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Prospective Longitudinal Study of Calf Morbidity and Mortality in Urban and Peri-Urban Dairy Farms at and Around Hawassa City

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Abstract: A prospective longitudinal study was conducted from November 2017 to June 2018 to estimate the incidence of calf morbidity and mortality and identify the potential risk factors in calves up to 1 year in 118 purposively selected urban and peri-urban dairy farms located at Hawassa, Yirgalem and Wondo Genet towns. A total of 497 calves were monitored for new cases of morbidity and mortality from any causes once every other week during the study period. Moreover, a questionnaire survey was undertaken during the first visit to each farm to collect data about calf management practices. Cox proportional hazards model was used to describe relationships between risk factors and the outcomes of interest. The overall calf morbidity and mortality risk recorded in the present study was 29.2 % and 10.1 %, respectively. Taking into account all calves added and withdrawn during the follow-up period, the overall morbidity and mortality rate were found 0.074 (74 cases/1000 calf-month at risk) and 0.023 (23 cases/1000 calf a month at risk), respectively. Among the risk factors assessed, water utensils (HR=1.4, *P*=0.038), sex of calf (male: HR = 1.5, *P = 0.012*), cleaning of calf houses (HR=1.68, *P*=0.004) and mixing calves with different age and size (HR=2.1, *P*=0.001) were significantly associated with the risk of calf morbidity. Calving difficulty (HR = 1.9, *P*=0.035) was the only risk factor associated with calf mortality. Diarrhoea was the most frequently observed disease syndrome that accounted for 46.94% of all calf morbidity cases. The other causes of morbidity were pneumonia (25.85%), external parasite (12.25%), lumpy skin disease (5.44%), mechanical trauma (4.44%) and foot and mouth disease (4.08%). Similarly, diarrhoea (45.8%) was the leading cause of calf mortality followed by pneumonia (27.08%). In laboratory examination of diarrheic feces, *E. coli*, other bacteria and gastrointestinal (GI) parasites were identified. Diarrhoea and pneumonia were also the two most frequently reported causes of calf morbidity and mortality by dairy farmers during the questionnaire survey. In conclusion, the present study investigated that mixing calves with different age and size, cleanness of calf house, sex of calves and sharing of watering utensils by calves were the most important risk factors for calf morbidity whereas assisted delivery for calf mortality. Thus giving equal attention to both male and female calves, using separate watering utensils, paying especial attention to calves assisted during delivery, management of calves according to their age and size and improving the hygienic condition of calf houses were recommended as feasible strategies for reducing calf morbidity and mortality in the study areas.

Key words: Calves · Morbidity · Mortality · Hawassa · Yirgalem · Wondo-Genet

INTRODUCTION

Ethiopia is known for its high livestock population, being the first in Africa and tenth in the world. The livestock sector was imminent that livestock products and by-products in the form of meat, milk, honey, eggs, cheese and butter supply provide mainly the needed animal protein that contributes to the improvement of the nutritional status of the people [1, 2]. Ethiopia holds large potential for dairy development [3]. According to the survey result, the total livestock population for the country is estimated to be about 59.5 million cattle, 30.7 million sheep, 30.2 million goats, 1.21 million camels, 2.16 million horses, 8.44 million donkeys, 0.41 million miles

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and 56.53 million poultry. In Southern Nations, Nationalities and People Regional States (SNNPRS), the total cattle population is estimated at 11.5 million [4]. Nearly all the cattle population (98.41%) is found in rural areas while a small proportion (1.59%) is found in urban areas [2].

The livestock sector is an important sub-sector of Ethiopia's economy in terms of its contributions to both agricultural value-added and national gross domestic product (GDP) and in subsistence agriculture in the quest to attain human food security and good welfare [5]. Despite a large number of livestock, productivity, in general, is low in the country, mainly due to the low genetic quality of local breeds, poor nutrition and animal health problems. Similar to low-income African countries, per capita consumption of food from a livestock origin is low, mainly due to uncontrolled animal diseases, poor husbandry and poor infrastructure [6].

The substantial demand-supply variance in milk and milk products for the major urban centers in Ethiopia is a great opportunity for the development and flourishing of peri-urban dairy farms. Large commercial and market-oriented smallholder urban and peri-urban dairy production systems have tremendous potential for development and could play a significant role in mitigating the acute shortage of dairy products in urban centers. For these systems to develop and flourish and to ensure their sustainability, the constraints with the systems need to be addressed [7]. To maximize the supply of dairy products, different strategies have been designed and implemented. One of the strategies is crossbreeding of local dairy cattle with exotic dairy cattle, to incorporate the adaptive nature of local breeds with high productivity of exotic breeds [8].

