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DAIRY CALF MORBIDITY AND MORTALITY AND ASSOCIATED RISK FACTORS IN SODO TOWN AND ITS SUBURBS, WOLAITA ZONE, ETHIOPIA

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ABSTRACT

A longitudinal observational study on calf morbidity and mortality in dairy farms in Sodo town and its suburbs was conducted from January 2013 to January 2014 with the aim of investigating dairy calf morbidity and mortality rate, determining potential risk factors associated with calf morbidity and mortality, and isolating some enteropathogens associated with diarrhea. All 30 dairy calves, which were born during the period from January 2013 to June 2013 at eight dairy farms, were enrolled for the study. Patterns of the calves' morbidity and mortality were followed up from birth to the end of their sixth months of age at individual level. In addition, a questionnaire survey on calf rearing practices was performed on the farms, where the experimental animals resided. The results of this study demonstrated 66.7 % (n = 20) calf morbidity and 20 % (n = 6) mortality. Diarrhea accounted for 63.3 % (n = 19) of the morbidity, while pneumonia accounted for 3.3 % (n = 1). The main cause of death was also diarrhea resulting in three out of six deaths. Based on the laboratory examination, *Eschericia coli* only was excreted by 26.3 % (n = 5) of the diarrheic calves, *Salmonella* only by 10.5 % (n = 2), and *Cryptosporidium* by 52.6 % (n = 10); *E. coli* + *Salmonella* were concurrently excreted by 10.5 % (n = 2) of the diarrheic calves. Overall, 76.9 % (n = 20) of the 26 examined animals were found to be infected by different gastrointestinal and ectoparasites. The association of 21 potential risk factors with dairy calf morbidity and mortality was investigated. Of these factors, among others poor body condition of the dam, short teat distant from the ground, feeding calves less than four liters of milk/day, were significantly associated with dairy calf morbidity ($p < 0.05$), whereas less than five year farm work experience of herd attendants, and a stock of less than ten animals in a farm were significantly associated with dairy calf mortality ($p < 0.05$). On the other hand, manure removal once at day was significantly associated with both calf morbidity and mortality ($p < 0.05$). In conclusion, calf morbidity and mortality was found to be relatively high in the examined area, and can have short-term and long-term detrimental effects on dairy production by suppressing growth rate of the calves and replacement capacity of the herd.

Key words: dairy calf; morbidity; mortality; risk factors; *Eschericia coli*; *Salmonella*; *Cryptosporidium*

INTRODUCTION

Dairy farming is a growing livestock production system in Ethiopia. It is primary source of income for urban and peri-urban poor communities. Because of better availability of milk market, most of the dairy farms are concentrated in urban and peri-urban areas of the country. Development of market-oriented dairy farming is given high attention in the country and is growing in Sodo town and its suburbs. Farmers show considerable interest in raising dairy cows and are organizing in unions to combine their efforts and money to run dairy farms. They also increase the use of exotic dairy cattle and their crosses in order to enhance milk production. However, since exotic cattle are less tolerant to local diseases, the dairy production is facing a great challenge due to high prevalence of diseases in dairy cows (Lemma *et al*., 2001) and their offspring.

A successful dairy farm operation requires that a large percentage of cows wean a live healthy calf every year. Rearing healthy dairy calves to weaning time requires maximizing the calf's level of immunity against

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disease while minimizing its exposure to infectious agents (Godden, 2008). However, among the factors that have been hindering success of dairy industry, morbidity and mortality of calves is the one, that causes major concern (Acha *et al*., 2004). Phiri (2008) also noted that morbidity and mortality are important causes of economic losses on dairy farms worldwide. In spite of advancement made in dairy husbandry practices, clinical medicine and diagnostic techniques, the morbidity and mortality rates of dairy calves are still unacceptably high even on many advanced dairy farms in developed countries (Mee, 2008). Thus, it is necessary to identify risk factors that are responsible for dairy calf morbidity and mortality in order to design and implement preventive measures.

According to Lorenz *et al.* (2011), calf morbidity and mortality have short-term and long-term detrimental effects on performance of a dairy farm. They impair both growth rate and replacement capacity of the herd (MacGurik and Ruegg, http://www.progressivedairy.com/dairy-basics/calf-and-heifer-raising/2230-0209-pd-calf-diseases-and-prevention.referred in November 2013). Calf hood diseases have, therefore, a significant financial impact on dairies resulting from treatment costs, genetic loss, and impaired future performance (Donovan *et al*., 1998). Furthermore, many of the infectious agents that cause calf diarrhea can pose a considerable threat to humans (*E. coli*, *Salmonella*, *Campylobacter*, and *Cryptosporidium*). The prevalence of multidrug resistance among the Salmonella strains has increased over the past two decades (Kevin *et al.*, 2010) causing an increase in treatment failure and hospitalization rates (Swai *et al.*, 2010; Varma *et al.*, 2005). Thus, controlling infections caused by these microorganisms in dairy calves can provide economic, health and welfare benefits in the dairy industry and may reduce the zoonotic risk.

