Prevalence and Risk Factors of Mastitis in Lactating Dairy Cows in Southern Ethiopia

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ABSTRACT

Mastitis is the most complex and costly disease of dairy cows occurring throughout the world. In Ethiopia, the disease is not well investigated. A cross-sectional study to elucidate its magnitude, distribution, and associated risk factors in lactating dairy cows in Southern Ethiopia was carried out from February 2001 to March 2002 in a total of 974 milking cows using California Mastitis Test and clinical inspection of udder. Of the total animals examined, 34.9% (340) had mastitis, 11.9% (116) clinical and 23.0% (224) subclinical. Prevalence of mastitis varied significantly ($\chi^2 = 54.5$, $P < 0.001$) between the study sites. It was higher in Areka (54.7%; odds ratio [OR], 7.5; 95% confidence interval [CI], 5.5–10.0) and Arbegona (55.0%; OR, 7.5; 95% CI, 5.0–10.9]) districts and lower (13.7%; OR, 1.0) in the Awassa district. Cows managed under semi-intensive husbandry practice were more affected (43.8%; OR, 2.0; 95% CI, 1.6–2.5) than those managed under extensive (25.8%; OR, 1.2; 95% CI, 1.0–1.4) and intensive (28.9%; OR, 1.0) systems. Prevalence of mastitis was significantly influenced by season ($\chi^2 = 28.7$, $P < 0.001$). During the long rain season, cows were at greater risk (OR, 2.6; 95% CI, 2.0–3.4) of acquiring udder infection than during the long dry season (OR, 1.0). Significant difference ($\chi^2 = 47.5$, $P < 0.001$) in prevalence of mastitis was reported between breeds. Holstein-Fresian cows were affected at a higher rate (56.5%; OR, 3.3; 95% CI, 2.5–4.4) compared with local zebu (30.9%; OR, 1.2; 95% CI, 1.0–1.5) and Jersey cows (28.9%; OR, 1.0). Udder/teat injuries caused mainly by ticks were the major predisposing factors of mastitis in Southern Ethiopia. Cows with repeated episodes of mammary glands infections were about 5 times (57.0%; OR, 4.5; 95% CI, 3.7–5.5) at higher risk of re-infection than previously uninfected ones (22%; OR, 1.0; $\chi^2 = 21.8$, $P < 0.001$). Inadequate sanitation of dairy environment, poor animal health service, and lack of proper attention to health of the mammary glands were important factors contributing to high prevalence of mastitis. Some recommendations were forwarded for improved control of mastitis in the region.

INTRODUCTION

Ethiopia, a country with a human population of 70 million (annual population growth rate, 2.9%) and a land size of 1.2 million km^2, is very much dependent on agriculture. Livestock represent a major national resource and form an integral part of the agricultural production system. The country has the largest livestock population of any African country with an estimated 35 mil-

lion Tropical Livestock Units (TLU); this includes 31 million cattle, 42 million sheep and goats, 7 million equines, 1.2 million camels, and more than 53 million chickens and immense bee and fishery resources.[1,2]

Cows represent the largest proportion of cattle population of the country. According to the Food and Agriculture Organization,[3] 42% of the total cattle heads for the private holdings are milking cows. Milk produced from these animals provides an important dietary source for the majority of rural as well as a considerable number of the urban and peri-urban population. However, milk production often does not satisfy the country's requirements due to a multitude of factors. Disease of the mammary glands known as mastitis is among the various factors contributing to reduced milk production.[4] Mastitis is one of the most complex diseases of dairy cows that generally involves an interplay between management practices and infectious agents, having different causes, degrees of intensity, and variations in duration and residual effects.[5]

In Ethiopia, the disease is insufficiently investigated, and information relating to its magnitude, distribution, and risk factors is scant. Such information is important to envisage when designing appropriate strategies that would help reduce its prevalence and effects. This paper describes the results of an investigation made to elucidate the prevalence and risk factors of mastitis in lactating dairy cows in Southern Ethiopia.

