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Review on Causes of Bovine Mastitis in Ethiopia: Environmental Versus Contagious

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Abstract: Mastitis has long been recognized as one of the most costly diseases affecting dairy cows and has erosive effect on the economy of dairy farms as it causes a direct loss in milk quantity and quality in affected cows/farms worldwide. Mastitis is a disease that occurs in two main forms: clinical and sub-clinical. Clinical mastitis produces obvious clinical signs while sub-clinical mastitis on the other hand often goes unnoticed and can only be detected if specific tests are performed on a milk sample. The occurrence of sub-clinical mastitis was high when compared to clinical ones. Mode of transmission of mastitis is through Contagious and Environmental pathogens. The most commonly implicated and reported pathogenic causes of mastitis include *Staphylococcus aurous, Streptococcus agalactiae*, coagulase negatives *Staphylococcus* species (CNS), *Pseudomonas aeroginosa* and *Klebsiella pneumonia*. Among this *Staphylococcus aureus* pathogen was the most frequently isolated from mastitic milk in Ethiopia due to its ability to evade and influence the host immune system. Regarding the predisposing factors of Mastitis in Ethiopia most of research authors do agree on considering breed, age, parity and stages of lactation as important risk factors influencing the prevalence of bovine Mastitis. Diagnostic methods like California mastitis test, clinical examination, somatic cell count and measurement of pH are important if applied correctly. Mastitis therapy: lactation and dry cow therapy are better to treat early. Since Contagious mastitis prevalence is considerably influenced by the milking procedures followed by milker, which made it more important, control and prevention strategies should include creating awareness of people on the management practices like milking and housing hygiene need to be initiated and promoted.

Key words: Bovine · Causes · Mastitis Test · Clinical Mastitis · Prevention Strategies · Somatic Cell Count · Prevalence · Mastitis

INTRODUCTION

Ethiopia, located in tropical region is greatly dependent on Agriculture. Livestock production represents a major national resource and forms an integral part of the Agricultural production system and livelihood of the society. Ethiopia has the largest cattle population in Africa with an estimated population of 56.71 million. Among this cow represents the biggest portion of cattle population of the country, around 20.7% of the total cattle heads are milking cows [1]. However, milk production often does not satisfy the country's requirements due to different factors. Mastitis is one of the most important disease problems contributing to reduced milk production in dairy farms [2]. Mastitis is also associated with a number of zoonotic diseases in which milk acts as a vehicle of infection [3].

Mastitis is defined as an inflammation of the parenchyma of mammary gland, which can reduce milk yield and alter milk composition. The occurrence of this disease is an outcome of interplay between three major factors: infectious agents, host resistance and environmental factors [4]. Mastitis in dairy cows occurs worldwide and can be caused by infections with bacteria, yeast and fungi [5]. There are two main classes of mastitis. The first is clinical mastitis, which manifests signs observed in the affected animal or the milk. The second is subclinical mastitis, which produces no visible signs on

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the udder and milk except when using diagnostic tools. Despite many years of research, subclinical mastitis remains the most economically damaging and zoonotic potential disease for dairy industry and consumer worldwide irrespective of species of animal [6].

Economic losses due to mastitis are recognized worldwide as a major problem on dairy farms. Financial loss involved as a result of permanent loss of production in individual cows, discarded milk following antibiotic therapy, early culling of cows, veterinary costs, drug costs, increased labor, death of per acute cases and replacement costs [7]. In Ethiopia, Bishi [8] reported that the economic losses from clinical and subclinical mastitis in Addis Ababa milk shed were approximately 270 Ethiopian birr (ETB) per lactation. Another researcher, Mungube [9], estimated the economic losses from mastitis in the peri urban areas of Addis Ababa (milk production loss, treatment cost, withdrawal losses and culling losses) to be 210.8 ETB/cow/lactation from which milk production loss contributed to 38.4%.

Most commonly, mastitis begins as a result of penetration of the teat duct by pathogenic bacteria [10]. However, some viral diseases affecting the epithelium of the teat orifice are mentioned to result in or predispose to mastitis [11]. The most commonly incriminated and reported causes of mastitis include *Staphylococcus aureus, Streptococcus agalactiae*, *Streptococcus species, coagulase negative Staphylococci species, Escherichia coli, Micrococcus species, Corynebacterium species, Bacillus species, Pasteurella species, Klebsiella species, Mycoplasma species* and *Nocardia species* [12, 13].