No investigation of dairy calf morbidity and mortality was carried out in the examined area before. Hence, large scale risk factor analysis is needed to quantify the calf morbidity and mortality as well as to identify associated risk factors. Understanding the causes of common calf morbidity and mortality, their methods of transmission, and associated risk factors in the studied area is the first step in developing effective programs to minimize their impact on calf health and thereby to reduce their threat to public health.

Therefore, the objectives of this study were: to investigate morbidity and mortality of dairy calves to the age of six months, to isolate *E.coli*, *Salmonella*, and *Cryptosporidium* from affected calves, to identify other parasites that affect the calves from the collected feces, and to explore risk factors associated with calf morbidity and mortality in order to give effective advice and realistic recommendations to farmers.

MATERIAL AND METHODS

Experimental animals

All 30 calves born during the period from January 2013 to June 2013 were enrolled for the study. A longitudinal observational study was conducted on 30 dairy calves at eight dairy farms that are distributed throughout Sodo town and its suburbs. Patterns of the calves' morbidity and mortality were followed up from birth to the end of their sixth months of age at individual level. Upon enrollment, the calves were given identification number and their date of birth, sex, breed, presence of delivery complications like dystocia, retained placenta and colostrum delivery strategy to the calves were recorded. In addition the dam's parity, breed, udder condition, health and milk yield were recorded. Body condition score of the dams was determined (Radostits *et al.*, 2007) and recorded at the late pregnancy during the farm visiting time by the first investigator. The farms, where the examined animals resided, were visited six times during the study period by the investigators. These visits enabled us to observe the health status of the calves. During each visit the calves management, housing and sanitation situations were also observed. Health issues of the calves occurred out of the visiting time were communicated by the owners with the investigators. The sick animals were treated after the clinical investigation and necessary samples were collected.

Sampling techniques

Fecal sampling for parasite examination

Fecal samples were collected in June and August 2013 from 26 dairy calves at eight farms. Four calves died before the fecal sample collection. The samples were collected directly from the recta of the calves with surgical gloves and were placed in clean dry screw-cup universal bottles. Each specimen was clearly labeled and transported to the laboratory of School of Veterinary Medicine, Wolaita Sodo University in an ice box at a temperature about +4 °C. In the laboratory, the samples were examined for the presence of parasites on the day of collection. Standard floatation and sedimentation methods were used in the diagnosis of parasitism in the examined animals (MAFF, 1979).

Fecal sampling for bacterial cultures and isolation

Fecal samples from 19 diarrheic calves were collected on the day of onset of diarrhea. A calf was considered as diarrheic if feces was semi-fluid (loose) to fluid with or without mucus and/or blood. About 50 grams of feces were collected directly from the rectum of affected animals with a sterile latex surgical glove

(HLL Lifecare Limited, Kerala, India) and placed into a sterile screw-cup universal bottle. Each specimen was clearly labeled and transported to the Wolaita Sodo Regional Laboratory at an ice cold condition for bacterial culture.

Samples were intended to examination for the presence of *E. coli* strain K99, *Salmonella*, and *Cryptosporidium*. However, due to the problem encountered to secure the ELISA kit for *E. coli* strain K99, *E. coli* was isolated only at the species level. The bacteriological examination was carried out according to standard methods of Quinn *et al*. (2002).

Detection of *Cryptosporidium*

Fecal samples were also examined for the presence of *Cryptosporidium*. This was done by modified Zeihl-Nelson staining technique, as described by Kaufmann (1996). Identification of oocysts from smears was made by comparing with the slide photograph in Kaufmann (1996). A smear was considered positive, when one or more oocysts were observed.

Identification of other calf diseases

Prevalence of other calf diseases was diagnosed by clinical examination of affected animal.

Questionnaire survey

In this study, a survey on calf rearing practices that might be involved in dairy calves' morbidity and mortality was performed on the farms, where the experimental animals resided. The farms are distributed throughout Sodo town and Sodo suburb. The questionnaire survey was designed to provide data on critical factors that might be associated with morbidity and mortality of dairy calves at the farm level. The on-farm survey included a face-to-face personal interview with the farm manager or senior worker by the investigators using a standard questionnaire (Wudu *et al*., 2008). The questionnaire was developed consisting multiple choice (yes or no) and semi-closed questions. We added some questions and modified others. The questionnaire was divided into nine groupings of management practices that could affect dairy calf health: herd size, farm, care of the newborn, calf-dam separation, calf housing, calf feeding, weaning and health constraints. The answers to the questions (data) were qualitative nominal (e.g., yes or no), or continuous (e.g. once in a day, number of liters of milk). The collected data were verified and validated at the same time on the farm. In addition the repeated visits to the farms permitted us to verify and validate the data collected via the questioner survey.

Data management and statistical analysis

Processing of data was done by a computer software. All the collected data were stored, filtered in Microsoft excel spread sheet and transferred to SPSS version 20.0 for analysis. P- value < 0.05 was considered as significant. Prevalence of calf morbidity and mortality (the dependent variable) and independent variables, such as farm attributes, farm management factors, calf management factors both at herd level and calf level were considered. The association between dependent and independent variables was tested using Chi-square test. The responses of all variables were dichotomized to facilitate analysis and interpretation of results. While dichotomizing continuous variables and those categorical variables with response of more than two levels, a care was taken to make the cutoff points sensible.