The foundation of a successful dairy industry using improved breed is laid on the consistent calf crop production. The proper care and management of calf crop, particularly for the replacement heifers is very crucial for the dairy enterprise to grow and prosper. Good calf rearing is important as it ensures the availability of good future replacement stock [9]. Optimal calf rearing is the key component in the replacement management procedure within the dairy and beef production systems. The successful raising of healthy calves that grow optimally and attain either reproductive life or market weight age is vital to the sustenance of the dairy or beef herds [10].

Calf morbidity and mortality are the major problems faced in raising replacement stock. High incidence of calf morbidity and mortality incurs a great economic loss to dairy producers. This arises from death loss, treatment cost, decreased lifetime productivity and survivorship. Calf mortality represents an irrefutable and irrevocable financial source of economic loss to the dairyman due to loss of the present value of the calf and loss of genetic potential for herd improvement [11, 12].

Few studies are available in Ethiopia about dairy calf mortality and morbidity [13-19]. Calf mortality between 0-1 year rangesfrom10% to 33% [19]. Moreover, based on producers' responses to the questionnaire, calf morbidity and mortality were ranked as next to the mastitis problem for the different settings of dairy production in Addis Ababa milk shed in Ethiopia [20]. Previous estimates [21] indicated that a calf mortality rate of 20% can reduce net profit by 38% and therefore in a profitable dairy farm, calf mortality rate should be kept below 5% [22].

There is paucity of information about the incidence and risk factors of dairy calf morbidity and mortality in the present study area (Hawassa, Irgalem and Wondo Genet). To the researcher's knowledge, there is only one published epidemiological study done to estimate the prevalence and incidence rates of calf morbidity in smallholder dairy farms in Hawassa. Therefore, this research was conducted to fill the prevailing information gap regarding the type and magnitude of the major causes of dairy calf mortality and morbidity in the study areas. The specific objectives of this study were to estimate the incidence of calf morbidity and mortality, to identify the major causes of calf morbidity and mortality and to assess risk factors associated with calf morbidity and mortality.

MATERIALS AND METHODS

Study Area: The study was conducted between November 2017 and July 2018 in urban and peri-urban dairy farms found at Hawassa, Yirgalem and Wondo Genet towns. Hawassa is the capital city in Southern Nation's Nationalities and People's Region and that of Sidama Zone of Ethiopia. It is located on the shores of Lake Hawassa in the Great Rift Valley 273 km south of Addis Ababa on the main road heading to Moyale. Hawassa lies at a latitude of 7° 3'N and longitude of 38° 28'E and its elevation is1708 meters above sea level [23]. Hawassa gets an annual average rainfall of 933.4 mm and has an average temperature of 19.5°C and humidity of 70-80 % [24].

Wondo Genet is one of the district in Sidama zone and a resort town in Ethiopia. It is located southeast of Shashemene and 27 kilometers west of Hawassa at a latitude of 7° 1'N and longitude of 38° 35'E. It has got an

elevation of 1723 meters. The cattle population of Wondo Genet district is about 61, 689. Irgalem (Amharic also spelled Yirgalem) is one of four Sidama zone administrative towns and the center of Dale district in Sidama Zone, SNNPR. It is located 315 kilometers south of Addis Ababa and 45 kilometers south of Hawassa. Geographically, the town lies at a latitude of 6° 44'N and longitude of 38° 28'E, at an elevation of 1776 meters, its average minimum temperature is 11.5°C and the max temperature is about 26°C and its annual rainfall is 1200mm [25].

Study Population: All breeds of calves from birth to 1year of age found in selected urban and peri-urban dairy farms at Hawassa, Yirgalem and Wondo Genet towns were the study population for this particular study. The total number of registered dairy farms found at Hawassa, Yirgalem and Wondo-Genet was estimated to be 163, 70 and 50, respectively. Out of these, 118 farms with five or more cows were selected purposively for the present study. The selected farms had a total of 2088 cattle which comprised 1141 (54.64%) cows, 425 (20.35%) heifers, 83(4%) bulls and 523(25.1%) calves <1 year of age. The management system of these farms varied from semi-intensive (33%) to intensive systems (67%). In intensive farms, cattle were kept indoors all the time and provided with roughages and concentrates. The semi-intensive farms are characterized by outdoor grazing at day times and provision of supplementary feed in the morning and evening before milking. House construction design in the study area varied from farm to farm. Some of them have built the wall with block and others built with wood and mud, whereas the floor was constructed in concrete, soil compact with or without beddings. The drainage system was not sufficient enough to remove the slurry. The size of the herds ranges from 5 to 150 cattle and the average herd size was 15. The breed of cattle was local, Jersey and HF cross with different blood levels.

Study Design: A prospective longitudinal type of study design was followed to determine the incidence of major calf health problems on selected dairy farms in the three towns mentioned above. The prospective longitudinal study involved monitoring of apparently healthy calves ≤1 year at regular intervals for a minimum of 5 to 7 months to determine the incidence rate of calf morbidity and mortality in the selected dairy farms. Besides, a cross-sectional questionnaire survey was also conducted at the beginning of the study to collect data on animal and management factors assumed associated with calf morbidity and mortality.

