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ORIGINAL RESEARCH

Occurrence of mastitis and associated risk factors in lactating goats under pastoral management in Borana, Southern Ethiopia

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Abstract Mastitis prevalence and related risk factors were studied in 1,072 udder halves of 536 lactating goats from October, 2008 to February, 2009. Clinical and subclinical mastitis were prevalent in 4.3% (95% CI=2.8, 6.5) and 11.2% (95% CI=8.7, 14.3) of the studied animals, respectively, resulting in an overall prevalence of 15.5% (95% CI=12.6, 18.9). Univariate analysis of the potential risk factors has depicted that mastitis was more prevalent in does with previous mastitis history, increased parity, poor body conditions, increased milk production, late lactation stage, long teat, and housed goats. Furthermore, prevalence was significantly higher ($p<0.05$) during the wet period of October to November than the dry periods of January to February. No significant variations ($p>0.05$) were observed in mastitis prevalence with udder tick infestation, mixing goat with sheep and flock size. With multivariable analysis, lactation stage, teat length, body condition, and season (wet months) have showed significant association with mastitis prevalence, and these factors maintained significant in the stepwise elimination of multivariable logistic regression model. As a result, does in late stage of lactation (OR=4.3, 1.8, 10.4), poor body condition (OR=5.0, 1.7, 10.0), long teats (OR=2.2, 95% CI=1.1, 4.2) and does examined in wet period were at higher risk of udder infections than early lactation, good body condition, short teat, and examined in dry period, respectively. The study showed occurrence of mastitis and associated risk factors in studied goats, which suggests the need for control intervention. Further investigations into pathogens involved in goat mastitis will optimize our knowledge of causative agents and control interventions.

Keywords Goats · Mastitis · Clinical · Subclinical · Prevalence · Risk factors · Borana · Ethiopia

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Introduction

Goats are important for livelihood of a large number of people in the third world, and especially to women, children, and the aged, who are the most vulnerable members of society in terms of undernourishment and poverty. In semiarid areas where animal feed availability is scarce and poor, goats are efficient utilizers of fibrous feeds, and having small body size and low feed intake they are more useful and economical to the owners (Peacok 1996). As a result, the average number of goats per holding in Borana has been reported to dominate other ruminant species (Solomon et al. 2006). However, goat production and productivity are constrained by multiple factors, of which mastitis is of significant consideration.

Mastitis, which is an inflammation of the mammary gland, is among the most important diseases in the dairy animals (Radostits et al. 2000). The occurrences, distribution, and causes of mastitis in dairy goats have been reported from different countries (Ameh and Tari 2000; Ndegwa et al. 2000; McDougall et al. 2002; Wakwoya et al. 2006), and literatures featuring mastitis in goats have been extensively reviewed (Haenlein 2002; Contreras et al. 2007). Milk yield loss in infected udder of small ruminants have been widely documented (Gonzalo et al. 2002; Leitner et al. 2004), and it appears that ewes and does are vulnerable to milk yield loss to subclinical mastitis (Silanikove et al. 2005).

Clinical mastitis in goat is obvious and can be detected by clinical examinations, while detection of subclinical mastitis depends on various test procedures including microbial examination, somatic cell count, and California mastitis test (McDougall et al. 2002; Wakwoya et al. 2006; Contreras et al. 2007). However, it is worth noting that the interpretation and methods for enumerating somatic cell counts in goat milk are different due to higher somatic cell count of milk of uninfected goats compared to cows or sheep (Contreras et al. 2007).

Extensive literature review by Contreras et al. (2007) has demonstrated that several pathogens have been reported to cause mastitis in goats while *Staphylococcus* spp. are the most frequently diagnosed causal microorganisms. Other pathogens such as *Streptococcus* spp., Enterobacteriaceae, *Pseudomonas aeruginosa*, *Mannheimia haemolytica*, *Corynebacteria*, and fungi can produce intra-mammary infection small ruminants. Similarly, in a study by Wakwoya et al. (2006) *Staphylococcus* spp. were the major isolates in Ethiopia, while *E. coli*, *P. aeruginosa*, *Citrobacter*, *Klebsiella*, *Acinetobacter*, *Micrococcus*, *Corynebacterium*, *Bacillus*, *Streptococcus*, and *Pasteurella* spp. were also identified.