RESULTS

The prevalence of diarrhea in the examined dairy calves during the follow up period was 63.3 % (n = 19) and respiratory (pneumonia) disease - 3.3 % (n = 1). The mortality found during the examination period was 20 % (n = 6). Of the diarrheic dairy calves, 68.4 % (n = 13) were affected at the age of less than two months, followed by 26.3 % (n = 5) at the age of 2–4 months, and 5.3 % (n = 1) at the age of 4–6 months. *Escherichia coli* only was excreted by 26.3 % (n = 5) of the diarrheic dairy calves, *Salmonella* only by 10.5 % (n = 2), and Cryptosporidium by 52.6 % (n = 10). Concurrent infection with two microorganisms (*E.coli* + *Salmonella*) occurred in 10.5 % (n = 2) of diarrheic dairy calves

Table 1: Bacterial and Cryptosporidium isolates

Age (month)	No. of calf (%)	*E. coli*	*Salmonella*	*Cryptosporidium*	Concurrent infection *E. coli* + *Salmonella*
< 2	13 (68.4)	4	1	6	2
2–4	5 (26.3)	1	1	3	0
4–6	1 (5.3)	0	0	1	0

(Table 1). The main cause of death was diarrhea accounting three out of six deaths. The three dairy calves showed classical clinical signs like profuse watery diarrhea, dehydration, weakness, depression and recumbence before death. Two calves died suddenly showing clinical signs of heart water while one calf died of pneumonia.

The parasite infestation of the examined animals is shown in Table 2. Four calves of the examined animals died before fecal sample for parasite investigation was collected. Overall, 76.9 % (n = 20) of the 26 examined animals were found to be infected by different parasites. *Trichostrongylus* was the parasite that affected large number of calves (65.4 %, n = 17, five of them were concurrently infected with other parasites.) followed by *Trichuris* (15.4 %, n = 4, all of them concurrently infected with other parasites), *Eimeria* (7.7 %, n = 2), and *Neoascaris vitulorum* (3.8 %, n = 1 concurrently infected with other parasites). Concurrent infestation with two or more parasites occurred in 23.1 % (n = 5) of the affected calves (Table 2). The peak parasite infestation of dairy calves occurred at the age of 2–4 months; 7.7 % of the calves (n = 2) were identified with skin lesions caused by ectoparasites (Table 2).

Factors related to dams associated with calf morbidity and mortality are shown in Table 3 and 4, respectively. Poor body condition of the dam was significantly ($p < 0.05$) linked to high morbidity and (not significantly) to increased mortality in dairy calves (83.3 %, n = 15/18 and 22.2 %, n = 4/18, respectively). Multiparity of cows accounted for significantly increased ($p < 0.05$) morbidity and slightly higher mortality (75.0 %, n = 18/24 and 20.8 %, n = 5/24, respectively) in dairy calves compared to the influence created by the primiparity of the dams. Despite morbidity and mortality in dairy calves, born from dams affected by dystocia and retained placenta, were high, they did not significantly differ from the rate of morbidity and mortality in calves born from cows without parturition problems. Significantly higher ($p < 0.05$) morbidity and non-significant but more mortality were attributed to less than 50 cm dams' teat distant from the ground (91.7 %, n = 11/12 and 25 %, n = 4/16, respectively). Increased morbidity (80.0 %, n = 8/10) and higher ($p = 0.053$) mortality (30.0 %, n = 3/10) were also observed in calves born from cows with large teats.

Factors related to calf associated with calf morbidity and mortality are shown in Tables 5 and 6. Higher morbidity (77.8 %, n = 14/18) and mortality (22.2 %, n = 4/18) were registered in calves below three months of age compared to 50 % (n = 6/12) and 16.7 % (n = 2/12), respectively in calves above three months of age. More female dairy calves (71.4 %, n = 15/21) were affected by diarrhea than male calves (55.6 %, 5/9), while relatively high percentage of male calves died (22.2 %, n = 2/9), than female calves (19 %, n = 4/21).

Association of herd level farm management practice with calf morbidity and mortality is summarized in Tables 7 and 8. There was higher morbidity (80.0 %, n = 4/5) and significantly more ($p < 0.05$) mortality of calves (60.0 %, n = 3/5) reared in farms having less than 10 animals, than in calves reared in farms having 10 or more animals (60.0 %, n = 15/25 and 12.0 %, n = 3/25, respectively). Hundred percent of dairy calves reared on mud floor were sick, compared to calves kept on a concrete floor (100 %, n = 6/6 and 20.8 %, n = 5/24, respectively). Significantly higher ($p < 0.05$) mortality was registered in farms where calves were reared by herd attendants having less than five years of dairy farm work experience (Tables 7 and 8). Morbidity of dairy calves cared by only male herd attendants was significantly higher ($p < 0.05$) than calves reared by female and male workers (88.9 %, n = 16/18 and 33.3 %, n = 4/12, respectively). Mortality