Selection of Dairy Farms and Calves: As the majority of dairy farms in the study areas were assumed to have a small number of calves, the selection of farms was based on herd size and willingness of the farmer to participate in the study. Accordingly, to increase the chance of getting more calves, those farms with five or more cows were purposively selected from the total list of dairy farms in the study areas. Based on this criterion, a total of 118 farms were identified (45 from Hawassa, 39 from wondo Genet and 34 from Yirgalem). At the beginning of the study, there were 417 calves from birth to one year of age in the selected farms. All these calves were screened for any clinically visible abnormality and health-related problems. Of these, 26 calves were found clinically diseased and consequently excluded from the prospective longitudinal study. Thus, 391 healthy calves were recruited initially for the prospective study. Moreover, 106 other calves were recruited progressively as they were born and purchased within the selected farms during the study period. Thus, the total number of calves monitored throughout the study period was 497.

Data Collection

Questionnaire Survey: A questionnaire survey was undertaken at the very beginning of the study. The owner or other person mostly responsible for the management of the animals in the selected farms was interviewed using a semi-structured questionnaire. The interview was focused on critical factors that might be associated with morbidity and mortality of dairy calves at the farm levels such as farm-related factors (educational status of the owners, whether dairy is a primary or secondary source of income for the owner), calf related factors (herd size, breed, sex and age of calves and parity of the dam), management-related factors (care of the newborn, calving facility, calf-dam separation, method of colostrum and milk provision, weaning ages of the calves, cleanness of calf house, housing condition of the calf; the occurrence of calf morbidity and mortalities in the previous year, vaccination and treatment history of the farms) and others.

Observation of Calves: The present study of calves started with identifying calves by their respective ear tags, color, or the dam's identification card. Then calves were followed up for a period of 7 months from November 2017 to June 2018. All eligible calves recruited for the study at the beginning in the selected farms were regularly visited every two weeks for a minimum of 5timesand a maximum of 14 times to determine the occurrence of new cases of calf morbidity and mortality.

Whenever any illness was encountered, the diseased calf was examined clinically; and fecal samples from diarrheic calves were collected for parasites and bacterial isolation and identification. All cases encountered were recorded until the end of the study period. Moreover, any cases of calf deaths were also recorded including the possible cause of death. At each visit, the physiological parameters (temperature, pulse and respiratory rate) of the diseased calves were measured.

Laboratory Examination: When diarrhoea was encountered, feces were collected directly from diarrheic calves through either rectal swabs or rectal stimulation. Once collected, fecal samples were clearly labeled & transported in a cool box to the laboratory of the Faculty of Veterinary Medicine of Hawassa University for parasitological and bacteriological examinations. For parasites, fecal floatation was used. The principle of fecal flotation is simply based on the density difference between flotation solutions. A centrifugation step is commonly included in the testing procedure to increase the detection sensitivity as the centrifugation concentrates the target for easy viewing under a microscope. In this study, fecal floatation was conducted for the identification of *Cryptosporidium* and *Eimeria* spp. which are commonly encountered protozoal parasites in diarrheic calves. When *Eimeria* spp. encountered, the Eggs per gram of feces (EPG) was determined by the McMaster technique. For isolation of the common bacterial causes of diarrhoea, fecal culture was carried out [26].

Study Variables
Dependent Variables:

- The occurrence of new cases of diseases from any cause (Yes/No)
- The occurrence of new cases of mortality from any cause (Yes/No)

Independent Variables: They are variables that influence the occurrence of the dependent variable (calf morbidity/calf mortality). These include animal housing condition, educational status of the owner, dairy as a source of income, method of colostrums feeding, frequency of cleaning calf barns, houses and pen, post-natal calf housing, calving facility, time of first colostrum feeding, the method of milk feeding, parity status of the dam, separation of the calf, mixing calf with a cow, mixing of calves with different age and size, feeding system of weaned calves, watering utensils (common/separate)and water sources, delivery status of calves and weaning age, contact with other animals, grazing (private or communal), health care (vaccination) and environment (climate, agro-ecology, landscape) or herd factor (sex, breed, herd size and age of calves).

Data Management and Analysis: All data collected from the questionnaire survey, clinical examination of calves and laboratory examinations and mortality were coded and entered into the Microsoft Excel spreadsheet. Data obtained through a questionnaire survey were summarized using descriptive statistics such as count and percentage.