As goats are important dairy animals in arid areas next to large ruminants, information on mastitis and associated risk factors has vital importance for control interventions. However, there is no information on the occurrence and potential risk factors for mastitis occurrence in goats kept by pastoral households in Ethiopia, which otherwise, is essential to optimize our knowledge on its epidemiology and control measures. The present study was, therefore, intended to estimate the prevalence and potential risk factors for the occurrence of mastitis in lactating goats in Borana pastoral areas of Southern Ethiopia.

Materials and methods

Descriptions of the study area

The study was conducted in selected goat flocks in Yabello areas of Borana lowland, Southern Ethiopia. Due to existing veterinary facilities, Yabello town was selected as the center for this study. The town of Yabello is geographically found at 5° 23′49 N 39° 31′52 E, at a distance of 565 km South of Addis Ababa. The Borana plateau gently slopes from high mountain massifs in the north (1650 m.a.s.l) to the south (1000 m.a.s.l) with slight variation due to central mountain ranges, and scattered volcanic cones and craters. The climate is generally semiarid with annual average rainfall ranging from 300 mm in the south to over 700 mm in the north. The rain pattern is bimodal type with the main rainy season, locally *Ganna* (65%) extending from mid-March to May and small rainy season, *Haggaya,* stretching from mid-September to mid-November. The other two seasons are the cool dry season (*Adoleessa*) extending from June to August and the major dry season (*Bonna*) extending from December to February (Coppock 1994).

Livestock production and flock management

Goats are often kept mixed with sheep during day and night with some possibility of keeping goats alone. The animals rest the night either with sheep or alone in tightly constructed open enclosure made from thorny bushes and acacia branches. It is also not uncommon to find flocks housed in roofed house. Kids up to 3 months of age are separately kept around a homestead during the day and housed separately in a specially constructed house with raised floor or may share house with people in case of small flocks. The number of goats per holding varies considerably from 10 to over 100 animals per flock in some instance. For this study, the median number of flock size was used to categorize the size as large or small. Goat milk is mainly used for household consumptions and regarded as useful for children. Milking is practiced often twice a day (in the morning and evening) by young girls or boys. More than one lactating does are milked by a single milker at a time.

Study design and sampling procedure

A cross-sectional study was conducted on traditionally managed lactating goats in Yabello areas of Borana. Double cross-transactional approach was used to select sampling sites (villages) depending on major directions from Yabello town; east–west, north–south, and other four sites between the major directions. Site selection was limited within 25 to 30-km radius from the center of this study. Accordingly, a total of nine sampling sites (villages) including the town were included in the study.

The mastitis prevalence report of 40.9% in goats in Ethiopia (Wakwoya et al. 2006) was considered as the expected prevalence to calculate the sample size with the assumption of 35% null hypothesis, 95% CI, 0.05 precision level, and 80% case detection power of the test using Epicalc 2000. Actually, a total of 536 lactating does were sampled from 76 flocks and examined for mastitis. Clinical examinations, milk sample collections, and recording of putative risk factors for mastitis prevalence were carried out in the morning at villages.

Clinical examination of udder

Animals were individually identified and clinically examined. During clinical examinations, palpation of udder and visual observation of udder lesion, clinical mastitis, udder

symmetry, and size were performed. Additionally, observation of milk consistency, color changes, and presence of grossly visible substances were carried out. Clinical mastitis was recognized by some pathological changes such as swelling, pain, redness, and heat in case of acute mastitis, whereas hardening of the udder, blockage of the teats, atrophy or fibrosis, and abscess formation were regarded as chronic mastitis.