Table 2: Parasite infestation of the dairy calves

Age (month)	No. of calf (%)	*Trichostrongylus* only	*Trichuris* only	*Neoascaris Vitulorum* only	*Eimeria* only	Ectoparasite only	No. of concurrently infested Calves
1–2	3 (11.6)	0	0	0	2	1	
2–4	11 (50.0)	7	0	0	0	0	4*
4–6	6 (38.5)	5	0	0	0	0	1**

*Calf 1 was infested by *Trichostrongylus* + *Trichuris* + *Neoascaris vitulorum*. Calves 2 and 3 were infested by *Trichostrongylus* + *Trichuris*, Calf 4 was infested by *Trichostrongylus* + Ectoparasite
**One calf was infected by *Trichostrongylus* + *Trichuris*

Table 3: Factors related to dam associated with dairy calf morbidity

Variable (Dam)	Description	No. of calves	No. of sick calves (%)	X²	df	p-value
Body condition	Poor Moderate	18 12	15 (83.3) 5 (41.7)	0.000	1	0.043
Parity	Multiparous Primiparous	24 6	18 (75.0) 2 (33.3)	0.000	1	0.027
Teat distant from the ground	≥ 50 cm < 50 cm	18 12	9 (50.0) 11 (91.7)	5.625	1	0.018
Teat size	Large Normal	10 20	8 (80.0) 12 (60.0)	1.200	1	0.273
Dystocia	Yes No	9 21	7 (77.8) 13 (61.9)	0.714	1	0.398
Retained placenta	Yes No	7 23	6 (87.5) 14 (60.9)	1.491	1	0.222

X² = Chi-square df = Degree of freedom Significant at $p < 0.05$

Table 4: Factors related to dam associated with calf mortality

Variable (Dam)	Description	No. of calves	No. of died calves (%)	X² 0.000	df 1	p-value 0.043
Body condition	Poor Moderate	18 12	4 (22.2) 2 (1.7)	0.139	1	0.709
Parity	Multiparous Primiparous	24 6	5 (20.8) 1 (16.7)	0.052	1	0.819
Teat distant from the ground	≥ 50 cm < 50 cm	14 16	2 (14.2) 4 (25.0)	1.875	1	0.171
Teat size	Large Normal	10 20	3 (30.0) 3 (15.0)	3.750	1	0.053
Dystocia	Yes No	4 26	2 (50.0) 4 (15.4)	2.960	1	1.107
Retained placenta	Yes No	4 26	2 (50.0) 4 (15.4)	2.596	1	0.107

X² = Chi-square df = Degree of freedom Significant at $p < 0.05$

Table 5: Factors related to calf associated with calf morbidity

Variable (Calves)	Description	No. of calves	No. of sick calves (%)	X²	df	p-value
Age	< 3 months ≥ 3months	18 (60.0) 12 (40.0)	14 (77.8) 6 (50.0)	2.500	1	0.114
Sex	Male Female	9 (30.0) 21 (70.0)	5 (55.6) 15 (71.4)	0.714	1	0.398

Table 6: Association of factors related to calf with calf mortality

Variable (Calves)	Description	No. of calves	No. of calves died (%)	X²	df	p-value
Age	< 3 months	18	4 (22.2)	0.139	1	0.709
	≥ 3months	12	2 (16.7)			
Sex	Male	9	2 (22.2)	0.635	1	0.426
	Female	21	4 (19.0)			

Table 7: Association of herd level farm management practice with calf morbidity

Variables	Description	No. of calf (No. of sick calf)	Morbidity rate	X²	df	p=value
Herd size	≥ 10 animals	25 (16)	64.0	0.718	1	0.397
	< 10 animals	5 (4)	80.0			
Floor of farm	Concrete	24 (14)	58.3	1.292	1	0.256
	Mud	6 (6)	100.0			
Farm work experience of herd attendants	< 5 years	19 (14)	73.7	1.148	1	0.284
	≥ 5 years	11 (6)	54.5			
Sex of herd attendants	Male	18 (16)	88.9	0.577	1	0.002
	Male and female	12 (4)	33.3			

Table 8: Association of herd level farm management practice with calf mortality

Variables	Description	No. of calf (No. of calf died)	Mortality rate	X²	df	p=value
Herd size	≥ 10 animals	25 (3)	12.0	6.000	1	0.041
	< 10 animals	5 (3)	60.0			
Floor of farm	Concrete	24 (5)	20.8	0.052	1	0.819
	Mud	6 (1)	16.7			
Farm work experience of herd attendants	< 5 years	19 (6)	31.6	4.342	1	0.037
	≥ 5 years	11 (0)	0.0			
Sex of herd attendants	Male	18 (4)	22.2	0.139	1	0.709
	Male and female	12 (2)	16.7			

was also moderately higher in the same farms (22.2 %, n = 4/18).