The incidence risk of crude calf morbidity was calculated by dividing the number of new cases of any clinical health problem over the total number of calves at risk at the beginning of the study. Only calves free of any disease at the start of the study period were considered to be at risk. The true incidence rate was computed as the number of new cases of any clinical health problem over animal time at risk. The periods at risk, or animal time at risk, is the sum of the periods of observation for each calf during which the latter is free from any disease (i.e., is at risk). As soon as a calf became diseased or died, it no longer contributed to this value. The contribution of each calf to the total animal time at risk was the difference between its date of exit or disease or death or end of the study and its date of entry (or the start of the study). The association between the potential risk factors and crude calf morbidity rate was analyzed on STATA version 14.2 (Stata Corp, 4905 Lakeway Drive, College Station, Texas 77845, USA) using the Cox regression (proportional hazards) model. The dependent variable was calf morbidity or mortality from any cause (Yes/No). The independent variables considered were breed, sex and age of the calf, parity status of the dam, herd size, delivery, educational status of the owner, dairy as a source of income, frequency of cleaning calf barns, management, calving facility, time of first colostrums feeding, method of colostrums feeding, separation from the dam, method of milk feeding, mixing of calves with different age groups, mixing of calves with cows, weaning age, feeding system of weaned calves, watering utensils (common/separate)and water sources. A P- value < 0.05 was considered as significant.

RESULTS

Questionnaire Survey: The questionnaire survey revealed that about 75% of the farm owners were male and 25% females. According to their educational status,

the majority of the farm owners/respondents were educated. That is33% completed primary education, 32% secondary education, 14.7% college/ university education and only 20.3% of the owners had no formal education, Of the total dairy farmers, 57 % run dairy as a primary source of income whereas 43 % as a secondary source. Regarding dairying experience, the majority (78 %) of the farms had 5 or more years of experience. The selected 118 dairy farms had a total of 2088 heads of cattle that were composed of 713 (34%) lactating cows, 344 (16.5%) dry cows, 83 (4%) bulls, 425 (20.35%) heifers and 523 (25.1%) calves less than 1 year (Table 1). The average herd size of dairy cattle per farm in the study area was 15and the range is from 5 to 150 heads of cattle.

The management system of the dairy farms varied from semi-intensive (33%) to intensive systems (67%). Of the calves included in the study, 62% were assisted during delivery while 38% were delivered normally. About 76% of the dairy farmers understand that colostrum is important for calves while 24 % didn't know its importance. Colostrum was provided to calves during the first 6 hours of life in 67 % of the farms. The method of colostrum feeding in most of the farms (66 %) was suckling by the calf. Nearly all (91%) farms didn't have a separate maternity pen for cows. As the study indicated only 54 % calves were separated from dams before nursing but 46 % calves were separated after nursing. Among selected dairy farms, 69 % responded that they kept calves with different age and size mixed while 31 % raised calves separately according to their age and size. On the other hand, there was a mixing of calves with cows inside barns in 40 % of the farms but not in 60% of the farms. As to the frequency of milk feeding, 87 % of farms feed twice a day but 13 % of feed only once per day. The majority of respondents (69 %) practiced residual suckling while 31 % allow calves to suckle before milking. Routine umbilical care practice or navel treatment during the birth of calves was common in only 12.1 % dairy farms whereas it was not commonly practiced in 87.9 % of the farms. The weaning age varied from farms to farms. In most of the farms (60.1%), the weaning age was ≥ 4 years while in 30.9% of farms it was below 4 years. As the study showed calf pen was cleaned regularly in 38% of the farms while infrequently in 62 %. The watering utensils for calves were common in 51% of the farms. Hand-dung well was the most common source of water for calves that reported in64% of the farms (Table 2). Among interviewed dairy farms, about 77.1% and 64% of dairy farm owners explained that calf morbidity and mortality is a problem in their farms, respectively. They further underscored that of the 431 calves born in the previous year 112(26%) have died from different causes. About the management of sick calves 80.5% of the farms call for a veterinarian, 17% took the sick calf to the veterinary clinic and the rest 2.5% have employed a veterinarian (Table 2).

About causes of calf morbidity, diarrhoea was the most (58%) frequently reported cause followed by respiratory problems (40%), ecto-parasites (25.4%) and septicemia (26%). Moreover, naval illness (21.2%) and fungal infection of the skin (8.5%) were also identified as causes of calf morbidity even though they were not most prevalent. The affection of farms by more than one disease or cause was more common (Table 3). Diarrhoea was also the most dominant cause of calf mortality claimed by 33 % of the dairy farmers. The other important causes of mortality reported were pneumonia (23%), unknown causes (11%), bloat (16%) and sudden death (12%; Table 4).

Cross-Sectional Study: At the onset of the study, a total of 417calves from birth to one year of age found in the selected dairy farms were examined for any visible health-related problems to recruit disease-free calves for the longitudinal study. Of those total calves examined, 26 (6.2%) calves were found clinically diseased due to diarrhoea (12), pneumonia (4), anthrax (2), LSD (2), mechanical trauma (1), arthritis (2) and external parasites (2). As a result, these calves were excluded from the prospective longitudinal study. Furthermore fecal samples from all the 417 calves were screened for gastrointestinal (GI) parasites. Accordingly, 169(40.5%) calves were found affected with one or more GI parasites (Table 5). Among those the GI parasites identified were *Eimeria* spp (36%), *Strongyles* (29.6%), *Ascaris* (5.86%) and *Trichuris* spp (4.1%). Concurrent infestation with two or more parasites occurred in 14.29% (n = 21)of the affected calves. A quantitative fecal examination was carried out using McMaster techniques to determine the intensity of infection by these parasites. The study showed that the mean oocyst per gram of feces (OPG) of *Eimeria* spp. was 700 OPG, the mean eggs per gram of feces for *Ascaris* were 600 EPG, the mean EPG of *Strongyle* type eggs was 500 EPG and that of *Trichuris* spp was 200 EPG (Table 6).