MATERIALS AND METHODS

Study Area

The study was carried out in 2 zones of Southern Ethiopia, namely, Sidama and Welayta. Sidama is located 270 km south of Addis Ababa. The altitude ranges from 1650 to 3500 meters above sea level (m.a.s.l) with an average annual temperature and rainfall of 18˚C and 1223 mm, respectively. Welayta is situated at 350 km southwest of Addis Ababa. The altitude falls in the range of 700 to 2900 m.a.s.l. The average annual temperature and rainfall are 19˚C and 1000 mm, respectively. Both areas experience bimodal rainfall pattern with the long rain season (about 75% of the total annual rainfall) extending from mid-May to September and the short rain season (about 25% of the total annual rainfall) extending from February to mid-April.

Study Animals and Husbandry Practices

Study animals include local zebu cows, Jersey, Holstein-Fresian, and their crosses. Local dairy cows are managed under traditional and extensive husbandry systems. They are relatively smaller in size with small udder and short teats. The average daily milk production from individual cows was relatively low (4 to 5 liters). Crossbred dairy cows are often managed under a small-scale, semi-intensive management system. They are often provided with some supplementary diet in addition to the natural pasture and agricultural byproducts and are maintained usually in separate stalls a short distance from each other in a house. This type of dairy husbandry system is increasingly becoming an important source of milk supplies to households and a means of income generation in urban and peri-urban areas of both the Sidama and Welayta zones. Intensive farms are owned by the government and managed under modern system. Cows are kept in exclusive stalls and provided with supplementary diets in addition to pastures and agricultural byproducts. Manure removal is made on a daily basis. Although milking is done by hand, pre-milking and post-milking hygienic procedures, such as udder washing and drying, were frequently practiced. Cows are allowed to dry off at late-lactation period by abrupt cessation of milking.

Study Design

The study involved cross-sectional observation in a multistage sampling technique.[6] Two zones, namely, Welayta and Sidama, were selected from Southern Ethiopia based on dairy cow population, trend in dairy investment, and the existence of different

husbandry practices. For estimation of disease prevalence (at standard error of the estimated prevalence (SE) = 1.38%, expected prevalence = 20%, and precision level = 95%), a sample size of 974 milking cows was determined based on the formula described by Putt et al.[7] From each zone, 4 districts were randomly selected followed by a sampling of 5 villages from each district (on average, clusters of 25 villages form a district). Again, 5 herds from each village were randomly selected, and all lactating cows within a given herd were examined (on average, a herd comprises of 5 milking cows) by cluster-sampling technique.

Clinical Inspection of Udder

The udder was first examined visually and then through palpation to detect possible fibrosis, inflammatory swellings, visible injury, tick infestation, atrophy of the tissue, and swelling of supramammary lymph nodes. The size and consistency of mammary quarters were inspected for the presence of any abnormalities, such as disproportional symmetry, swelling, firmness, and blindness. Mammary quarters often became blind when there were repeated infections and little or no treatment was provided. Information related to the previous health history of the mammary quarters and causes of blindness was obtained from interviews with owners of the farm. Viscosity and appearance of milk secretion from each mammary quarter were examined for the presence of clots, flakes, blood, and watery secretions. The udder was also inspected for the presence of any grossly visible injury and ticks. Injuries caused by ticks and vigorous calf suckling were described based on location, size, and nature. Injuries caused by ticks were identified as indurated necrotic lesions following detachment of the parasites; these could be with or with out abscess formation.[8] Injuries caused by vigorous calf suckling were identified as circumscribed lesions around the teats.

Detection of Mastitis

Mastitis was detected using the California Mastitis Test (CMT) and results of clinical inspection of udder.[9–11] Grades of the CMT were evaluated and the results graded as 0 and 1 for negative and 2 and 3 for positive.[9] Disease identification was made based on clinical examination, nature and appearances of milk secretion, and reaction to CMT.[10,11] Accordingly, milk with pus flakes, clots, or blood-tinged watery secretion, yet no visible or palpable changes in mammary quarters, and acute mastitis with signs of systemic involvement were diagnosed as clinical mastitis. Subclinical mastitis was diagnosed based on CMT results and the nature of coagulation and viscosity of the mixture, which show the presence and severity of the infection, respectively.[5,11,12]

Data Collection

A semi-structured questionnaire was developed and pretested, and all information relating to the study objectives was recorded. Data collected include type of dairy husbandry system, breed, age, parity, and lactation stage. Udder and milk abnormalities (injuries, blindness, tick infestation and indurations, swelling, milk clots, abnormal secretion, etc.) were recorded.

