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Calf Morbidity and Mortality Rate and the Associated Risk Factors in Small Holder Dairy Farms in Kembata Tembaro Zone, Southern Ethiopia

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Abstract: A prospective cohort study and cross-sectional survey were conducted from December 2021 to July 2022 in Kembata Tembaro zone, Southern Ethiopia. The objectives of the study were to estimate the incidence rate of calf morbidity and mortality and identify associated risk factors. A total of 140 new born calves from sampled small-holder dairy farms were enrolled and followed for 6 months/180 days. The recruited calves and those born after the initial visit were ear-tagged at the earliest farm visit. The speed at which an event occurs per unit time at risk (true rate) was calculated to define the risk of morbidity, mortality and other specific disease conditions. The incidences risk of calf morbidity and mortality found in this study were 41.7% and 9.5%, respectively. Calf diarrhea, pneumonia, navel ill, septicemic conditions, non-specific and other miscellaneous cases were disorders encountered during this study. The most frequently encountered disease condition was calf diarrhea with the incidence risk of 14.8% followed by septicemic condition 11.3% and calf pneumonia 10.4%in the period observed. Generally, Condition of birth, Time of first colostrum ingestion and Parity of dam were found significantly associated with crude mortality. Condition of birth, Site of birth, Floor of birth place, Time of first colostrum ingestion, Parity of dam, Source of breeding service and breed were found significantly associated with crude morbidity by multivariable Cox-regression at P <0.05. Calves born easy were at lower risk (HR=0.6, p=0.001) of morbidity than assisted calves. The relative hazard (HR=0.9, p=0.008) of morbidity of calves born indoor were at lower risk than those born outdoor. The relative hazard (HR=0.6, p=0.009) of morbidity of calves which ingest colostrum with in six hour after birth were at lower risk than calves which ingest colostrums after six hour. Further more, floor of birth place, parity of dam, breed and source of breeding service were found to be additional risk factors of calves' morbidity. Time of first colostrum ingestion, parity of dam and condition of birth were also the risk factors determining calf mortality. A sound dairy calf management practice, needs understanding and manipulating of the above-mentioned calf health determinant factors with subsequent application of tailor-made interventions.

Key word: Calf · Kembata Tembaro · Morbidity · Mortality · Prospective Cohort

INTRODUCTION

Livestock production is one of the most important means to achieve better living standards in many regions of the developing world. The national economies and the livelihood of rural communities in sub-Saharan African countries like Ethiopia are largely depended on livestock production. Ethiopia has the largest livestock population in Africa. Dairying is becoming one of the most important parts of livestock sector where calves are future herd of a dairy farm in Ethiopia and currently the country has given the priority on the development of dairying at farmer level to increase the supply of milk from smallholder dairy farms [1].

The dairy industry is a large and dynamic segment of the agricultural economy of many nations and the major suppliers of milk and milk products to the urban and per urban consumers [2]. Per urban and urban dairies are intensive production systems, which keep high grade cows and have improved management practices but this is usually associated with increased susceptibility to disease, poor survival rate and poor reproductive performance [3].

Calf morbidity and mortality are perennial problems for dairy producers worldwide especially in the tropics which is not an ideal location for calf rearing as the high temperature and humidity introduce many potential disease problems to milk fed calves which impair

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appropriate heifer replacement [2]. Heifer replacement markedly influences the ability of dairymen to increase production by allowing him to practice selective culling of low productive cows [4].

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 [5]. Calf hood diseases have, therefore, a significant financial impact on dairies resulting from treatment costs, genetic loss and impaired future performance [6]. Furthermore, many of the infectious agents that cause calf diarrhea can pose a considerable threat to humans (*E. coli, Salmonella, Campylobacter and Cryptosporidium*) [7]. Gastrointestinal helminthes are important pathogens which affect young livestock in many tropical and subtropical environments [8]. 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 [9].

Farms in young stock, a good nutritional strategy optimize rumen development and growth while minimizing stress and disease. Livestock housing and surrounding environment of dairy farm greatly affects health and productivity. Following Hygienic conditions and Cleanliness of the barn influences calf health, as calves housed in unclean barns are at higher risk of disease than calves housed in clean barns [10]. Colostrum contains a high level of immunoglobulins and other nutrients important for calf health and gives immunity against a variety of infectious agents. The poor immune system and lack of previous exposure to infection make new born calves susceptible to infectious diseases and poor management [11].