Prospective Longitudinal Study: About 391 healthy calves were recruited initially for the prospective longitudinal study of calf morbidity. Moreover, 106 calves added during the study (74 from birth & 32 from purchase)

Table 1: Socio-demographic characteristics of the dairy farmers (N = 118 farms)

Variable	Category	No	Proportion (%)
Dairying experience	<5 Yrs	26	22
	5-10 Yrs	44	37
	>10 Yrs	48	41
Sex of the owner	Male	88	75
	Female	30	25
Educational status of the owners	No formal education	24	20.3
	Primary school	39	33
	Secondary school	38	32
	College/university	17	14.7
Dairy farm as a source of income	Primary	67	57
	Secondary	51	43

Table 2: Description of management practices and calf morbidity and mortality in the dairy farms

Variable	Category	No of farms	Proportion (%)
Type of management practices	Intensive	81	67
	Semi-intensive	39	33
Maternity facility	Yes	11	9
	No	107	91
Is colostrum important to the calves	Yes	90	76
	No	28	24
How soon is colostrum feed to the newborn	Birth to 6hrs	79	67
	6 to 12hrs	32	27
	After 24hrs	7	6
Methods of colostrum feeding	Suckling	78	66
	Hand-fed	40	34
Methods of milk feeding to calves	Bottle/bucket	60	51
	Residual suckling	58	49
Routine umbilical care	Yes	60	12.1
	No	437	87.9
Mixing of calves with different age and size	Yes	82	69
	No	36	31
Mixing of calves with cows inside barns	Yes	47	40
	No	71	60
Weaning ages of calves	<4 month	47	39.8
	≥4 month	71	60.2
Cleaning of the calf pen	Regularly	45	38
	Infrequently	73	62
Type of floor	Concrete	83	70
	Soil	35	30
Bedding in the calf pen	Yes	46	39
	No	72	61
Watering utensils	Separate	58	49
	Common	60	51
Source of drinking water for calves	Tap	40	32
	Hand-dug well	75	64
	Motorized well	3	2
Is calf morbidity is a problem on your farm?	Yes	91	77.1
	No	27	22.9
Is calf mortality is a problem on your farm	Yes	76	64
	No	42	46
Management sick calves	Call a veterinarian	95	80.5
	Take to a nearby vet clinic	20	17
	Have employed veterinarian	3	2.5

Table 3: Major causes of calf morbidity in the dairy farms based on a questionnaire survey

Causes	No of farms claimed	No of the farms surveyed	Proportion (%)
Diarrhoea	68	118	58
Resp. Problem	47	118	40
Septicaemia	31	118	26
Naval illness	25	118	21.2
Ectoparasites	30	118	25.4
Fungal infection of the skin	10	118	8.5

Table 4: Major causes of calf mortality in the dairy farms based on a questionnaire survey

Causes	No of farms claimed	No of the farms surveyed	Proportion (%)
Diarrhoea	39	118	33
Pneumonia	27	118	23
Bloat	19	118	16
Sudden death	14	118	12
Unknown cause	13	118	11

Table 5: Type of clinical health problems and GI parasites detected in dairy calves during cross at the beginning of the study

	Calf-level			Herd-level		
Cause of calf morbidity	No of the calves examined	No of calves affected	Prevalence (%)	No of the farms examined	No of farms affected	Prevalence (%)
Diarrhoea	417	12	2.9	118	8	6.78
Pneumonia	417	4	0.95	118	3	2.57
External parasite	417	2	0.48	118	2	1.7
Anthrax	417	2	0.48	118	2	1.7
LSD	417	2	0.48	118	2	1.7
Mechanical trauma	417	1	0.24	118	1	0.84
Lameness	417	1	0.24	118	1	0.84
Total	417	26	6.2	118	19	16

Table 6: Prevalence and intensity of each type of GI parasite in dairy calves in the study area during the cross-sectional study (N = 417)

GIT parasites identified	No of calves affected	Prevalence (%)	Proportion (%)	Mean OPG/EPG	OPG/EPG range
Eimeria spp	61	14.6	36	700	100-1200
Strongylus	50	12	29.6	500	100-1900
Trichuris spp	7	1.7	4.1	200	100-400
Ascaris	30	7.2	10	300	100-1700

were also included in the study. Therefore, the total number of calves monitored during the study period for the incidence of calf morbidity was 497. These calves were followed for 5 to 7 months and thus, contributed for a total of 59, 308 animal days at risk which is equivalent to 1, 977 animal months at risk. For the incidence of calf mortality, a total of 523 calves (including those calves with the clinical disease at the beginning of the study and new calves added during the study) were followed up. These calves contributed for a total of 62, 291 animal days at risk which is equivalent to 2, 076 animal months at risk (Table 7).

