. Introduction

Somalia boasts the world's largest camel population, with these one-humped camels (*Camelus dromedarius*) being vital for both milk and income in arid and semi-arid regions of the Middle East and Africa [1]. Nomads consume camel milk in various forms, and in the realm of farm animals, mastitis, an inflammation of mammary gland tissue, significantly impacts animal health and productivity [2]. Camel mastitis remains insufficiently researched globally, especially concerning the prevalence of subclinical mastitis [3]. Despite the sizable camel population in Somalia, milk production is hindered by diseases like mastitis [4]. This disease stands as a major economic blow for dairy camel farmers in developing countries, leading to substantial losses [5]. Mastitis is a global challenge affecting animal health, milk quality, and the economics of milk production, affecting both developing and developed nations.

Transmission of udder infection leading to mastitis in camels is primarily through the teat channel, either from the environment or from infected udders of other animals, transmitted to the mammary gland during milking [6]. The severity and spread of this disease, which is widespread and a significant issue globally, are influenced by various risk factors, including breed, milk production level, hygiene, milking practices, age, parity, and stage of lactation [7]. Diagnosis involves clinical observation, including inspection and palpation, for clinical mastitis and the California Mastitis Test (CMT) for subclinical mastitis [8].

In a study conducted in the Deyniile District, Benadir Region of Somalia, the overall prevalence of mastitis was 16.66%, with clinical and subclinical mastitis at 22.78% and 9.85% on an animal basis, and 9.37% and 6.15% quarterly, respectively [9]. Mastitis poses a frequent and significant challenge to livestock herds across the globe, with risk factors including parity of the she-camel, presence of ticks, age, and lactation stage [10]. Despite this, there remains a need for a comprehensive understanding of the status of camel mastitis and associated risk factors, especially in the context of intensive and semi-intensive farms in Somalia.

Thus, this study was conceived to determine the prevalence of mastitis and its related risk factors among lactating camels on dairy farms in Benadir, Somalia.

2. Materials and Methods

2.1. Ethical Approval and Informed Consent

The ethical review committee approved our study protocol and procedures (Reference number BUERC178). All participants provided informed consent.

2.2. Study Area

The Benadir region in Somalia, comprising 17 districts, shares borders with the middle Shebelle in the north and east, the lower Shebelle in the west, and the Indian Ocean in the south. This study focused on five districts within Benadir: Dharkenley, Hodan, Dayniile, Hiliwaa, and Karan. Geographically, the region lies between latitude 2˚2'59"N and longitude 45˚15'44"E. Despite being the smallest administrative region in Somalia, Benadir has the largest population, estimated at approximately 2.3 million, and covers an area of around 96,878 km². Specific data regarding the camel population in Benadir were unavailable; hence, these five districts were selected based on their significant animal population. Samples were collected randomly from both semi-intensive and intensive camel dairy farms.

2.3. Study Design

A cross-sectional study design was employed, involving 96 lactating camels from managed intensive and semi-intensive farms in the selected districts. The study was conducted from May to September 2022, covering the Dharkenley, Hodan, Dayniile, Hiliwaa, and Karan districts within the Benadir region.

2.4. Selection of Study Area and Sampling Technique

The districts in Benadir were chosen based on the presence of dairy camel farms. The employees and owners of the dairy farms were then selected randomly. As no records were available, the age of camels was estimated by observing the eruption and wearing of permanent front teeth.

2.5. Sample Size

The sample size for lactating camels was determined using Thrusfield's formula (2005) for simple random sampling:

$$N = \frac{1.962\ p\ exp\ (1 - pexp)}{d2}$$

$$n = \frac{(1.96)\ 2 * 0.5 * 0.5}{(0.05)\ 2} = 384 \text{ Sample.}$$

Where N = required sample size; P exp= expected prevalence; d = desired absolute precision (usually 0.05).

Accordingly, the prevalence of Mastitis in camels was not estimated previously. Thus, adopting a p of 50% and L of 5%, a total of (96 camels * 4 quarters) 384

camel milk samples were sampled for the present study.

3. Milk Sample Collection

Milk samples were collected in adherence to the Mastitis protocol. The udder was washed and dried using sterile water and towels. Teat ends were swabbed with cotton soaked in 70% ethyl alcohol. Approximately 5 - 10 ml of milk was aseptically collected from each quarter of the lactating camel into a sterile container, and an equal volume of California Mastitis Test (CMT) was added. CMT is a cost-effective and swift screening test for Mastitis.