Depending on clinical inspection and CMT results, cases were categorized as either positive or negative. Positive case was further categorized as clinical and sub-clinical mastitis. Seasons of the year were classified as long rain season (mid-May to September), long dry season (October to January), short rain season (February to mid-April), and short dry season (mid-April to mid-May). Age of the animals was determined from birth records and dentition characteristics[13] and categorized as young adults (>3 to 6 years), adults (>6 to ≤10 years), and old (>10). Stage of lactation was categorized as early (1st to 4th month), mid (4th to 8th month), and late (8th month to the beginning of dry period). Parity was categorized as few (with ≤3 calves), moderate (4–7 calves) and many (>7 calves). Ticks (if present) were collected, counted, and recorded as few (<15 ticks), moderate (16–30 ticks) and many (>30 ticks), and some ticks from mastitis

Table 1. Prevalence of mastitis in milking cows in Southern Ethiopia as influenced by site, husbandry system, and season of the year.

Risk factor	No. Examined	CM	SCM	Total	χ^2	OR (95% CI)
Site					54.5*	
Welayta Zone						
Soddo	160	14 (8.8)	20 (12.5)	34 (21.3)		1.7 (1.2-2.5)
Areka	170	23 (13.5)	70 (41.2)	93 (54.7)		7.5 (5.5-10.0)
Boditi	99	7 (7.1)	282 (8.3)	35 (35.4)		3.4 (2.2-5.0)
Badessa	88	7 (7.9)	36 (40.9)	43 (48.9)		6.0 (3.9-9.1)
Sidama Zone						
Awassa	146	13 (8.9)	7 (4.8)	20 (13.7)		1.0
Shebedino	116	9 (7.8)	9 (7.8)	18 (15.5)		1.1 (0.7-1.9)
Dale	95	6 (6.3)	36 (37.9)	42 (44.2)		4.9 (3.3-7.3)
Arbegona	100	37 (37.0)	18 (18.0)	55 (55.0)		7.5 (5.0-10.9)
Husbandry System					100.3*	
Intensive	83	11 (13.0)	13 (15.7)	24 (28.9)		1.0
Semi-intensive	297	39 (13.1)	91 (30.6)	130 (43.8)		2.0 (1.6-2.5)
Extensive	594	27 (4.6)	159 (26.8)	186 (25.8)		1.2 (1.0-1.4)
Season					28.7*	
Long rain season	222	67 (30.2)	41 (18.5)	108 (48.7)		2.6 (2.0-3.4)
Long dry season	255	7 (2.8)	62 (24.3)	69 (27.1)		1.0
Short rain season	209	25 (11.9)	47 (22.5)	72 (34.5)		1.4 (1.3-1.5)
Short dry season	288	17 (5.9)	74 (25.7)	91 (31.6)		1.2 (0.9-1.6)

CM = clinical mastitis, SCM = subclinical mastitis, OR = odds ratio.
Numbers in parenthesis indicate percentage.
*$P < 0.001$ (highly significant).

cows were identified based on standard morphological descriptions.[8,14] Data relating to previous history of udder exposure to infection and causes of abnormalities to the mammary quarters were obtained from clinical records of the farms and interviews with the owners of the animals.

Statistical Analysis

Prevalence of mastitis related to specific risk factors was determined as the proportion of affected cows out of the total examined.[15] Effects of specific variables (breed, husbandry practice, age, parity, lactation stage, site, season, and udder/teat injuries) on prevalence of mastitis were investigated using chi-square (χ^2) test.[15] Similarly, the variation in prevalence of mastitis-induced blind quarters was assessed using the same statistical method. The association between mastitis occurrence and udder/teat injuries and repeated episodes of udder infection was investigated also by chi-square test. Odds ratio (OR) was calculated to assess the risk levels of categories under each risk factor as the ratio of the odds of disease occurring among cows exposed to a factor and the odds of disease occurring among cows not exposed to a factor.[6] In all chi-square test applications, a probability level of $P < 0.001$ was considered statistically significant. Relative frequency was determined as the proportion of cases related to specific variables out of the total cases.[6]

RESULTS

Of the total 974 lactating cows examined, 34.9% (340) had mastitis; 11.9% (116) clinical, 23.0% (224) subclinical. Prevalence of mastitis varied significantly ($\chi^2 = 54.5$, $P < 0.001$) between the study sites (Table 1). It was higher in the Areka district of the

Table 2. Prevalence of mastitis in milking cows in Southern Ethiopian as influenced by breed, stage of lactation, age, and parity.