Of the total 497 calves monitored during the study period, 147 calves were found affected with one or more clinical health problems. Accordingly, the crude morbidity rate (due to all causes) was estimated at 0.074 cases per calf month or 74 cases per 1000 calf months at risk. Of the 391 calves initially at risk, the number of disease cases recorded was 114. Thus, the crude incidence risk of calf morbidity is 29.2%. Of the total 523 calves monitored for incidence of mortality, a total of 48 calf deaths were recorded during the follow-up time from different causes and thus, the crude mortality rate was calculated to be 0.023 cases per calf month or 23 cases per 1000 calf months at risk. Of the 417 calves initially at risk of mortality, the number of mortality cases recorded was 42. Thus, the crude incidence risk of calf mortality is 10.1% (Table 7).

The present indicates that diarrhoea was the leading cause of calf morbidity and most frequently observed clinical disorder (46.94%), followed by pneumonia (25.85%), external parasites (12.25%), LSD (5.44%), mechanical trauma (4.44%) and foot and mouth disease (4.08%) (Table 8). The causes of calf mortality in their order of importance were diarrhoea alone (45.8%), pneumonia alone (27.08%), unidentified causes (14.6%) and diarrhoea and pneumonia (12.5%) (Table 9).

During the follow-up period, from a total of 69 diarrheic calves observed, 59 untreated representative fecal samples were collected and examined for GI parasites and cultured for bacterial isolation. Feces were collected directly from the rectum of affected animals and intended to examine for the presence of *E. coli, Salmonella* and GI parasites. According to the lab examination result, 49.2 % were positive for *E. coli*, 15.3% for Salmonella, 22 % for GI parasites and 13.5% for other bacteria (Table 10).

Table 7: Incidence of calf morbidity and mortality in dairy farms of Hawassa, Wondogenet and Yirgalem towns

Description	No calves initially at risk	No of calves monitored	Calf days at risk	Calf months at risk	No of new cases	Incidence rate	Incidence risk (%)
Crude morbidity	391	497	59, 308	1977	147	0.074	29.2
Crude mortality	417	523	62, 291	2076	48	0.023	10.1

Table 8: Causes of calf morbidity identified in the study calves

Causes	Total number of calves affected	No of calves affected	Proportion (%)
Diarrhoea	147	69	46.94
Pneumonia	147	38	25.85
External parasite	147	18	12.25
Mechanical trauma	147	8	5.44
FMD	147	6	4.08
LSD	147	8	5.44

Table 9: Causes of calf mortality identified in the dairy farms

Causes	Total No of calves died	No of the calves died by each disease	Proportion (%)
Diarrhoea	48	22	45.8
Pneumonia	48	13	27.08
Diarrhoea and pneumonia	48	6	12.5
Unidentified case	48	7	14.6
Total	48	48	100

Table 10: Causes of diarrhoea based on laboratory examination

Causes of diarrhoea	No of calves positive	Total number of diarrheic calves	Proportion (%)
E. coli	29	59	49.2
Salmonella	9	59	15.3
GIT parasites	13	59	22
Other bacteria	8	59	13.5
Total	59	59	100

Table 11: Final multivariable model Cox regression analysis of incidence rate of calf morbidity with potential risk factors in the study farms

Factor	Category	Haz. Ratio	Std. Err	z	P>|z]	95% Conf. Interval for HR
Water utensils	Common Separate	1.4 Ref	0.24	2.08	0.038	1.02 -2.0
Mixing calves with different age and size	No	Ref				
	Yes	2.1	0.47	3.29	0.001	1.35-3.27
Cleaning of calf houses	Regularly	Ref				
	Infrequently	1.68	0.30	2.92	0.004	1.18-2.37
Sex of calf	Male	1.5	0.25	2.52	0.012	1.1-2.11
	Female	Ref				

Ref = Reference category

Table 12: Final multivariable Cox regression analysis of calf mortality rate with potential risk factors in the study dairy farms

Factor	Category	Haz. Ratio	Std. Err	z	P>|z]	95% Conf. Interval for HR
Calving difficulty	Normal	Ref				
	Assisted	1.9	0.61	2.11	0.035	1.04 - 3.58