Subclinical mastitis test

Apparently, normal udder halves of lactating animals were examined using a mastitis indicator paper (Bovivet®, indicator paper, Kruuse, Denmark) to detect subclinical mastitis. Although, there is no literature information on use of mastitis card for goat milk, we used it because of its availability in the local market, feasibility, and simplicity to use in remote area. All milk samples from each udder half of sampled animals were screened using Mastitis Card Test. The test was carried out by adding drops of milk sample to the spot indicated on the indicator paper and observing for possible color changes. A change of color from yellow to green or bluish green on the indicator paper was considered positive for subclinical mastitis. Those weak reactions with light green color were regarded as doubtful and not included in the result as positive.

Questionnaire survey

Forty-two flock owners of the investigated animals were interviewed using a semi-structured questionnaire format. The questionnaire has mainly focused on housing type, flock type (mixed or single), breeding season, cleaning frequency, kid management, weaning, milk practice, person involved in milking, time of milking, knowledge of goat mastitis, importance of mastitis, treatment and general information on production, and reproduction of goats.

Data collection and analysis

Putative biological and environmental factors believed to be associated with the epidemiology of mastitis were recorded. These include individual animal identification, age, stage of lactation, body conditions, previous mastitis history, parity, flock size and stock composition, night resting or housing type, and climatic conditions. Univariate analysis of the association of individual variables with prevalence of mastitis was assessed using logistic regression analysis of STATA version 9.0 SE (Stata Corp College Station, TX). A multivariable logistic regression analysis was carried out to identify risk factors contributing to prevalence of mastitis in goats. Variables either strongly linked to the biology of udder infections or those with a P value <0.25 from univariable analyses were included in the final multivariable logistic model. Variables were tested for interaction effects using cross-product terms. Validity of the model to the observed data was assessed by computing the Hosmer–Lemeshow goodness-of-fit test.

Results

In the study area, it was found that over 76% of the investigated households kept both sheep and goat together. Most of the flocks were housed in open enclosure, while some of them (11%) were housed under roofed house. Reported cleaning frequency includes everyday (71.4%), every 2 days (23.8%), and every 3 days (4.8%). Lactating does are mainly milked manually by young girls or boys in the morning and over 70% in the evening. As goat milk is only used for household consumption, intensity of milking may depend on the amount of milk harvested from cattle or camel. As a result, goats are milked less during seasons of milk abundance. Mastitis is commonly encountered in goats and clinically well recognized by flock owners. All of the respondents agreed that mastitis is important in impacting milk production, 45.2% of them responded to affect does health and 14.3% reported to reduce performance of kids. Although, clinical mastitis is well recognized by family members, treatment of doe's mastitis is less commonly practiced and the disease takes natural course. Only 15% of the flock owners responded to visit veterinary service for doe mastitis treatment. Most of the flock owners often attempt treatments at an advanced stage of the problem, and consequently, the outcome is unsuccessful.

The study showed that mastitis was prevalent in the studied villages ranging from 5.7 to 31.5% at doe level. Table 1 shows animal level prevalence of mastitis at the studied villages. Although, village level prevalence showed difference, it was not included in the analysis as villages were sampled during different seasons. Clinical and subclinical mastitis were prevalent in 4.3% (95% CI=2.8, 6.5) and 11.2% (95% CI=8.7, 14.3 of the studied animals, respectively. This gives an overall mastitis prevalence of 15.5% (95% CI=12.6, 18.9). Most of the clinical mastitis cases were acute (19 out of 23) with both bilateral and unilateral udder half involvements. Some does had teat lesion (1.5%), blind teats (0.9%), and varying degrees of udder tick infestations (7.5%). Taking mastitis and blocked teats into account, the study revealed that 16.4% of the does do not have sound teats for milk production.