Association of calf feeding practice with dairy calf morbidity and mortality is presented in Tables 9 and 10. Delayed first colostrum feeding led to increased morbidity and mortality (80.0 %, n = 8/10 and 40.0 %, n = 4/10, respectively) compared to early colostrum consumption (60.0 %, n = 12/20 and 10.0 %, n = 2/20, respectively). High morbidity and mortality were evidenced in dairy calves fed milk from the pool (76.5 %, n = 13/17 and 29.4 %, n = 5/17, respectively) compared to calves fed milk collected individually from their dams (53.8 %, n = 7/13 and 7.7 %, n = 1/13, respectively). Morbidity in calves fed less than four liters of milk per day was significantly high ($p < 0.05$) compared with calves fed four liters and above milk per day (92.9 %, n = 13/14; 43.8 %. n = 7/16, respectively). Although not significant, mortality was also high in calves fed less than four liters of milk per day (21.4 %, n = 3/14). In this study, limited water supply of calves was found to be associated with increased morbidity and relatively low mortality (77.3 %, n = 17/22 and 18.2 %, n = 4/22, respectively), whereas *ad libitum* water supply was associated with low morbidity and higher mortality (37.5 %, n = 3/8 and 25.0 %, n = 2/8, respectively).

The association of herd level calving management and care of the newborn with calf morbidity and mortality is indicated in Tables 11 and 12. More calves that were born in the tie-stall were sick and dead (69.2 %, n = 9/13 and 30.8 %, n = 4/13, respectively) than calves born in calving pen (64.7 %, n = 11/17 and 11.8 %, n = 2/17, respectively). Increased morbidity was recorded in navel untreated calves compared to navel treated calves (70.8 %, n = 17/24 and 50.0 %, n = 3/6, respectively). Differencing from calf morbidity, significantly high percentage ($p < 0.05$) of calves with disinfected navels at birth died compared to calves without disinfected navels (50.0 %, n = 3/6; 12.5 %, n = 3/24, respectively). It was also noted that manure removal frequency significantly influenced dairy calf mortality ($p < 0.05$) and morbidity ($p < 0.01$) (31.6 %, n = 6/19 and 89.5 %, n = 17/19, respectively). All of the calves died among the examined animals belonged to the herds, where manure was removed only once a day. The current study revealed that mortality was higher (30.8 % (n = 4/13) in calves from farms with calf stocking space of less than 1.6 meter square per calf (< 1.6 m^2/calf) whereas morbidity in the same stocking was slightly higher (69.2 %, n = 9/13).

Table 9: Association of herd level calf feeding practice with calf morbidity

Variables	Description	No. of calf (No. of sick calf)	Morbidity rate	X^2	df	p=value
First colostrum feeding time	> 6 hrs	10 (8)	80.0	1.200	1	0.273
	≤ 6 hrs	20 (12)	60.0			
Source of milk	Pool	17 (13)	76.5	1.697	1	0.193
	The dam	13 (7)	53.8			
Amount of milk fed/day	< 4 liters	14 (13)	92.9	8.103	1	0.004
	≥ 4 liters	16 (7)	43.8			
Water supply	*Ad libitum*	8 (3)	37.5	2.131	1	0.144
	Limited	22 (17)	77.3			

Table 10: Association of herd level calf feeding practice with calf mortality

Variables	Description	No. of calf (No. of sick calf)	Mortality rate	X^2	df	p=value
First colostrum feeding time	> 6 hrs	10 (4)	40.0	3.750	1	0.584
	≤ 6 hrs	20 (2)	10.0			
Source of milk	Pool	17 (5)	29.4	2.171	1	0.141
	The dam	13 (1)	7.7			
Amount of milk fed/day	< 4 liters	14 (3)	21.4	0.033	1	0.855
	≥ 4 liters	16 (3)	18.8			
Water supply	*Ad libitum*	8 (2)	25.0	0.170	1	0.680
	Limited	22 (4)	18.2			

Table 11: Association of herd level calving management and care of the newborn with calf morbidity

Variables	Description	No. of calf (No. of sick calf)	Morbidity rate	X^2	df	p=value
Calving location	Calving pen	17 (11)	64.7	0.068	1	0.794
	At the tie-stall	13 (9)	69.2			
Navel treatment	Practiced	6 (3)	50.0	0.938	1	0.333
	Not practiced	24 (17)	70.8			
Manure removal	Once/day	19 (17)	89.5	12.129	1	0.000
	> Once/day	11 (3)	27.3			
Calf stocking	< 1.6 m²	13 (9)	69.2	0.068	1	0.197
	≥ 1.6 m²	17 (11)	64.7			

Table 12: Association of herd level calving management and care of the newborn with calf mortality

Variables	Description	No. of calf (No. of calf died)	Mortality rate	X^2	df	p=value
Calving location	Calving pen	17 (2)	11.8	1.663	1	0.197
	At the tie-stall	13 (4)	30.8			
Navel treatment	Practiced	6 (3)	50.0	4.219	1	0.040
	Not practiced	24 (3)	12.5			
Manure removal	Once/day	19 (6)	31.6	4.342	1	0.037
	> Once/day	11 (0)	0.00			
Calf stocking	< 1.6 m²/calf	13 (4)	30.8	1.663	1	0.197
	≥ 1.6 m²/calf	17 (2)	11.8			

DISCUSSION

This study attempted to determine dairy calf morbidity and mortality, identifying the importance and magnitude of the factors that put dairy calves at risk of morbidity and mortality, and isolating some of the pathogenic agents that caused diarrhea in the calves.