It is therefore, essential to explore the existing dairy production environment, analyze constraints of dairy production and devise pertinent and workable strategies for sustainable market-oriented dairy development in the country [12]. Dairying based on indigenous cattle alone would not be a quick and suitable option to meet the increasing demands for milk and milk products in Ethiopia, as the indigenous cattle in the tropics is limited by low milk yield, low lactation length and poor growth rates [13]. The most favored alternatives in this regard could be incorporating crossbreeding (Local with improved European dairy breeds) scheme and intensification of animal production and shifting of subsistence livestock production systems towards large scale commercial production units [3].

The current Ethiopian livestock breeding policy emphasizes upgrading the genetic makeup of the local stock through crossing with high-grade exotic breeds of cattle. As a result, the proportion of crossbred calves is gradually increasing in the smallholder dairy farms mainly in the highlands of the country, suggesting a susceptible population that will need improved health and proper management. One of the major health and management intervention areas recently proposed in the Livestock Development Master Plan is aimed at reducing young and adult stock mortality [14].

Calf morbidity and mortality cause significant economic loss in the dairy farms industry due to the death loss, treatment costs, poor growth performance and decrease life time productivity. It also causes the loss of genetic material for herd improvement and decrease the number of dairy heifers available for herd replacement and expansion. These loss rates have increased in recent years [15]. In order to minimize losses, the causes of calf morbidity and mortality and the associated risk factors need to be identified and appropriate control measures are implemented [16]. Except one longitudinal observational study done on calf morbidity and mortality in dairy farms in Sodo town and its suburbs [17], so far, no reliable estimates found on the incidence of calf morbidity and mortality with detailed epidemiological analysis of risk factors in urban and peri-urban dairy production systems of Kembata Tembaro zone and surrounding zones. Thus, there is a need to conduct exhaustive study in order to devise tailored recommendations to improve calf health and production performances in the study areas. Therefore, this study was aimed to estimate the incidence rate of major causes of calf morbidity and mortality and identify associated risk factors in Kembata Tembaro zone in Central Ethiopia Region.

MATERIALS AND METHODS

Description of the Study Area: The study was conducted from December 2021 to July 2022 in Kembata Tembaro zone, Southern Ethiopia (Figure 1). Kembata Tembaro zone is one of the zones in SNNP region of Ethiopia. It is bordered on the south by Woliata zone, on the west by the Omo River or Dawro zone, on the north by Hadiya zone and on the east by Halaba zone. The absolute location of Kembata Tembaro zone is lies between Latitude 07°12'30.1" - 07°17'08.3" N and Longitude 37°47'48"-37°50'30.6"E. Average temperature (°C) and annual rainfall of the area is ranges between 14°C to

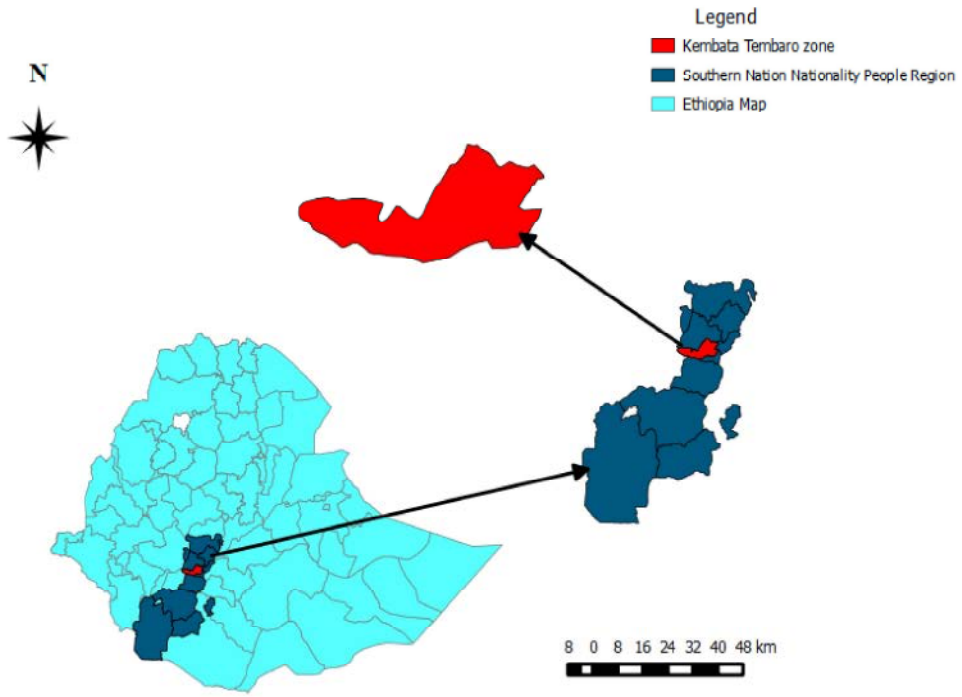

Fig. 1: Map of the Study Area

26°C and 800 ml to 1200 ml rainfall. The study had covered Hadero, Shinshicho and Durame towns and their surrounding kebeles in Kembata Tembaro zone. The estimated livestock population of the Kembata Tembaro zone is 812175 cattle, composed of 575020 local zebus and 237155 crossbreed. There are 125358 farms in Kembata Tembaro zone; from these in Durame town and its surrounding 3471 small holder dairy farms, Shinshicho town and its surrounding 2584 small holder dairy farms and Hadero town and its surrounding 2172 small holder dairy farms [18].