Apart from mastitis-causing organisms, other bacteria that are pathogenic to humans may infect the udder. These include *Mycobacterium bovis*, which can cause tuberculosis in humans [14], *Brucella abortus* (the causative agent of brucellosis or undulant fever), *Listeria monocytogenes*, *Coxiella burnetii*and *Salmonella* species [15].

In practice, whether a case of mastitis is classified as clinical or subclinical often depends on how carefully the cow is observed when diagnosis is made [16]. Contagious mastitis is transmitted from cow to cow by pathogens for which the udder is the primary reservoir. It tends to be sub-clinical in nature. Bacteria that live on the skin of the teat and inside the udder [17] mostly cause it. The primary reservoir of contagious pathogens is the mammary gland itself [18]. Transmission occurs mainly at milking time through contaminated milking machines, clothes and hands of milkers or machine operators. There are several studies of bovine mastitis in Ethiopia. However, the types of bacteria incriminated in mastitis have not been well reviewed. Therefore the objectives of this review paper are:

- ✓ To review causes of bovine mastitis in Ethiopia
- ✓ To summarize the prevalence and risk factors associated with mastitis
- ✓ Finally, to show which type (contagious or environmental mastitis) is more important in the country.

Causes of Bovine Mastitis: The causes of mastitis may be either- infectious or non- infectious agents. The infectious ones are bacteria, fungi, yeasts and viruses. The non-infectious causes are injury and bruising/ rough milking [19]. A total of about 140 microbial species, sub species and serovars are isolated from the bovine mammary gland through micro biological techniques [7].

Bacterial Cause

Major Bacteria (Pathogens): The most important major pathogens involved in bovine mastitis worldwide are *Staphylococcus aureus*, *Streptococcus uberis*, *Streptococcus dysgalactiae*, *Streptococcus agalactiae*, *Escherichia coli* and *Klebsiella spp* [20]. These bacteria are capable of causing clinical mastitis, udder tissue damage and long term or chronic subclinical infections. The major bacteria can be split into two categories, those that are cow associated (or contagious) and those which are environmental in origin. The cow-associated bacteria are *Staph. aureus and Strep. agalactiae* while the main environmental bacteria are *Strep. uberis*, *Strep. dysgalactiae*and coliforms [21].

Minor Bacteria (Pathogen): These bacteria cause less udder damage but cause slight to moderate increases in SCC. While these infections usually remain subclinical, clinical episodes can occur [21]. Some organisms, particularly non-hemolytic coagulase negative Staphylococci (CNS) and *Corynebacterium bovis* are almost ubiquitous inhabitants of the bovine mammary gland and are regarded as part of the normal flora [22].

Fungal Cause: Fungal infection of bovine mammary tissue is attributable to super infection by certain fungal species as consequence to strict mastitis control programmes that render natural udder immunity quiescent. Indiscriminate antibiotic therapy might also be a contributory factor for fungal super infection of udders.

Moreover factors like micronutrient inadequacy particularly that of vitamin A and zinc in cattle are precipitating. Contamination of teat dips, intramammary infusions and moldy surroundings play significant role. The important mycotic mastitogens are *Aspergillus fumigatus* and *Candida albicans* [7].

Fungal invasion of bovine mammary tissue often occurs as mixed infection; however, fungi can be isolated as independent mastitogens as well from udder infections. Algal agent like Protothecazopfii is also incriminated in bovine mastitis, as a result of algal contamination of feed and fodder, drinking water and cattle premises by house hold sewage, discarded food items including bread, rotten vegetables and fruits and thrown out junk food items. The disease is more prevalent in the regions where cattle are often grazed in the vicinity of public parks, lakes and tourist places [23]. *Aspergillus* species are opportunistic fungi and rarely gain access to the udder through the same mechanism as yeasts. *Cryptococcus neoformans* has been reported to cause mastitis and present a public health hazard if contaminated raw milk is consumed [7].

Other Causes: Conditions that affect the milking process will increase the milking time and may predispose the udder to mastitis. Milk machine faults are responsible and the severe forms can predispose to mastitis and/or the development of black spot. Injury and bruising are non-infectious mastitis causes [19].