Ref = Reference category

Analysis of Risk Factors for Calf Morbidity and Mortality Calf Morbidity: Management and animal level risk factors evaluated for their association with an incidence rate of calf morbidity in unavailable Cox regression analysis were housing condition, method of colostrums feeding, house cleanness, the method of milk feeding, sex, age and breed of calves, parity of the dam, separation of a calf, mixing of calves, water sources, time of first colostrums feeding, calving facility, delivery status of calves and weaning age. However, in the backward stepwise multivariable Cox regression model only four factors namely, water utensils, mixing of calves of different age and size, sex and frequency of cleaning of calf house were observed to have a significant effect on

the incidence rate of crude calf morbidity. The rate of calf morbidity was higher in dairy farms where the water utensils for calves are common (HR = 1.4, *P = 0.038*), there is the mixing of calves with different ages and size (HR = 2.1, *P* = 0.001), in infrequently cleaned farms (HR = 1.68, *P* = 0.004) and male calves (HR = 1.5, *P*=0.012) compared to the reference group shown (Tables 11).

Calf Mortality: Management and animal level risk factors evaluated for their association with the calf mortality rate in uni-variable Cox regression analysis were housing condition, method of colostrum feeding, house cleanness, the method of milk feeding, sex, age and breed of calves, parity of the dam, separation of a calf, mixing of calves, water sources, time of first colostrum feeding, calving facility, delivery status of calves and weaning age. In the backward stepwise multivariable Cox regression model, only delivery was observed to have a significant effect on the incidence rate of crude calf mortality. The rate of calf mortality was significantly higher in calves required assisted delivery (HR = 1.9, *P* = 0.035) than those born without assistance (Table 12).

DISCUSSION

Calf morbidity and mortality are among the major problems of the dairy farming system worldwide. The present study was conducted to estimate the incidence rate of calf morbidity and mortality and investigate the underlying risk factors in 118 selected dairy farms in Hawassa, Yirgalem and Wondo Genet towns. A total of 497 healthy calves were monitored for 5 to 7 months for new cases of calf morbidity and mortality. The overall morbidity rate for the study period was 0.074 (74 cases per 1000 calf-months at risk) while the overall mortality rate was found to be 0.023, (23 cases per 1000 calf-months at risk). On the other hand, taking only those calves initially at risk, the overall morbidity risk and mortality risk were computed 29.2% and 10.1 %, respectively. The present mortality risk is lower than the wide range of findings (10.2 – 71.1%) reported by several studies from Ethiopia and abroad [12, 14, 18, 27-35]. However, it is relatively higher than the 3.4%, 6.5%, 7% and 9.3% figures reported by Hailemariam *et al*. [13], Shiferaw *et al*. [16], Amuamuta *et al*. [36] and Megersa *et al.* [37], respectively. It is also higher than the3 to 5% calf mortality that can be achieved through good calf management and above the economically tolerable level at least by the standard of the western production systems [38, 39].

The current crude calf morbidity risk (29.2%) is lower than that reported by previous authors: 66.7% by Asefa and Ashenafi [34]; 62.0% by Wudu *et al*. [18], 47.3% by Yeshwas *et al.* [19]; 29.3% by Megersa *et al.* [37] and 61.5% by Hossain *et al*. [12] but higher crude calf morbidity finding than that of 4.42% by Bangar *et al.* [40]. The lower morbidity and mortality risk of calves found in this study might be due to relatively better farm management practices, awareness among dairy farmers and veterinary services in the study areas.

The present research showed that calf diarrhoea (46.94%) is the predominant calf health problem and the leading cause of death in most calves aged 0- 3 months followed by pneumonia (25.85%). Our finding is in agreement with other studies in Ethiopia and many other countries [7, 15, 18, 41- 44] which reported diarrhoea and pneumonia as the first and second important disease complexes that affect calf health even though, there are some studies which found pneumonia as the leading cause of calf mortality contrary to our finding [16, 38]. The reason why diarrhoea was the predominant cause of calf morbidity and mortality might be due to poor hygienic conditions of calf houses, sharing of water utensils, mixing of calves of different age and size, the effect of sex of calves and assisted delivery. The present study also investigated other health problems of calves diagnosed less frequently such as external parasites (12.5%), mechanical trauma (4.44%), FMD (4.08%) and LSD (5.44%).

As indicated by previous reports [18, 26], viruses such as rotavirus and corona virus; estrogenic bacteria particularly *E. coli* and salmonella and protozoal infections such as cryptosporidium and coccidian are incriminated as causes of diarrhoea and consequently, mortality at an early age. This study also attempted toinvestigatetheinfectious agents associated with calf diarrhoea based on the available lab facility. Accordingly, *E. coli* and *Salmonella* spp. were isolated from 49.2% and 15.3% diarrheic calves, respectively. In agreement with the present finding, several authors reported *E. coli* as cause of calf diarrhoea from different parts of Ethiopia [34, 45- 48]. The dominance of *E. coli* in calf diarrhoea could be due to failure in proper management practices, such as inadequate sanitation, improper hygienic management which increases the opportunity for exposure to these organisms [45].