Risk Factors	No. Examined	CM	SCM	Total	χ^2	OR (95% CI)
Breed					47.5*	
Local zebu	446	21 (4.7)	117 (26.2)	138 (30.9)		1.2 (1.0-1.5)
Zebu × Holstein-Fresian	259	35 (13.5)	38 (14.7)	73 (28.2)		1.0
Holstein-Fresian	186	49 (26.3)	56 (30.1)	105 (56.5)		3.3 (2.5-4.4)
Jersey	83	11 (13.3)	13 (15.7)	24 (28.9)		1.0
Lactation Stage					28.0*	
Early	214	64 (29.9)	34 (15.9)	98 (45.8)		2.4 (1.8-3.2)
Mid	403	31 (7.7)	73 (18.1)	104 (25.8)		1.0
Late	357	20 (5.6)	118 (33.1)	138 (38.7)		1.8 (1.5-2.2)
Age					30.3*	
Young adults	326	53 (16.3)	24 (7.4)	77 (23.6)		1.0
Adults	399	48 (12.1)	104 (26.1)	152 (38.1)		2.0 (1.6-2.4)
Old	249	15 (6.0)	96 (38.6)	111 (44.6)		2.6 (2.0-3.4)
Parity					124.9*	
Few	328	25 (7.6)	12 (3.7)	37 (11.3)		1.0
Moderate	331	31 (9.4)	74 (22.4)	105 (31.7)		3.6 (2.9-4.6)
Many	315	60 (19.0)	138 (43.8)	198 (62.9)		12.8 (10.7-16.9)

CM = clinical mastitis, SCM = subclinical mastitis, OR = odds ratio.
Numbers in parenthesis indicate percentage.
*$P < 0.001$ (highly significant).

Welayta zone (54.7%; OR, 7.5; 95% CI, 5.5–10.0) and the Arbegona district of the Sidama zone (55.0%; OR, 7.5; 95% CI, 5.0–10.9) and lower (13.7%; OR, 1.0) in the Awassa district of the Sidama zone. Significant difference ($\chi^2 = 100.3$, $P < 0.001$) in prevalence of mastitis was reported between dairy husbandry systems (Table 1). Cows managed under semi-intensive system were more affected (43.8%; OR, 2.0; 95% CI, 1.6–2.5) than those managed under extensive (25.8%; OR, 1.2; 95% CI, 1.0–1.4) and intensive (28.9%; OR, 1.0) systems. Season had significantly ($\chi^2 = 28.7$, $P < 0.001$) influenced mastitis occurrence (Table 1). Cows were about 3 times (48.7%; OR, 2.6; 95% CI, 2.0–3.4) at greater risk of acquiring mammary gland infection during the long rain season than during the long dry season (27.1%; OR, 1.0).

Breed ($\chi^2 = 47.5$, $P < 0.001$), stage of lactation ($\chi^2 = 28.0$, $P < 0.001$), parity ($\chi^2 = 124.9$, $P < 0.001$), and age ($\chi^2 = 30.3$, $P < 0.001$) showed significant influence on prevalence of mastitis (Table 2). Holstein-Fresian cows were affected at higher rate (56.5%; OR, 3.3; 95% CI, 2.5–4.4) than their crosses with zebu and Jersey cows. Mastitis prevalence was higher in early lactation (45.8%; OR, 2.4; 95% CI, 1.8–3.2) and lower in mid lactation (25.8%; OR, 1.0). Older cows (>10 years) were more affected (44.6%; OR, 2.6; 95% CI, 2.0–3.4), particularly by subclinical mastitis (38.6%), than younger cows (23.6%; OR, 1.0) in which clinical mastitis was predominant (16.3%). Cows with many calves (>7) were at about 13-times greater risk (62.9%; OR, 12.8; 95% CI, 10.7–16.9) of developing an udder infection than those with fewer (≤3) calves (11.3%; OR, 1.0).