Risk Factors of Bovine Mastitis: There are plenty of/abundant predisposing factors that can influence emergence of mastitis at individual and herd level in dairy cattle. The factors may be physiological, genetic, pathological or environmental [24].

Many factors influence the incidence of mastitis, such as production stages of a cow, lactation number, herd management, husbandry environment temperature, humidity, seasons, breeds and milking characteristics [2, 25, 26]. Age of cows has significant effects in the occurrence of mastitis. It has been shown that manifestation of mastitis in infected quarters increases with advancement of age in cows, the highest occurrence are being observed in cows of more than 7 years of age [27]. This may be due to more dilated teat canals in older age, permanent udder tissue damage resulting from the primary infection or due to an increased cellular response to intra mammary infection [7]. Another reason may be effective innate host defense mechanism that makes the younger animals less susceptible to infection [28]. Moreover, cow's parity has significant influence on prevalence of mastitis in farms. Cows in parity number more than 3 have considerably higher mastitis prevalence than those of parity 2-3 and primiparous one [25].

Berry and Meaney [29] showed that primiparous cows have stronger defense mechanism than multiparous cows that make them less susceptible to Mastitis. They have also reported that the risk of a cow developing in the subsequent month of lactation is also a function of number of cases of clinical mastitis in the previous lactation, number of clinical cases in the previous months of the current lactation and the occurrence of clinical mastitis in the current month. The risk of contracting clinical mastitis is greater if the animal experienced clinical mastitis in the previous stage of lactation.

The prevalence of infected quarter's increases with age, peaking at 7 years [30] these may be as a result of a greater cellular response to infection or of a greater amount of permanent udder damage after infection in older cows. Older cows, especially after four lactations were submitted to more lactation, increasing the risk for mastitis and udder tissue damage [31]. Predisposing factors in the management and environment cause mastitis by negatively influencing the local and systemic barriers and defense of the cow and/or by increasing exposure of the udder to micro-organisms. In general the risk factors of mastitis can be categorized into environmental factor, host factor and factor [24].

Types of Bovine Mastitis

Depending on Mode of Transmission: Based on mode of transmission causal agents of mastitis could be classified in to two namely: - Contagious mastitis caused by: *Streptococcus agalactiae* and *Staphylococcus aureus* and Environmental mastitis caused by: Coliforms- *Eschrichia coli, Klebsiella pneumoniae, Klebsiella oxytoca*and *Enterobacter aerogenes* and Environmental *Streptococci- Streptococcus uberis* and *Streptococcus bovis*and *Enterococcus faecium* and *Enterococcus faecalis* [32].

Environmental Mastitis: Environmental mastitis is caused by bacteria such as coli form bacteria (e.g. *E. coli*) of which the main cause is a contaminated environment e.g., manure. Dairy cows may lie down in an enclosed area with a lot of manure present; therefore the coli form like bacteria can get easy access to the udder and teat canal [33]. Environmental bacteria are present in the cows

Table 1: Summary of bovine mastitis causing Pathogens

Environmental pathogens	Contagious pathogens	References
Streptococcus uberis	*Streptococcus dysagalactiae*	[35, 36, 37]
Pseudomonas species	*Corynebacterium species.*	
Klebsiella pneumonia	*Mycoplasma species.*	
serratiamarcescens	*Staphylococcus aureus*	
Citrobacter species	*Streptococcus agalactiae*	
Enterococcus faecalis	*Coagulase negative staphylococci (CNS)*	
Enterococcus faecium		
Proteus species		
Arcanobacteriumpyogenes		
Escherichia coli		
Streptococcus species		
Yeast species.		
Streptococcus agalactiae		

Table 2: Over all prevalence of bovine mastitis in different parts of Ethiopia (2000-2019).