In the current investigation, 21 potential risk factors for calf morbidity and mortality were analyzed by using Cox regression analysis. Of those factors, only four risk factors namely, cleaning of calf houses, water utensils,

mixing calves with different age and size and sex of the calves were found significantly associated with the incidence rate of calf morbidity. The cleanness of the calf house was an important risk factor found to significantly affect crude morbidity risk in calves. The risk of calf morbidity was 1.68 times higher in calves kept in infrequently cleaned houses than in those reared in regularly cleaned houses. As most infectious agents are acquired by calves from the immediate environment, the high risk of calf morbidity in unclean houses observed in the present study is logically supported and consistent with the findings of other researchers in different areas [7, 16, 34, 37, 48].

In the present study, mixing of calves with different age and size was the other important factor that significantly affected calf health. The rate of morbidity was 2.1 times higher in calves kept mixed with different age and size than in those managed separately according to their age and size. The reason for higher morbidity in calves may be given that poor management practice of calves and their increased susceptibility to disease and environmental stress than older animals and an increased risk of exposure to different types of diseases from older aged calves too young too. These results are in agreement with Bangar *et al*. [40] and Duguma *et al.* [49].

The present study also showed that water utensils were significantly associated with calf health problems. The rate of morbidity was 1.4 times higher among calves used watering utensils in common than those provided water in separate utensils. The reason for this the fact that watering utensils can serve as fomites upon which infectious agents can be carried from one calf to another as a result of contamination of water by infected animals. This finding is consistent with what has been stated in the literature [50].

The sex of calves was significantly associated with calf morbidity. Male calves were at higher risk of morbidity as compared to female calves. Perhaps this is associated with the fact that more emphases and health care were given to female calves rather than male calves due to their replacement ability. Moreover, although the weaning age of the male calf is more or less the same as a female calf, male calves were provided with fewer amounts of milk and colostrum and consequently, they had more chances to acquire the disease. This finding correlates with what has been reported by Uetake [33], Bangar *et al*. [40] Zelalem *et al*. [51], Raboisson *et al*. [52]; Abdullatief *et al*. [53] and Islam *et al*. [54]. How it is contrary to other authors who reported sex has no significant effect on calf mortality and morbidity [34, 35].

Calving difficulty was the only risk factor associated with calf mortality rate. Calves that required assisted delivery were at increased risk of mortality (HR = 1.9; P = 0.035) than those that were born without assistance. The current finding is in agreement with Lombard *et al*. [55] and Asmare [56] who noted that calves that were born from cows with dystocia have higher mortality. When calves are suffering from pain after calving assistance, they become weak to stand and suckle. 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 (Ig) absorption efficiency as well as delayed or decreased intake of colostrum and resulted in a higher risk of mortality in calves that were assisted during birth.

CONCLUSION AND RECOMMENDATIONS

The present prospective cohort study established the incidence, major causes and risk factors of calf morbidity and mortality in dairy farms found at Hawassa, Yirgalem and Wondo Genet towns. The total crude calf morbidity rate was 0.074 (74 cases per 1000 calf-months at risk) while the mortality rate was found to be 0.023 (23 cases per 1000 calf-month at risk). In the current study diarrhoea and pneumonia, singly or concurrently, were identified as major causes of calf morbidity and mortality but also mechanical trauma, external parasites, lumpy skin disease and foot and mouth disease were recorded as causes in some farms. Gastrointestinal parasites such as *Eimeria* spp*, Ascaris, strongyles* and *trichuriasis* were also identified in the study calves up on fecal examination. In the present study, 21 potential risk factors were evaluated with dairy calf morbidity and mortality. Of these, commonly used water utensils, mixing calves of different age and size, lack of regular cleaning of calf house and sex of calves (special male calf) were significantly associated with dairy calf morbidity whereas assisted delivery was the single factor that affected dairy calf mortality rate.

Based on the above conclusion the following recommendations were forwarded:

- Efforts should be made to prevent diarrhoea and pneumonia as they are the most common causes of calf morbidity and mortality in the study area.
- Regular cleaning of calf sheds should be practiced in all farms.
- In the dairy farms, calves should be managed according to their age and size.

- An appropriate disinfection regime should be used in calf houses.
- Dry cow vaccination should be practiced to provide the calf with the needed protection through the consumption of the dam's colostrums as they are susceptible to diarrhoea in the first two weeks of age.
- Male calves should be treated equally as to the female calves
- Watering utensils should be separate for each calf to reduce the risk of water contamination.
- Dairy farmers need to give special attention to those calves required assistance at delivery to reduce the risk of calf mortality
- Further studies using highly sensitive and specific tests are required to isolate and characterize the specific agents causing diarrhoea, pneumonia and septicemia in calves to control and prevent losses due to these diseases.
- Finally, awareness creation of dairy farmers on the major risk factors of calf morbidity and mortality through continued extension service is of paramount importance to reduce losses and enhance dairy profitability.

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