Udder/teat injuries ($\chi^2 = 35.0$, $P < 0.001$), tick load ($\chi^2 = 44.9$, $P < 0.001$), and previous exposure to udder infection ($\chi^2 = 21.8$, $P < 0.001$) are shown in Table 3. Cows with open udder/teat injuries were at

Table 3. Prevalence of mastitis in milking cows in Southern Ethiopian as influenced by udder/teat injuries, udder tick load and previous exposure to the mammary gland infection

Risk factor	No. Examined	CM	SCM	Total	χ^2	OR (95% CI)
Udder/Teat Injuries					35.0*	
Absent	653	35 (25.2)	84 (43.6)	119 (18.2)		1.0
Present	321	81 (5.4)	140 (12.9)	221 (68.8)		14.0 (10.6-17.1)
Total	974	116 (11.9)	224 (23.0)	340 (34.9)		
Udder Tick Load					44.9*	
Low		1 (3.7)†	—	1(1.4)†		
Moderate		3 (11.1)	5 (11.6)†	8 (11.4)		
High		9 (33.3)	15 (34.9)	24 (34.3)		
Severe		14 (51.9)	23 (53.5)	37 (52.9)		
Total		27 (38.6)	43 (61.4)	70 (100.0)		
Previous Exposure to Mastitis					21.8*	
Exposed	349	40 (11.5)	159 (45.6)	199 (57.0)		4.5 (3.7-5.5)
Not exposed	625	76 (12.2)	65 (10.4)	141 (22.0)		1.0
Once		32 (62.8)†	45 (22.1)†	77 (22.7)†	32.3*	
Two times		12 (23.5)	72 (35.3)	84 (24.7)		
More than two		7 (13.7)	87 (42.7)	94 (27.7)		
Total		51 (20.0)	204 (80.0)	340 (100.0)		

CM = clinical mastitis, SCM = subclinical mastitis, OR = odds ratio.
Number in parenthesis indicate percentage.
*$P < 0.001$ (highly significant).
†Relative frequency.

far higher risk (OR, 14.0; 95% CI, 10.6–17.1) of acquiring udder infection (clinical = 25.2%, subclinical = 43.6%) than those with no injuries (clinical = 5.4%, subclinical = 12.9%). Cows with severe udder tick load were affected at higher rate (52.9%) than those with lower infestation (1.4%). Cows with previous exposure to udder infection were more likely (OR, 4.5; 95% CI, 3.7–5.5) to be re-infected than those never exposed. Cows with repeated episodes (>2) of udder infection were more affected by subclinical mastitis (42.7%) whereas those exposed only once were more affected by clinical mastitis (62.8%).

Occurrence of mastitis-induced blind mammary quarters was significantly influenced by breed ($\chi^2 = 48.9$, $P < 0.001$), age ($\chi^2 = 64.8$, $P < 0.001$), and parity ($\chi^2 = 57.7$, $P < 0.001$) (Table 4). Higher occurrence was reported in zebu-Holstein-Fresian cross-bred dairy cows (11.3%; OR, 3.4; 95% CI, 2.8–4.0) than in Jersey cows (3.6%; OR, 1.0); in older cows (11.7%; OR, 4.2; 95% CI, 3.4–4.9) than in younger cows (3.1%; OR, 1.0); and in cows with many calves (9.2%; OR, 3.9; 95% CI, 3.4–4.9) than in those with fewer calves (2.6%; OR, 1.0). However, there was no association ($\chi^2 = 0.14$, $P > 0.5$) between stages of lactation and occurrence of blind mammary quarters. All 3 stages of lactation had equal chance of having blind mammary quarters (OR, 1.0–1.1).

DISCUSSION

The overall 34.9% mastitis prevalence reported in this study is comparable with the reports in Dire-Dawa in Eastern Ethiopia (36.9%),[16] in the Chaffa valley in Northern Ethiopia (38.6%),[4] and in Debre-Zeit in central Ethiopia (39.5%).[17] However, it was lower than the reports from Bahir Dar

Table 4. Prevalence of mastitis-induced blind mammary quarters among milking cows of different breeds, stages of lactation, age, and parity in Southern Ethiopia.