4. Questionnaire Survey

The study used a carefully designed and pretested questionnaire that was thoroughly tested at the Kaliil and Alrayan Camel dairy farms. The questionnaire was prepared in English and then translated into the local language, Somali. To ensure accuracy and consistency, it was later back-translated into English. This meticulous process instills confidence in the reliability of the study's findings. A questionnaire survey was conducted among 20 farm employees/owners to gather information on hygiene, parity, lactation stage, tick infestation, and udder/teat lesions. Data regarding parity and lactation stage were obtained through owner interviews.

5. Data Analysis

The data collected on specifically designed forms were recorded and entered into a Microsoft Excel spreadsheet for analysis using SPSS version 20 statistical software. The prevalence of Mastitis (clinical and sub-clinical) was calculated as a percentage, and potential associations with risk factors were analyzed using the Chi-square test and predictive value (P-value).

6. Results

A total of 96 camels (4 quarters) were sampled, which is equivalent to 384 camel milk samples. Additionally, 20 farm employees and owners were interviewed.

6.1. Prevalence of Clinical and Subclinical Mastitis at Camel and Quarter Level

Table 1 illustrates the camel-level Mastitis prevalence using CMT, indicating a rate of 34.4% (33 out of 96 camels), with clinical cases at 4.6% and subclinical cases at 29.2%. Likewise, at the quarter level, the prevalence is 46.3%, with clinical and subclinical Mastitis at 4.6% and 41.2%, respectively.

Table 1. Prevalence of clinical and subclinical Mastitis at camel and quarter level.

Category	The total number of examined	The total number of positive	Prevalence (%)
At Camel level			

Continued

Clinical	96	5	5.2%
Subclinical	96	28	29.2%
Overall	96	33	34.4%
At Quarter level			
Clinical	384	18	4.7%
Subclinical	384	160	41.6%
Overall	384	178	46.3%

Table 2. Prevalence of subclinical Mastitis at a quarter level in Banadir region.

Quarter	Positive	Negative	Total	Prevalence (%)
RFQ	38	58	96	39.5%
RHQ	58	38	96	60.4%
LFQ	26	70	96	27%
LHQ	56	40	96	58.3%
TOTAL	178	206	384	46.3%
Quarter	**Positive**	**Negative**	**Total**	**Prevalence (%)**
RFQ	38	58	96	39.5%
RHQ	58	38	96	60.4%
LFQ	26	70	96	27%
LHQ	56	40	96	58.3%
TOTAL	178	206	384	46.3%

6.2. Prevalence of Subclinical Mastitis at a Quarter Level in Banadir Region

Table 2 presents the quarter-wise prevalence of Mastitis. The right hind quarter exhibited the highest prevalence at 60.4% (58 out of 384), followed by the left hind quarter at 58.3% (56 out of 384). In comparison, the right front quarter showed a prevalence of 39.5% (38 out of 384), and the left front quarter had a prevalence of 27% (26 out of 384). The collective subclinical quarter-level prevalence in the Benadir region was 46.3% (178 out of 384).

6.3. The Prevalence of Mastitis at the Camel Level in the Farms

Shows the prevalence of Mastitis at the animal level. Subclinical Mastitis was the most prevalent, accounting for 29.2% (28 out of 96), whereas clinical Mastitis had a lower prevalence at 5.2% (5 out of 96).

6.4. Association between the Occurrence of Mastitis, Stage of Lactation, and Age Group

Table 3 suggests that Mastitis prevalence is significantly higher in the early lactation stage (1 - 3 months) compared to the mid and late lactation stages. The odds of Mastitis occurrence are 6.68 times higher in the early stage than in other stages. The Chi-square value of 6.68 indicates a significant association between Mastitis and the lactation stage. This information is crucial for understanding the vulnerability of lactating camels to Mastitis at different stages of lactation.

Table 3. Associations between mastitis occurrence and lactation stage, as well as age group.

Category	Positive	Negative	Total	Prevalence%	OR	Chi-2	P-value
Lactation Stage							
Early stage (1 - 3 m)	21	23	44	21.8%		6.68	00.5
Mid stage (4 - 9 m)	7	27	34	7.2%			
Late stage (10 - 18 m)	5	13	18	5.2%			
Total	33	63	96				
Age Group							
5 - 7 years	4	23	27	4.1%			
8 - 10 years	9	27	36	9.3%		16	0.05
11 - 14 years	20	13	33	20.8%			
Total	33	63	96				

Table 4. Association between the occurrence of Mastitis and parity.