Study area	% of CM	% of SCM	Over all prevalence	Sources
Adami Tulu			38.2%	[12]
Cent. highlands of Ethiopia			46.6%	[40]
Southern Ethiopia	11.9%(116)	23.0%(224)	34.9%	[2]
Sebeta			52.8%	[18]
Selale,		89.5 %		[41]
Shashemene			37.1%	[42]
Holeta	10.0% (43/428)	34.8% (149/428)	71.1%	[43]
Holeta	10.3	33.8%	44.1%,	[38]
Gondar	.93	31.67%	32.6%,	[44]
WolaitaSodo	9 (2.6%)	94 (26.9%)	29.5%	[45]
Addis Ababa			373 (74.7%)	[46]
Addis Ababa	21.2%	46.8%	68%,	[47]
Adigrat			64.3	[48]
West Arsi Zone of Oromia	7.3% (26/358)	30.7% (110/358)	38%	[49]
Hawassa, Wondo Genet and ArsiNegelle	3.4%	59.2%	62.6%	[50]
WolaitaSodo	3.75	22.5	26.25	[51]
Gurage zone	62(31.2%)	137(68.8%)		[52]
West Hararghe Zone,	(4.6%)	(33.9%)	38.6%	[53]
Haramaya	6.77%	56.25%	63.02%	[54]

environment like *Streptococcus species* (*Streptococcus uberis*, *Streptococcus dysagalactia*) and environmental coliforms like *Eschercia coli*, *Klebsiella* species, *Enterobacter* species [34]. The majority of infections caused by environmental pathogens are clinical and of short duration [26].

Contagious Mastitis: Contagious mastitis are caused by bacteria which are spread from infected quarter to other quarters or from infected cow to healthy cows. The most common contagious mastitis pathogens are *Staphylococcus aureus* and *Streptococcus agalactia*. *Mycoplasma bovis* is less common cause of contagious mastitis [7].

Bovine Mastitis in Ethiopia

Prevalence: In Ethiopia, the prevalence of bovine mastitis has been investigated in different parts of the country [38]. Different studies conducted in different parts of Ethiopia showed variable prevalence of mastitis depending on the type of farm and management systems [2]. The great variation in prevalence of bovine mastitis could result from differences in environment and management [22].

In most reports clinical mastitis is far lower than subclinical mastitis including Ethiopia [3, 18, 39].

Causes: Different studies in Ethiopia shows a range of bacteria are most common causes of mastitis. In general, mastitis studies in Ethiopia recorded *staphylococcus* spps specifically S. *aureus* is the predominant agent followed by streptococci spp [42, 43, 46, 53, 55, 56, 57]. In addition of these studies most of the papers reviewed here from different parts of the country, Ethiopia, shows *S. aureus* is the most prevalent (the most frequently isolated from mastitic milk in Ethiopia). Therefore, these shows that contagious mastitis is implicated as the most important in Ethiopia which need due attention (Table 3).

Table 3: Prevalence of major bacteria isolated from bovine mastitic milk in Ethiopia (2000 - 2019)

No	Authors	Study area	Sample size	Prevalence (%)																						
				S. areous	*CNS*	*S.hyius*	*S. epidermedius*	*Staphylococcus intermedius*	*Stapy.spp*	*Micrococcus spp*	*Corynebacterium*	*A. pyogenes*	*Bacilluspp*	*P. aeroginosa*	*Enterococcus faecalis*	*S.dysagalactiae*	*st .uberis*	*S. agalactiae*	*Streptococci*	*Escherichia col*	*Klebsella pneumonae*	*Proteus Spp*	*Ent.aerogen*	*Coliforms*	*Cont*	*Env.*
1	[13]	Regi and	111	40.5		-	-	-	-	-	5	-	-	-	-	-	-	-	16.5	-	-	-	-	9	45	25.5
2	[58]	hawassa and	124		36.7	*1*	*1.5*	-	-	-	*7*	-	*7.6*	-	-	5.6	5.1	13.1	-	10.1	4.1	-	-	-	59.4	32
3	[18]	Sebeta	134	*44.03*	-	-	*14.93*	-	-	6.72	*.6*	*5.97*	-	-	-	*4.48*	*2.99*	*3.73s*	2.99	*.75*	-	-	-	-	74.49	12.7
4	[41]	*Selale*	122		9.42	5.07	34.41	23.19	-	5.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	77.89	
5	[59]	Sellale	121	42.6	-	-	22.1	-		-	-	-	-	-	-	30	10.3	42.8	-	-	-	-	-	-	137.5	10.3