The study was conducted in the urban and per-urban smallholder dairy farms, which located in and around Hadero, shinshicho and Durame towns in Kembata Tembaro zone in SNNP region of Ethiopia. The smallholder dairy farms located in the towns were taken as urban dairy farms, which cover semi-intensive management and are engaged in market oriented dairy production. Dairy farms located on the outskirts of the respective towns were considered us per urban dairy farms. Accordingly, a total of 63 study farms, peri-urban (34) and urban (29) were used for this study. Of which, 89 and 51 female and male calves were recruited respectively for the study cohort. In this study, according to Muraguri *et al*. [19], a smallholder dairy farm was defined as one with at least 1 and at most 20 cattle of all ages and sexes. All breeds of dairy calves of both sexes reared under smallholder dairy farms and calves aged between births to 6 months were considered in the study. However, still born calves, calves with deformities and wasting diseases were excluded from this study. Following recruitment into the study, routine monitoring of study calves was done at 2-weeks intervals until 6 months age. In addition to regular visits, emergency visits were paid in response to calls from dairy farm owners for calf health problems.

Study Design: The study was conducted by a prospective cohort study design. The study was conducted using questionnaire and field observation for the assessment of associated risk factors on calf morbidity and mortality. The questionnaire survey was carried out by interview to smallholder dairy producers during the study period to obtain herd-level data relating to farm characteristics, calf and dam factors, management, health and environmental associated risk factors. It was used to support the prospective cohort results.

Calf Recruitment Criteria: A total of 140 new born calves from sampled small-holders dairy farms were enrolled and followed for 6 months/180 days. Calves of less than one months of age at the initial visit and whose disease history and date of birth known were recruited retrospectively (concurrent cohort) and allowed to join into the prospective cohort.

Other calves were recruited progressively as they were born within the selected farms during the study period. Purchased or entrusted calves were not included in this study. The recruited calves and those born after the initial visit were ear-tagged at the earliest farm visit. All selected calves were regularly visited in 2 week intervals by the investigator as well as by kebele animal health professionals (assigned enumerator) until the calves reached 6 months of age. Calves were withdrawn from the follow up when they completed their 6 months of age. When calf loss happened during the follow up period, date and reason of loss was recorded. Individual calf risk factors were identified by means of check-off forms provided by the investigator at the beginning of the study. Calf level recording off sheet is attached (Annex II).

Sample Size Determination: The desired sample size was calculated using the standard formula described by Dohoo *et al*. [20] and expected relative risk10.1 %, that is taken from the previous finding at Hawassa by Agegnehu and Rahmeto [21] as follows;

$$n = Z^2 - pq/L^2;$$

where *n* =sample size, $Z\alpha$ = the value of standard normal distribution at 95% level of confidence ($Z\alpha$ = 1.96), p=expected relative risk 10.1%, q=1-p, L= the required absolute precision of the estimate (5%). 1.96^2x0.101x0.899/0.0025 = 140

Accordingly, the calculated sample size was 140 calves.

Sampling Technique: Study sites were selected purposively based on their dairy potential. The sampling units were all local and crossbreed dairy calves aged between birth and 6 months. The selection process of farmers was done purposely 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 all-dairy farms in the study areas.

Data Collection: Data was collected on hypothesized risk factors that were presumed to be associated with dairy calf health and survival. Risk factors were grouped into farm and calf level factors. Data on farm-level factors include farm description, calf colostrum management, calf housing, health and overall feeding management. Calf-level factors include recording of genealogy of the calf, place of birth, calving events, colostrum administration, initial housing, routine management practices applied to the calf and health problem incidents that were observed during the monitoring period. Records of mortality, specific disease events and treatments were maintained by the investigator by using standardized case definitions. Standardized case definitions are shown in Annex III.

The major activities that have been accomplished during the regular visits were;

- Asking calf attendants about the occurrence of calf health problem incidents between the visits and recording of the history of the calf health problem.
- Clinical examination of calves for any health problem. This involved physical examination of calves and taking normal body parameters like body temperature, respiratory rate and pulse rate when abnormalities are suspected.
- Observation on cleanness of the calf house and assessment of the condition of the barn floor (housing type, ventilation, drainage system) and general hygiene in calf house and its surroundings.
- Observation of calf feeding practices and type of feeds given (concentrate, hay or straw /crop residue).
- In addition to regular visits, emergency visits were paid in response to calls from dairy farm owners for calf health problems.