Risk Factors	No. Mammary Quarters Examined	No. Mammary Quarters Blind	Prevalence (%)	χ^2	OR (95% CI)
Breed				48.9*	
Local zebu	1784	86	4.8		1.4 (1.1-1.8)
Zebu × Holstein-Fresian	1036	117	11.3		3.4 (2.8-4.0)
Holstein-Fresian	744	54	7.3		2.1 (1.5-2.7)
Jersey	332	12	3.6		1.0
Stage of Lactation				0.14†	
Early	856	59	6.9		1.0
Mid	1612	114	7.1		1.1 (0.9-1.3)
Late	1428	96	6.7		1.0
Age				64.8*	
Young	1304	40	3.1		1.0
Adults	1596	113	7.1		2.5 (2.1-3.0)
Old	996	116	11.7		4.2 (3.4-4.9)
Parity				57.7*	
Few	1312	34	2.6		1.0
Moderate	1324	116	8.8		3.6 (3.0-4.4)
Many	1260	119	9.2		3.9 (3.4-4.9)

OR = odds ratio.
*$P < 0.001$ (highly significant).
†$P > 0.5$ (not significant).

(44.6%),[18] Arsi (53.0%),[19] and Soddo (45.9%).[20]

The reported significant variation ($P < 0.001$) in prevalence of clinical (11.9%) and subclinical mastitis (23.0%) closely agrees with previous findings.[4,17,18] It was generally concluded that that subclinical mastitis is far higher than clinical mastitis.[21] The 23.0% prevalence of subclinical mastitis reported in this work was, however, far lower than reported by Abaineh[22] and Abaineh, et al[23] (65% in Fiche and 47.5% in Modjjo farms in central Ethiopia, respectively).

Because mastitis is a complex disease involving interactions of several factors, mainly of management, environment, and factors relating to animal and causative organisms, its prevalence is expected to vary from place to place. This study also showed a wider difference in prevalence of mastitis between localities, which could be attributed to the variation in veterinary service coverage. In Areka, where higher prevalence (54.7%) was reported, there were few animal health centers delivering service to only about 43% of total livestock population in the district. On the other hand, in Awassa, where lower prevalence (13.7%) was reported, there was relatively better animal health service and the government initiative has been supported by various non-governmental organizations. In support of our premise that mastitis prevalence is a function of the available veterinary service, the 21.3% prevalence in Soddo compared with the 45.9% prevalence reported several years ago[20] suggests its decreasing trend over time. According to the regional Ministry of Agriculture, animal health service coverage has been increased by 20% from a decade ago (personal communication, Southern Nations and Nationalities and Peoples Regional Government, Ministry of Agriculture, 2003).

The significant difference in prevalence of mastitis between husbandry practices could be attributed to the variation in hygienic standards of dairy environment and milking conditions, as well as genetic variation in disease resistance among the breeds maintained in the systems. Semi-intensive dairy farms in the area were overwhelmingly dominated by Holstein-Fresian cows and their crosses (50% to 85% blood levels); Holstein-Fresian pure breeds were affected at a higher rate both by clinical (26.3%) and subclinical (30.1%) mastitis. Previous works confirmed that this breed is much more susceptible to udder infection, particularly in areas where hygienic condition is poor and treatment of mastitis cases is not well pursued.[17,24] The intensive farm was a state-owned farm and comprises only Jersey cows maintained under relatively good management.

The reported high prevalence of mastitis during rainy seasons suggests its association with poor sanitation. In semi-intensive and extensive dairy farms, cows were maintained in dirty and muddy common barns with bedding materials that favor the proliferation and transmission of mastitis pathogens. Breed influence on prevalence of mastitis could be attributed to the difference in certain physiological and anatomical characteristics of the mammary glands. Occurrence of mastitis may be influenced by some heritable characteristics such as capacity of milk production, teat structures, and udder conformation.[11,25] The possible difference in mammary pathogenicity of the organisms involved in intra-mammary infection among the genotypes could also exist.[26] Our findings, therefore, are in agreement with earlier reports. For zebu cows, however, the prevalence was slightly higher (30.9%) than the previous finding (18.8% in Oromiya zone, Northern Ethiopia).[4] In Ethiopia, currently there is a tendency among experts to associate high occurrence of mastitis only with exotic breeds. This study, however, confirmed that mastitis was also widely distributed in extensive dairy husbandry practices and becoming a major health problem of indigenous dairy cows despite the previous opinion that the breed is relatively resistant.