0No	Authors	Study area	Sample size	Prevalence (%)																						
				S. arecus	*CNS*	*S.hyius*	*S. epidermedius*	*S. intermedius*	*Stapy.spp*	*Micrococcus spp*	*Corynebacterium*	*A.pyogenes*	*Bacilluspp*	*P. aeroginosa*	*Enterococcus*	*S.dysagalactiae*	*st. uberis*	*S. agalactiae*	*Streptococci*	*Escherichia col*	*Klebsella*	*Proteus Spp*	*Ent.aerogen*	*Coliforms*	*Cont*	*Env.*
6	[60]	Asella	144		41.4	-	-	-	-	-	-	-	-	-	-	-	-	-	24.8	-	-	-	-	33.8	41.4	58.6
7	[61]	Adama	99	*14.7*	*21.2*	-	-	-	-	*15.9*	-	-	2.2	-	*10.6*	*6.4*	*3.3*	*11.6*	-	*7.5*	-	-	-	-	56.1	21.4
8	[43]	Holeta	153	*47.1*	30.1	-	-	-	-	3.3	*2*	-	*1.3*	-	-	-	-	-	7.2	4.6	3.3	-	1.3	-	83.8	16.4
9	[62]	Gondar	105	16.5		-	-	-	-	-	-	-	-	-	-	14	-	15.9	-	-	-	-	--	-	46.4	
10	[42]	Shasheme	70	28.1	-	-	-	-	22.1	1.4	-	-	*.5*	*1.4*	-	-	14.3	*10.1*	-	*10.6*	*7.8*	-	*3.7*	-	62.2	37.8
11	[63]	Hawassa	84	*53.5*	-	-	-	-	-	-	-	-	-	-	-	-	-	*26.5*	-	*12.5*	*2.5*	-	*5*	-	*80*	20
12	[38]	Hareghe	121	*35.5*	-	*4.9*	-	*6.6*	-	-	-	-	-	-	-	*5.8*	*5.8*	*19.9*	-	*5.8*	2.5	-	-	-	*76.8*	19

No	13	14	15	16	17	18	19	20
Authors	[46]	[64]	[65]	[56]	[48]	[66]	[49]	[67]
Study area	Addis	Addis	Holeta	Areka	Adigra	w.Gen	w Ars	WolaytaSo
Sample size	80	81	180	250	698	51	83	134
Prevalence (%)								
S. areous	*28.7*	*21.13*	43.3	54.4	*51.7*	52.9	*44.6*	-
CNS				-	-	-		-
S.hyius	-	-	-	-	-	-	-	-
S. epidermedius	-	-	--	*4.4*	-	-	-	-
S. intermedius	-	-	-	*8.4*	-	-	-	-
Stapy spp	-	*8.45*	-	-	-	-	-	43.54
Micrococcus spp	*5*	-	17.2	-	-	-	-	-
Corynebacterium	-	-	-	*0.8*	-	5.9	-	-
A. pyogenes	-	*4.23*	-	-	-	-	-	-
Bacillus spp	-	*5.63*	-	-	-	9.8	-	-
P. aeroginosa	*7.5*	-	-	-	-	-	*3.6*	-
Enterococcus	*5*	-	*2.8*	-	-	-	-	-
S.dysagalactiae	8.7	*5.63*	7.2	*24.8*	-	-	-	-
st uberis	-	*4.23*	*2.8*	*5.2*	-	-	-	-
S. agalactiae	*21.2*	18.31	12.2	*1.6*	*20.3*	-	*18.1*	-
Streptococci	-	-	-	-		23.5	8.4	28.89
Escherichia col	-	*7.04*	-	*0.4*	*20.9*	*7.8*	*4.8*	-
Klebsella	-	*4.23*	-	--	-	--	*3.6*	-
Proteus Spp	-	-	-	-	-	-	-	-
Ent aerogen	-	-	-	-	-	-	-	-
Coliforms	-	-	-	-	-	-	-	19.35
Cont	63.6	56.3	79.9	94.4	72	92.1	79.8	43.54
Env.	36.2	23.95	5.6	5.6	20.9	7.8	20.4	48.24