The overall morbidity and mortality recorded in this study were 66.7 % and 20 %, respectively. This result is very close to the findings of Wudu *et al.* (2008), where the crude dairy calf morbidity was 62.0 % and mortality 22.0 %. Although diarrhea was the most important cause of morbidity in both studies, the prevalence of diarrhea in this study was higher (63.3 %) than the incidence of diarrhea indicated by Wudu *et al*. (2008) (42.9 %). The outcome of this study confirmed the finding of Gulliksen *et al.* (2009) that diarrhea is the most frequent health disorder of calves. Very low morbidity of calves was attributed to respiratory disease (3.3 %) in this study compared to the findings of McGurik (2008) (25 %). Wudu *et al*. (2008) also found 4.9 % incidence of calf pneumonia, which is very close to the result of this study. The low incidence of calf pneumonia in the present study may be because cases of pneumonia were not detected by the animal keepers. Identification of early signs of calf pneumonia depends on good observational skills of the herd attendants. As Sivula *et al.* (1996) have shown in their study, animal keeper diagnosis of pneumonia is only 56 % sensitive. The high incidence of diarrhea (78.9 %) among the diarrheic dairy calves occurred at the age of less than two months. This may be because newborn calves at their early age are highly susceptible to diarrhea causing agents. According to McGurik and Ruegg, (http://www.progressivedairy.com/dairy-basics/calf-and-heifer-raising/2230-0209-pd-calf-diseases-and-prevention. referred in November 2013), the highest morbidity and mortality rates generally occur in baby calves prior to weaning. The calf mortality (20 %) rate registered in this investigation is consistent with the findings of Swai *et al.* (2010) (21 %) and Wudu *et al.* (2008) (22 %), and higher than 8.4 % by McGuric (2008), 16.81 % by Bangar, *et al.* (2013). On the other hand, it was less than the 25.0 % mortality indicated by Sisay and Ebro (1998) and the 50 % by Hassan (1996) in Ethiopia. The relatively less mortality rate in our study compared with the findings of Sisay and Ebro (1998) and Hassan (1996) was probably due to current better access to veterinary service in towns and their suburbs. In addition, the low number of calves reared in each farm of this study coupled with the extension work of the development agents might made the sick calf management relatively better.

From the 19 fecal samples collected from the nineteen diarrheic calves, five (26.3 %) were *E.coli* only positive, followed by two (10.5 %) *Salmonella* only positive, and ten (52.6 %) *Cryptosporidium* positive. Concurrent infection with two microorganisms (*E.coli* + *Salmonella*) occurred in 10.5 % (n = 2) of diarrheic dairy calves. Serotyping of the isolated *E. coli* was not performed due to failure of securing a kit. *E. coli* can be isolated from healthy calves and adult cows as well as calves with diarrhea. It can be normal intestinal flora. This creates uncertainty if the *E. coli* recovered from the samples is causative to the disease. However, based on the clinical signs shown by the diarrheic calves, situation of the dairy calves' environment, and as the disease is self-limiting, it may be possible to come to conclusion that the most likely cause of the diarrhea problem is *E. coli.* Unless there is an outbreak, *E. coli* can be isolated at species level for simple diagnosis purpose.

Overall 76.9 % of the 26 examined calves were found to be infected by different parasites. Peak parasite infestation occurred at the age of two to four months. This was probably the age when calves start to consume increased amount of grass and are naive to parasite infestation. In addition the calves that were reared at the suburbs of Sodo were allowed to graze around the farms where adult cows were grazing. The rest of the calves consume grass bought from the market. Thus, probably the calves acquired infective larval stages of parasites from the grass they consumed. The calves might be infected by *Eimeria* and *Cryptosporidium* when they ingest infective oocysts from the manure-contaminated environment.

A total of 21 different potential risk factors were assessed to determine the magnitude of their association to occurrence of dairy calf morbidity and mortality in the followed up farms. Morbidity in calves fed less than four liters of milk per day was significantly ($p < 0.05$) higher compared to calves fed four and above liters of milk per day. Although not significant, calf mortality was also higher in calves fed less than four liters of milk per day. Milk is an excellent source of nutrition providing large amounts of crude protein, energy, vitamins and minerals for the calves at their early ages, which are essential among others to maintain efficacy of their body defense mechanism. Feeding a calf less than four liters of milk per day mainly at its early age, when it does not consume solid feed, was below standard. A study by Rincker *et al.* (2006) showed benefits of feeding calves larger amounts of milk than the traditional 10 to 12 % body weight per day. Those calves that were fed less than four liters of milk per day probably suffered hunger. The restricted diet and the stress caused by the hunger might have immunosuppressive effect making them vulnerable to diseases.