Parity	Positive	Negative	Total	Prevalence (%)	OR	Chi-2	P-Value
Primiparous	7	27	34	7.3%			
Multiparous	26	36	62	27%	2.78	4.43	0.05
Total	33	63	96				

The age distribution of lactating camels affected by Mastitis. The majority, comprising 20.8%, fall within the age range of 11 - 14 years. Additionally, 9.3% were aged between 8 - 10 years, and 4.1% were in the age group of 5 - 7 years. Notably, the highest number of positive Mastitis cases was observed in old-age camels. This study underlines a significant difference in Mastitis prevalence across different age categories.

6.5. Association between the Occurrence of Mastitis and Parity

Table 4 indicates that lactating camels with a parity of more than two calvings were 2.78 times more likely to contract Mastitis compared to camels with a parity of two or fewer calvings.

6.6. Association between the Occurrence of Mastitis and Tick Infestation

Table 5 reveals that lactating camels infested with ticks were 0.813 times more likely to contract Mastitis than camels without tick infestations.

Table 5. Association between the occurrence of Mastitis and tick infestation.

Tick infestation	Positive	Negative	Total	Prevalence (%)	OR	Chi-2	P-value
Infested	8	13	21	8.3%			
Free	25	50	75	26%	.813	.165	.685
Total	33	63	96				

Table 6. Association between the occurrence of Mastitis and udder lesion.

Udder lesion	Positive	Negative	Total	Prevalence (%)	OR	Chi-2	P-value
With lesion	12	23	35	12.5%			
Without lesion	21	40	61	21.8%	1.00	.000	.989
Total	33	63	96				

Table7. Association between the prevalence of Mastitis and body condition.

Body condition	Positive	Negative	Total	Prevalence (%)	OR	Chi-2	P-value
Normal	7	48	55	7.2%			
Thin/Bad	26	15	41	27%	11.88	26.75	0.05
Total	33	63	96				

6.7. Association between the Occurrence of Mastitis and Udder Lesion

Table 6 indicates that the majority, accounting for 21.8% (21 out of 96), of the camels tested positive for Mastitis without any udder lesions. Following this, 12.5% (12 out of 96) tested positive for udder lesions. Therefore, no significant association was found between udder lesions and camel mastitis.

6.8. Association between the Prevalence of Mastitis and Body Condition

Table 7 illustrates various body conditions in relation to the number of positive cases. Approximately 27% (26 out of 96) of the lactating camels exhibited a thin body condition, while 7.2% (7 out of 96) were normal. The results strongly suggest that lactating camels with a thin body condition are more susceptible to Mastitis. Furthermore, the data establishes a significant association (P = 0.005) between body condition and camel mastitis.

6.9. Management and Hygienic Practices in the Camel Dairy Farms

In this study focusing on management and hygienic practices in camel dairy farms, 40% milk camels twice daily, while 60% prefer thrice. All farms (100%) use hand milking, primarily by herd keepers (90%). Hygiene concern arises as 80% don't wash their hands before milking, and udder washing is neglected.

Table 8. Management and hygienic practices in the camel dairy farms.

Management practices		Frequency	Percentage
Milking rates	Twice a day	8	40%
	Thrice a day	12	60%
Wash hands before milking	Yes	4	20%
	No	16	80%
Wash udder before milking	Yes		
	No	20	100%
Udder drying after washing	Yes		
	No	20	100%
milking Mastitis last	Yes	4	20%
	NO	16	80%
Milking practice	Hand	20	100%
	Machine		
Who milks the camels	Owner	2	10%
	Herd keeper	18	90%
Husbandry system	Intensive	20	100%
	Semi-intensive		
	Extensive		
Hygienic score	Good	3	15%
	Bad	17	85%

Milking-infected mastitis animals are rare (20%). Husbandry is mainly semi-intensive (100%), but 85% have poor hygiene scores. Enhancements in hand washing, udder drying, and hygienic scoring are imperative, alongside adjusting milking rates and involving diverse milking personnel (**Table 8**).

7. Discussion

In the study conducted, the prevalence of camel mastitis was found to be 34.4%, which is higher than the findings of other studies [11] reported a prevalence of 30.5% in Hargeisa, Somalia, while [12] reported a prevalence of 29% in Jijiga Zone, Somali Regional State, Ethiopia. However, the prevalence in this study was lower than that reported in the Afar Region, North Eastern Ethiopia (59.8%), and Sudanese camel herds (66.8%). In this study, the proportion of clinical and subclinical mastitis was found to be 5.2% and 29.2%, respectively. These findings are consistent with the results of [13], who reported a subclinical mastitis prevalence ranging from 28.6% to 37.6% and clinical mastitis ranging from 10% to 17% in dromedary camels in the Borana area of Southern Ethiopia. Moreover, the prevalence of clinical mastitis in this study aligns with the findings of other studies, which reported a prevalence of 5.9% in Sudan and 8.3% in Jijiga [14].