No	21	22	23	24	25	26	27
Authors	[51]	[68]	[69]	[70]	[53]	[71]	[72]
Study area	WolaitaS	Addis	East Shewa	WolaitaSodd	Bale Zone	sebeta	*Mekelee*
Sample size	133	193	211	51	364	220	55
Prevalence (%)							
S. areous	39.85	46.63	*46*	*21.5*	33.24	*25*	21.8
CNS				-			*54.5*
S.hyius		-	-	*3.9*	-	*5*	-
S. epidermedius		-	-	*3.9*	9.34	*5.5*	-
S. intermedius		-		*9.8*	-	*10.5*	-
Stapy spp		-	-	-	-	-	-
Micrococcus spp		10.69		-	-	-	*1.8*
Corynebacterium		-		-	4.40	-	*1.8*
A. pyogenes		-		-	-	-	-
Bacillus spp		3.74		-	-	5	*1.8*
P. aeroginosa		-	-	-	2.2	-	-
Enterococcus		-	-	-	-	-	*3.6*
S.dysagalactiae	13.53	-	-	7.8	5.77	5.5	*3.6*
st. uberis		5.88	-	-	3.85	*1.4*	*1.8*
S. agalactiae	12.03	*2.07*	*19.4*	*17.64*		*12.3*	3.6
Streptococci		-	-	-	-	-	-
Escherichia col	8.27	-	10.9	*13.72*	7.42	*5*	*1.8*
Klebsella		-	-	*9.8*	2.75	-	*3.6*
Proteus Spp		*5*	-	-	-	-	-
Ent aerogen		-	-	-	-	-	-
Coliforms		-	-	-	-	-	-
Cont	85.71	77.67	89.1	64.54	82.14	79.3	*94.3*
Env.	8.27	*5.69*	10.9	23.52	16.22	6.4	9

Sample size in above (table-3) indicates: For No-3, 8, 10, 12-19 and 21-27 isolates identified and For No -1,2,4-7,9,11 and 20 mastitis positive cows subjected to bacteriological examination.

Staphylococcus and Streptococcus frequent colonization of teats (makes ease of access to the teat canal during milking or suckling and facilitates transmission from quarter to quarter and from cows to cows during milking) and their ability to exist intracelullarly and localize within in the udder hence, resistant to antibiotic treatment could also be important factor contributing to the predominance of these organisms. The high prevalence of *S. aureus* is from the absence of dry cow therapy and low culling rate of chronically infected animals practice [49], might be due to lack of effective udder washing and drying, post-milking teat dip and drying and hand washing. The *Staphylococci* have also adapted to survive in the udder; they usually establish chronic, subclinical, infection and are shed in the milk which serves as a source of infection for other health cows during the milking process [7].

CONCLUSION AND RECOMMENDATIONS

Ethiopian livestock sector has been contributing considerable portion to the economy of the country even if many diseases like mastitis, is known to be a complex and costly disease of dairy cows, have been affecting the sector. There are many factors (intrinsic and extrinsic) like age, parity, breed, stage of lactation, previous mastitis record, udder hygiene, drainage/slope, floor type and grazing system that were found to be risk factors significantly related to mastitis prevalence. The higher prevalence level of sub clinical mastitis as compared with clinical form in these reviewed areas indicates the magnitude of subclinical mastitis problem and low level of attention that is given to it in terms of diagnosis and treatment in the country. The predominant bacterial species isolated in the reviewed areas were *Staphylococci* followed by *Streptococci species and coliforms* showing the importance of contagious mastitis. Poor milking procedures, milk handling practices including the surrounding environment and treatment practices has greater influence on the bacterial contamination of raw milk and contributes to zoonotic pathogens. From the above facts the following recommendations are forwarded:

- All dairy producers know that early detection of intramammary infection is important for selecting and implementing proper therapy. Unfortunately, most infections are not detected until they become clinical and by then extensive and costly damage can result. Routine milk cultures should be an ongoing part of any mastitis control program. The sampling strategies for any ongoing program require the input of the herd veterinarian as well as herd management.
- Since the bacteria isolated from cows' milk samples are types that cause both contagious and environmental mastitis, correct and good milking techniques are essential in the prevention strategies. Furthermore, regular screening for the detection of subclinical mastitis and proper treatment of the clinical cases as well as appropriate treatment of cows during dry and lactation period should be practiced.
- Awareness creation should be given to the dairy herds on the impacts of bovine mastitis
- All quarters of the udder of each cow should be periodically checked for the timely treatment and prevention.

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