Higher morbidity ($p = 0.273$) and mortality ($p = 0.053$) were revealed in calves born from dams having large teats. This might be because calves faced difficulty in handling the large teats resulting in consumption of inadequate quantity of colostrum. All the calves in the monitored dairy farms were allowed to remain with their mother after birth and suckle colostrum without interference. Morin *et al.* (2010) warned that there is no guarantee that calves will have a sufficient intake by leaving them to suckle colostrum without interference. Vasseur *et al*. (2009) also stated that poor colostrum intake caused high morbidity and mortality in dairy calves. Therefore, in this case low colostrum intake probably caused morbidity and mortality of the calves. Furthermore, significantly ($p < 0.05$) high morbidity and more mortality ($p = 0.171$) were recorded in calves born to dams having udders hanged too low less than 50 cm teat distant from the ground. Consequently, the calves probably had trouble of finding the teats and pushing the heavy udder upward in order to be able to suckle colostrum ending up in consuming inadequate quantity of colostrum.

Dystocia and retained placenta were found to be other risk factors associated with morbidity and mortality of calves. Quigley (1997) noted that calves that were born from cows with dystocia have a higher mortality. Newborn calves stressed due to dystocia are weak enough to adapt to life in the external environment. This stress to the calves probably reduced the immunoglobulin absorption efficiency as well as delayed or decreased intake of colostrum. Hence, the longer calves are without adequate colostrum Ig, the more opportunity for the pathogens that provoke diarrhea to invade the gut. According to Lombard *et al.* (2007) dystocia has been estimated to increase calf death risk by 4– to 8–fold. The investigators of this study observed that some of the dairy farmers falsely believe that feeding colostrum from dam with retained placenta will harm the calf. Thus they refrained from feeding their calves colostrum on time waiting until the retained placenta was removed.

Poor body condition of the dam at late pregnancy was significantly ($p < 0.05$) associated with calf morbidity and insignificantly associated with increased calf mortality ($p = 0.709$). Many researchers and farmers determine the nutritional well-being of the cow by the body condition score (Weaver *et al.*, 2000). Thus, the poor body condition of the dam reflects its suffering from deficiency of energy, protein, vitamins and other nutrients. The prepartum diet affects colostrum quality (Lemma *et al.*, 2001). According to Arthington *et al*. (2000), calves that were fed colostrum, obtained from cows that were fed restricted amounts of energy and crude protein, showed reduced absorption of IgG by 21.8 %. Furthermore, Quigley (1997) declared that calves born from the dams with inadequate nutrient intake before parturition might be more susceptible to morbidity and mortality. Therefore, the total amount of immunoglobulin available to calves probably was much less than the required in the situation where the cows scored poor body condition.

The Chi-square analysis of morbidity and mortality in dairy calves with respect to parity showed that calves born from multiparous cows had significantly ($p < 0.05$) high morbidity and non-significantly high mortality ($p = 0.819$) comparing to calves born from primiparous cows. This was probably because multiparous cows are susceptible to mastitis. The susceptibility of cows varies considerably and new infections are most common in older cows at early lactation and when the management is poor. According to Sargeant *et al*. (2000) and Radostits *et al*. (2007), the risk of clinical mastitis also increases with increasing parity. Cows that are affected by either clinical or subclinical mastitis shed pathogenic micro-organisms through the milk. The calves that consumed the contaminated milk might be affected by diarrhea.

It was also noted that more female calves were sick compared to male calves, while higher mortality occurred in male calves than in female calves. More female calves were sick probably because there were more female calves among the studied animals (70 %). The other explanation to this finding could be that perhaps farmers watched female calves more carefully due to their economic importance and thus diagnosed many clinical cases more effectively. More male calves died probably because postnatal mortality for males and females had a very high genetic correlation, with direct heritability being highest for males (Hanssen *et al*., 2003). According to the findings of Swai *et al*. (2010), male animals in Tanga, Tanzania were three times more likely to die than females. Similar result was obtained by Bangar *et al.* (2013) in India.

In this investigation, less than five years farm work experience of herd attendants was found to be significantly ($p < 0.05$) associated with calf mortality and non-significantly ($p = 0.284$) associated with calf morbidity. This was probably because taking care of sick calves required more work experience than caring for healthy calves. Sex of the herd attendants was also found to significantly ($p < 0.05$) influence morbidity of dairy calves. Significantly higher ($p < 0.05$) percentage of calves was sick in herds where only male herd attendants took care of calves compared to calves cared by both male and female farm workers. This might be because of the influence of women's activity regarding to calf rearing in the working team. A woman knows better how to take care of young life.

All calves kept on mud floored farm were sick compared to calves kept on concrete floor. This might be because of difficulty in keeping mud floors clean and dry. Besides, they were also less effectively disinfected. As Lindsay (2012) stated, muddy, wet conditions have proven to be the source of increased morbidity because disease causing bacteria can grow rapidly. Significantly ($p < 0.05$) high mortality of dairy calves occurred in farms where less than ten animals were kept. The most important determining factor of whether a herd had high or low calf morbidity and mortality is the quality of calf management. Ninety percents of the surveyed farms served as the secondary source of income to the owners. Farmers working in farms with less number of animals will have much less income from the farm. Thus, they probably spent much of their time on working in other places to cover their cost of living. This probably partially diverted their attention that should have been fully paid to calves. This poor caring of sick calves might result in the significantly high mortality.