Stage of lactation was found to affect mastitis prevalence significantly ($\chi^2 = 28.0$, $P < 0.001$). Early stage and the period of involution of the mammary glands were the most susceptible stages with prevalence of 45.8% (OR, 2.4; 95% CI, 1.8–3.2) and 38.7% (OR, 1.8; 95% CI, 1.5–2.2), respectively. The figure was lower for cows at mid lactation (25.8%). These results are consistent with previous reports.[11,27,28] Absence of dry cow therapy regime could possibly be among the major factor contributing to high prevalence at early lactation. During a dry period due to the low bactericidal and bacteriostatic qualities of milk, the pathogens can easily penetrate into the teat canal and multiply; this can be carried over into the postparturient period and ultimately develop into clinical mastitis. The increased prevalence of mastitis with advancing lactation number and age agrees with the findings of previous investigators.[5,11,29]

Prevalence of mastitis was significantly associated with udder/teat injuries (OR, 14.0; 95% CI, 10.6–17.0; $\chi^2 = 35.0$, $P < 0.001$) and that as many as 68.8% of cows with udder/teat injuries had mastitis compared with only 18.2% of cows with no injuries. High tick infestation and vigorous suckling by bigger calves might have contributed to the occurrence of injuries. This suggests the prevailing inadvertence to udder management. Udder tick infestation was another factor that significantly affected prevalence of mastitis ($\chi^2 = 44.9$, $P < 0.001$).Of the 2500 ticks collected from udders of mastitis cows, *Amblyoma variegatum* were the predominant species (53.0%) followed by *Amblyoma cohaerens* (29.0%), *Amblyoma gemma* (9.0%), *Rhipicephalus evertsi* (3.5%), *Rhipicephalus parvus* (2.9%) and *Boophilus decoloratus* (2.6%). Injuries caused by ticks are known to cause direct inflammatory reaction to the mammary gland, necrosis, and abscess formation, which may lead to udder damage and/or

exposure to serious secondary infections.[30] Therefore, in developing a mastitis control strategy, the role of tick infestation should be given due attention.

As part of the traditional dairy husbandry practices, calves are kept away from their dams over a long period of time and are only allowed to suckle for a short duration during the night; because of this as well as inadequate milk supply, calves suckle vigorously, inducing teat injuries and hence exposing dams to teat injuries and subsequent infection of the mammary glands. Previously infected cows were at greater risk of being re-infected, suggesting that repeated challenges of the mammary tissues with micro-organisms coupled with other stress factors could put the glands at greater risks of re-infection.

The high occurrence of mastitis-induced blind mammary quarters, which has a direct influence on milk production with a subsequent impact on food security, signifies the importance of the problem. Lack of screening and treatment of subclinical mastitis and inadequate follow-up of clinical and chronic cases coupled with persistent challenges of the mammary glands by microbial pathogens could be the main predisposing factors to quarter blindness. This hidden and gradual destruction of the mammary tissues would end with non-functional quarters. Though estimation of productivity losses incurred by mastitis is beyond the scope of this study, it may not be difficult to imagine the losses given the high proportion of non-functional quarters.

In Southern Ethiopia, dairy farms have been intensified through introduction of high–milk-yielding exotic breeds, and this has increased the supply and consumption of milk and milk products. This study, however, showed that mastitis is a major health problem of dairy cows in the area and undoubtedly will have an adverse effect on productivity of dairy industry and hence warrants serious attention. Most previous studies on mastitis had focused on intensive dairy farms that constitute only a small proportion of the dairy industry; there has been a tendency to link high occurrence of the disease with exotic breeds and consequently no adequate information is available regarding mastitis in local dairy cows. In the present study, it was shown that mastitis was assuming equal importance in extensive dairy farms.

Inadequate hygienic condition of dairy environment, poor animal health service, and lack of proper attention to health of the mammary gland were important predisposing factors of mastitis in the area. Adequate housing with proper sanitation and regular screening for early detection and treatment, follow up of chronic cases, culling of older cows with repeated attacks, tick control measures, and prompt treatment of teat/udder injuries are recommended to alleviate the problem.

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