Univariable analysis of potential risk factors showed that prevalence was significantly higher (P<0.05) in does with increased parity, poor body conditions, higher milk production, long teats, and housed does compared to those animals in other respective groups. Furthermore, mastitis prevalence

Table 1 Distribution of animal level mastitis and blind teat prevalence per sampling sites

Sites	Total samples	Subclinical mastitis (%)	Clinical mastitis (%)	Blind teat (%)	Udder health problems (%)[a]
Adegalchat	25	4 (16.0)	4 (16.0)	0 (0)	8 (32.0)
Areri	31	2 (6.5)	2 (6.5)	1 (3.2)	5 (16.1)
Dadim	60	6 (10.0)	2 (3.3)	0 (0)	8 (13.3)
Darito	88	10 (11.4)	5 (5.7)	2 (2.3)	17 (19.3)
Dida Yabello	69	3 (4.3)	1 (1.4)	0 (0)	4 (5.8)
Gololcha	108	11 (10.2)	1 (0.9)	0 (0)	12 (11.1)
Harawayu	36	1 (2.8)	0 (0)	1 (2.8)	2 (5.6)
Tulawayu	46	7 (15.2)	1 (2.2)	0 (0)	8 (17.4)
Yabello	73	16 (21.9)	7 (9.6)	1 (1.4)	24 (32.9)
Total	536	60 (11.2)	23 (4.3)	5 (0.9)	88 (16.4)

[a] Udder health problems include mastitis and blind teats

was significantly higher ($P<0.05$) in does sampled during the wet period from October to November than the dry periods from January to February. There was an increasing trend of mastitis prevalence with increasing age. Conversely, udder tick infestation, mixing with sheep, and flock size did not show significant differences for mastitis prevalence.

A multivariable logistic regression model was constructed based on two-step procedures (univariable analysis and stepwise selection). Upon testing for interactions, some variables showed interaction with others; age with parity and flock size, while milk production showed interaction with season, body condition, stage of lactation, and teat length. Based on the evaluation of their interactions, P values in multiple logistic regression and relevance, age and milk production were excluded from multivariable model. After construction of the final logistic regression model, model validity was assessed using the Hosmer–Lemeshow goodness of fit, and found that the model fitted the data well ($\chi^2=23.2$, $df=23$, $P=0.447$). The final multivariable logistic regression model (Table 3) showed that the major risk factors for mastitis prevalence in the studied does were poor body condition, long teat, late lactation, and wet season. Does in poor body conditions were about five times at more risk than animals in good body condition. Similarly, does in late stage of lactation (OR=4.3, 1.8–10.4) and those with long teats (OR=2.2, 95% CI=1.1, 4.2) were at more risks for udder infections compared to those in other groups. Animals tested during the wet period (October–November) had higher odds (about 3.3 times higher) of being mastitis positive than those tested during the dry period (January–February).

Discussion

Current knowledge of mastitis in small ruminants has been reviewed by authors such as Bergonier et al. (2003) and Contreras et al. (2007). The annual incidence of clinical mastitis in small ruminant is generally anticipated to be lower than 5% with a possibility of sporadic increase of incidence. On the other hand, the prevalence of subclinical mastitis has been estimated at 5–30% or even higher (Contreras et al. 2003). The low prevalence of clinical mastitis (4.3%), teat lesion (1.5%), and udder tick (7.5%) infestation in this study is comparable to the work of Wakwoya et al. (2006), in which clinical mastitis, udder injury, and tick infestation prevalence were 2.4, 1.2, and 1%, respectively. Conversely, the subclinical prevalence (11.2%) is lower than the study finding of 38.5% in Ethiopia (Wakwoya et al. 2006. This difference could be due to environmental differences and differences in animal breeds, management system, and diagnostic methods used. In the present study, mastitis card that used to detect subclinical mastitis was not evaluated for goat mastitis, and could cause potential difference compared to California mastitis test.