In this study, calves that had their first colostrum meal after six hours of age had experienced increased mortality and morbidity. This observation was consistent with the findings of Wudu *et al.* (2008). On farms colostrum administration practice is the primary determinant of calf health. According to the observation of the investigators some of the herd men/women in this study area wrongly believed that consumption of the first colostrum causes diarrhea in calves. As the result, they milk and discard the first colostrum before the newborn suckles. Hence, the newborn calves were probably allowed to consume colostrum late. Furthermore, according to Godden (2008) colostral immunoglobulin content is reduced with each successive milking; therefore the first milking colostrum has more immunoglobulin content than the second milking colostrum. To ensure adequate protection against disease, calves rely on the intake of an adequate amount of quality colostrum within a few hours of birth (Arthington *et al*., 2000). The ability of the neonate to absorb immunoglobulin starts to decline progressively after 6 to 12 hours from birth (Radostits *et al*., 2007). Colostral Ig concentration also decreases by 3.7 % during each subsequent hour post-calving (Morin *et al*., 2010). Therefore, the late a calf consumes colostrum after birth, the lower the level of immunoglobulin absorption. As Arthington *et al.* (2000) noted, low blood Ig concentration is directly related to calf morbidity and mortality.

There was higher morbidity and mortality in calves delivered at the tie-stall compared with the calves born in calving pens. In 43.3 % of the farms calves were delivered at the tie-stall (Table 11) and they remain there for 24 hr or more. Under such conditions there was high chance of contamination of the udder and teats with feces and urine. Thus calves might acquire massive doses of pathogens at birth from the tie-stall floor contaminated by the manure of adult animals before they found colostrum. They might also ingest pathogens from the manure at the udder and teat during colostrum suckling. *E. coli* and *Salmonella* infection is common where sanitation is poor. The infection of intestine by pathogens suppresses absorption of immunoglobulin, which probably resulted in diarrheal disease and death of the dairy calves. The result of this study was in agreement with the finding of Svensson *et al*. (2003).

In this study, mortality was significantly high ($p < 0.05$) in calves where navel treatment was practiced, while morbidity was higher in navel untreated calves although was not statistically significant ($p = 0.333$). The increased morbidity of navel untreated calves might be attributable to the entrance of pathogens from the contaminated calves environment through the umbilicus. Navel infection is one of the disease conditions which has serious impact on the survival of calves (Wudu *et al.*, 2008). According to Quigley (1997), early disinfection accelerated drying up of the umbilicus to reduce infections so that calf respiratory and enteric diseases and mortality are decreased. Disinfection of the umbilicus did not positively influence mortality of the calves in this study.

Removal of manure from the stall only once a day was significantly associated with dairy calf morbidity and mortality ($p < 0.01$, $p < 0.05$, respectively). Manure is important source of pathogens. Accumulation of manure in the stall might contaminate calves' feed and water exposing the calves to overwhelming pathogens. Among the management risk factors investigated, cleanness of the calf house was found important (Wudu *et al*., 2008; Marce *et al*., 2010) in relation to calf mortality and morbidity. Furthermore, Phiri (2008) reported that newborn calves had a higher risk of diarrhea when stalls were not cleaned periodically. Although not significantly, calf stocking was found to be associated with high calf morbidity and mortality ($p = 0.197$ for both). This result was in accordance with the previous report by Benadli *et al.* (1999). This might occur due to increased pathogen contamination from fellow animals and posed stress.

In this study, high morbidity was demonstrated in calves fed milk from the pool and had restricted water access. On the other hand, these factors were not associated with calf mortality. Water should be provided free-choice starting at four days of age. Providing calves with water ad libitum increases solid feed intake and weight gain. In a research study, depriving calves of drinking water decreased starter intake by 31 % and decreased weight gain by 38 % over those calves provided water *ad libitum*. Proper dry matter and energy intake is critical in providing resistance to disease in young calves. In calves, a higher plane of nutrition improves immune function (Drackley, 2005) and also lowers mortality and the incidence of diarrhea (Kevin *et al*., 2010). 76.5 % of the surveyed herds in our study fed their calves milk from the pool. Weaver *et al.* (2000) and Lindsay (2012) do not recommend the use of pools because pooling milk may increase calves' exposure to milk-borne pathogens.

CONCLUSIONS

Calf morbidity and mortality was found to be relatively high in the examined area and can have short-term and long-term detrimental effects on dairy production by suppressing growth rate of the calves and replacement capacity of the herd. The association of 21 potential risk factors with dairy calf morbidity and mortality was investigated. Of these factors, poor body condition of the dam, multiparity, short teat distant from the ground, male herd attendants, once a day manure removal, less than four liter of milk consumption per day were significantly associated with dairy calf morbidity. Whereas less farm work experience of herd attendants, treated navel, once a day manure removal and a stock of less than ten animals per farm were significantly associated with dairy calf mortality. This risk factor assessment may be considered as the first step on devising an intervention strategy to prevent dairy calf morbidity and mortality and, thereby, improve dairy production in the examined area.

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