During a study, udder or teat lesions were found to be a critical risk factor for mastitis in camels, as they increase the chances of bacterial entry and cause permanent tissue damage. Out of 96 camels, 12.5% (12/96) tested positive for mastitis if they had udder or teat lesions. The researchers observed both penetrating and non-penetrating superficial skin lesions in the udder or teat, which could be due to the thorny plants in the area. Similar studies in Southern Ethiopia found a higher prevalence of mastitis (72.2%) in camels with udder lesions [15]. Trauma

was also found to be a direct factor responsible for mastitis. Although tick infestation was considered a potential risk factor, it was not found to be significant in causing camel mastitis, unlike previous studies that suggested it predisposes the udder to mastitis-causing pathogens [16].

Statistically significant variation in subclinical mastitis prevalence was noted concerning the stage of lactation. It was higher in the early 21.8% and mid-stage of lactation 7.2%, and lower in the last stage of lactation, in line with the findings of studies conducted in southern Ethiopia, which shows a high prevalence of subclinical mastitis in the early stage of lactation [17]. The highest prevalence in the mid-stage of lactation might be attributed to the common practice in the study area of not milking she-camels for the first two to three weeks after giving birth, potentially decreasing udder contamination. Variation was also observed among she-camels in different parities; in animals at their first calving, subclinical mastitis was 7.3%, sharply rising to 27% in she-camels that had three or more births. This aligns with the findings of [18], who reported a higher prevalence of subclinical mastitis in she-camels with three or more parities [19]. However, this study contradicts the findings [20]. who noted that during the first, second, and third calving, the prevalence of mastitis was 25%, increasing to 43.8% at the fourth and fifth calving and decreasing to 16.7% in the sixth, seventh, and eighth calving. The increase in subclinical mastitis with parity could be linked to lower immunity defense, changes in udder morphology (higher elasticity of mammary gland), and an increase in udder trauma with the number of parties; The study faced difficulties in restraining and palpating animals, collecting milk samples from lactating animals, and obtaining a sufficient number of participants for the questionnaire.

8. Conclusion

This study highlights the significant occurrence of mastitis among lactating camels in Benadir, which is attributed to inadequate hygiene practices and tick infestations. It is worth noting that mastitis is more prevalent in the early stages of lactation. Therefore, it is crucial to implement effective management practices, including proper sanitation and tick control measures, to prevent mastitis. Public awareness and education are also essential in promoting the right herd health practices and hygienic milking processes, which can ultimately reduce the impact of mastitis on milk quality and yield.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix I: Questionnaire

Section A: Individual animal (camel)

Data

1. Age ……
2. Breed
   a. Exotic breed
   b. Local breed
3. Parity
   a. Primiparous
   b. Multiparous
4. Lactation stage
   a. Early (1 - 3 months)
   b. Mid (4 - 9 months)
   c. Late (10 - 18 months)
5. Body condition
   a. Normal
   b. Thin
6. Teat lesion
   a. With lesion
   b. Without lesion
7. Udder Tick infestation
   a. Tick free
   b. Infested

Section B: Management and hygienic practices in Camel dairy farms

8. Do wash hands before milking.
   a. Yes
   b. No
9. Do you prepare (wash) the udder before milking?
   a. Yes
   b. No
10. Udder drying after washing
   a. Yes
   b. No
11. Milking mastitis camel last
   a. Yes
   b. No
12. Milking frequency
   a. twice a day
   b. Three times a day
13. Housing condition
   a. Poor
   b. Good
14. Husbandry system

a. Intensive
b. Semi-intensive
c. Extensive

15. Hygienic scoring
    a. Good
    b. Fair
    c. Poor
16. Milking practice (method)
    a. Hand Milking (manual)
    b. Machine Milking
17. How often do you remove the manure from the farm?
    a. Once a week
    b. Once a Month
    c. Once two months
    d. three months
    e. Others (specify)
18. Who milks the camels
    a. Owner
    b. employee
    c. Others (specify)
19. Have you heard of mastitis in camels?
    a. Yes
    b. No
20. Have you ever had any case of mastitis?
    a. Yes
    b. No
21. If yes, what signs did you see that indicated it was mastitis?
    a. Swollen and painful Udder/quarter
    b. Bloody milk
    c. Reduced milk
    d. Other signs (specify)
22. Was any treatment given?
    a. Yes
    b. No
23. Who administered the treatment?
    a. Veterinary doctor b. Animal Health technician
    c. Community Animal Health worker
    d. Self-treatment
    e. Others (specify)