The association of different variable with mastitis prevalence was assessed and illustrated (Tables 2 and 3). Mastitis prevalence has progressively increased with age and parity number of the does studied, and in agreement with other studies (Ameh and Tari 2000; McDougall et al. 2002; Moroni et al. 2005). Mastitis is not sufficiently treated in traditionally managed goats of the Borana area, and only 17% of the respondents sought health care for does with mastitis case. As a result, and the disease takes natural course to chronic status and a possibility of carryover of infection from the first parity to the next may occur. This may increase the prevalence of mastitis in multiparous animals. In line with this, the occurrence of increased mastitis prevalence in does with previous mastitis history may also support the possibility of carryover infection to subsequent parities. Furthermore, due to prolonged exposure to pathogen in multiparous animals compared to primiparous or with less parity, prevalence augments in the former. When the duration of exposure to

Table 2 Univariable analysis of potential risk factors thought to be associated with subclinical mastitis prevalence in studied goats (n=536)

Variables	Levels	Tested	Positive	Prevalence	Odds ratio	P value
Months (season)[a]	Oct–Nov	181	27	14.9	1.0	
	Dec	194	23	11.9	0.8 (0.4, 1.4)	0.384
	Jan–Feb	161	10	6.2	0.4 (0.2, 0.8)	0.012
Flock size	<30	264	35	13.3	1.0	
	≥30	272	25	9.2	0.7 (0.4, 1.1)	0.137
Housing type	Open enclosure	476	51	10.7	1.0	
	Housed	60	12	20.0	2.1 (1.0, 4.2)	0.039
Mixed with sheep	No	476	57	12.0	1.0	
	Yes	60	5	8.3	1.5 (0.6, 3.9)	0.409
Age group	2–3 years	108	9	8.3	1.0	
	4–5 years	257	25	9.7	1.2 (0.5, 2.6)	0.676
	> 5 years	171	26	15.2	2 (0.9, 4.4)	0.096
Parity	1–2 kidding	149	11	7.4	1.0	
	3–4 kidding	226	24	10.6	1.5 (0.7, 3.1)	0.294
	5–8 kidding	161	25	15.5	2.3 (1.1, 4.9)	0.028
Lactation stage	<3 months	211	16	7.6	1.0	
	3–4 months	279	32	11.5	1.6 (0.8, 2.9)	0.155
	>4 months	46	12	26.1	4.3 (1.9, 9.9)	0.001
Body condition	Poor	44	10	22.7	1.0	
	Good	492	50	10.2	0.4 (0.2, 0.8)	0.014
Udder/teat ticks	No	496	54	10.9	1.0	
	Yes	40	6	15.0	1.4 (0.6, 3.6)	0.43
Teat length	≤2 cm	254	16	6.3	1.0	
	>2 cm	282	44	15.6	2.8 (1.5, 5.0)	0.001
Previous mastitis	No	487	50	10.3	1.0	
	Yes	49	10	20.4	2.2 (1.1, 4.8)	0.036
Milk yield[b]	<360 ml	254	18	7.1	1.0	
	≥360 ml	282	42	14.9	2.3 (1.3, 4.1)	0.005

[a] Months were grouped according to precipitation as October to November wet period, and January to February as dry while December is in between

[b] Milk yield is considered low when below 360 ml, which is a measurement of locally used cup, called "koky" and above 360 ml is considered high yield

infection is long and spontaneous cure rate is low, prevalence increases.

Poor body condition was the major risk factor for increased mastitis prevalence and this factor remained significant in the final model. This could be associated with the reduced defense status of the animals, which increases susceptibility to udder infections by opportunistic organisms. Association of poor body conditions with increased mastitis prevalence has been already demonstrated in dairy cattle (Mungube et al. 2004). Several factors may contribute to poor body condition including malnutrition or parasitic infection and old age compounded with reproduction stresses. Intervening of these

Table 3 Multivariable logistic regression analysis of potential risk factors for mastitis prevalence in studied goats (n=536)

Variables	Levels	No	Positive (%)	β	SE (β)	OR (95%CI)	P value
Lactation stage	<3 months	211	16 (7.6)			1.0	
	3–4 months	279	32 (11.5)	1.2	0.5	1.5 (0.8, 2.9)	0.234
	>4 months	46	12 (26.1)	3.3	1.9	4.3 (1.8, 10.4)	0.001
Body condition	Poor	44	10 (22.7)			1.0	
	Good	492	50 (10.2)	−3.2	0.1	0.2 (0.1, 0.6)	0.002
Teat length	≤2 cm	254	16 (6.3)			1.0	
	>2 cm	282	44 (15.6)	2.3	0.7	2.2 (1.1, 4.2)	0.019
Months (Season)	Oct–Nov	181	27 (14.9)			1.0	
	Dec	194	23 (11.9)	−0.4	0.3	0.9 (0.5, 1.7)	0.659
	Jan–Feb	161	10 (6.2)	−2.7	0.1	0.3 (0.2, 0.7)	0.007

The Hosmer–Lemeshow goodness-of-fit test showed that the model fits well (χ^2 =23.2, df=23, P=0.447)

contributing factors by improving animal feeding and treatment of parasitic disease may indirectly reduce mastitis prevalence.

Increased mastitis prevalence with lactation stage in the current study could be explained by increased exposure to pathogens and lower spontaneous cure rate of early infections. A previous study (McDougall et al. 2002) has demonstrated the existence of significantly lower spontaneous cure rate of mastitis in does compared to ewes. Additionally, does of the study area are milked manually by one milker at a time, which could facilitate transmission of pathogen from one to another. Thus, there is always a potential for ongoing transmission of infection from infected to non-infected does during hand milking, contributing to increased prevalence at late lactation stage. The literature information of mastitis prevalence with stage of lactation is variable; either showing increased prevalence (Ndegwa et al. 2000; Moroni et al. 2005) or no difference (McDougall et al. 2002).

Higher prevalence of mastitis during the wet period than dry months is due to favorable micro-environmental conditions for the mastitis pathogens maintenance and transmission. During wet months, it was observed that the goat enclosures and houses were wetted and spoiled by animal excretions, which subsequently soiled the udder halves and teats. The risk of infection is greatest when dirty teat is wetted due to rain or excess discharge. Wetness or water allows bacteria to be mobile and end up at teat end with subsequent udder infection (Ingalls 2003).

The possible explanation for higher mastitis prevalence in housed does than those in open enclosure may be due to confinement and increased contamination of the house with animal discharges. When the floor is contaminated with ample quantities of manure, urine, leaked milk, and other discharges and warmed up by body heat, rapid and explosive growth of bacteria could occur in houses compared to open enclosure. Such conditions may harbor a variety of infectious agents that may contaminate the udder and teats. Open enclosure, on the other hand, has more space and exposed to sunlight and natural ventilation that facilitate dry-up of the discharges, so that it reduces udder contamination. In a study by Ndegwa et al. (2000), poor housing has been significantly associated with udder infection status of the does. Does housed on earth floor had a higher prevalence than timber floor, as a result of dirt, wet bedding, and muddy spoiled with animal discharge with consequent opportunistic udder infections. Thus, this finding calls for frequent cleaning and drying of goat houses and open enclosures in order to reduce udder infections.

Various animal factors that predispose goats to mastitis, such as teat end to-floor distance, teat diameter, and teat end shape (Inverted/ pointed) have been studied by Ameh and Tari (2000) and no association was observed between these factors and mastitis prevalence. In the present study, increase in teat length and milk production was significantly associated with mastitis prevalence and these factors also showed positive interactions. This could be explained by the fact that long teats have probably large surface area and wider diameter of teat orifice, which could be prone to contamination and subsequent infection.

In conclusion, the present study revealed that mastitis is widely prevalent in lactating goats of the study area and several risk factors were found to predispose udder to infections. The study may provide essential information for similar agro-ecological zones and contributes to control intervention of goat mastitis. Although, mastitis is commonly encountered in does of the study area and reported to reduce milk production, it was accorded little attention. Thus, it is worth noting that efficient treatment of mastitis cases in lactating goats could reduce the problem. Among the risk factors, poor body condition can be improved through supplementary feeding of lactating does and treatment against parasitic infections. Further investigations into pathogens involved in goat mastitis will optimize our knowledge of causative agents and control interventions.

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