Data Management and Statistical Analysis

Estimation of Morbidity and Mortality Rates: Morbidity and mortality are the outcome measures of interest in this study. Morbidity is defined as any sickness with recognizable clinical signs which ultimately ended in death or warranted therapeutic intervention during the course of follow up period. Whereas, mortality is defined as any observed death irrespective of cause. As animals in this longitudinal study were recruited at different times and were followed for different periods of time and thus incident density (true rate) was used in describing diseases occurrences. The speed at which an event occurs per unit time at risk (true rate) was calculated to define the risk of morbidity, mortality and other specific disease conditions [19]. Therefore, the incidence rates (IR) or cause specific rates were estimated by the following formula:

$$IR(x) = \frac{\text{number of events occured during observation period}}{\text{Total calf days risk}}$$

The numerator is the number of occurrences of the outcome of interest, whereas the denominator is the number of calf-days at risk for the given period. Number of calf days at risk was calculated by adding the number of days at risk of obtaining a new case in each calf from birth up to 6 month of age or the time of removal from the herd. In the calculation to describe crude morbidity rate, a calf recovered from an illness was considered to be at risk for another illness. Similarly, two or more cases of the same disease condition was considered as different cases in calculating the incidence of that disease condition as far as the second occurred after the disappearance of the clinical sign of the first [22]. For this study purpose, total calf days at risk were converted to calf months at risk, as the age of calf is defined up to six months. Moreover, to facilitate result comparisons with other findings and because of directly taking true rate results tend to overestimate calf morbidity and mortality rates [23], true rates calculated for mortality, morbidity and other specific disease conditions were derived into risk rates based on the formula ($RR= 1^{-e -True\ Rate}$) [24].

Investigation of Risk Factors for Morbidity and Mortality: Generally, 27 potential risk variables were recruited associated with crude morbidity and crude mortality. Of which, 5, 5, 8, 7 and 2 were calf, dam, management, farm attributes and environmental risk factors respectively (Annex IV). The responses (outcome) of all variables were dichotomized to facilitate analysis and interpretation of results.

Survival Analysis and Modeling Risk Factors: The association between the potential risk factors and crude calf morbidity and mortality was analyzed on STATA version 14 (Stata Corp, 4905 Lake way Drive, College Station, Texas 77845, USA, Serial number: 501406202773) used to run Cox regression. Furthermore, to evaluate and quantify the association between explanatory variables and survival up to 180 days of age, Cox's proportional hazard model was used. Initially, the association of individual risk factor with an outcome variable was screened by univariable Cox-regression. Those variables significantly associated with the outcome variable at 5% significance level in the univariable analysis were recruited for multivariate analysis using multivariable Cox-regressions to see their independent effect. In the multivariable analysis a model was fitted for each outcome variable by stepwise backward elimination of insignificant variables ($P>0.05$).

RESULTS

Herd Level Study Based on Questionnaire

Household Characteristics of the Respondents: The household and dairy performance characteristics of smallholder respondents are presented in Table 1. Among the total smallholder dairy producers interviewed in Kembata Tembaro zone, 46% were urban and 54% were peri-urban smallholder dairy farms and 77.8% of households were male headed and 22.2% were female headed, the age of 36.5% of the house hold was =45 years and 63.5% was >45 years old. As to the respondent's literacy rate, 9.5% of dairy farm owners were illiterate, elementary education 34.9%, high school completed 41.3% and the remaining 14.3% were professionals, of which only 3.2% were found related to animal production and animal health.

About sixty-six (66.7) % of respondents had knowledge of the advantage of feeding colostrum to calves over ordinary milk and fed colostrum with in six hours of birth. But the remaining 33.3% respondents did not have the knowledge of the advantage of early colostrum feeding and hence new born calves were enforced to suckle partial residual colostrum (they discard first colostrum) and are allowed to suckle colostrum lately, after the retained placenta is expelled out. Modes of calf feeding were free grazing (12.7%) stall feeding (63.5%) and grazing with partially supplement (23.8%). Source of water for calves was tap water (36.5%), from river (31.7%) and from open well (4.8%). Only 7.9% of dairy farm owners had not provides the bedding materials and the rest 92.1% farm owners provide bedding material.

Calf-level Study/Longitudinal Observation

Distribution and Dynamics of the Cohort: A total of 140 calves (104 cross and 36 local) calves were recruited from 63 selected small holder dairy farms in urban and peri-urban dairy farms from Kembata Tembaro zone. Almost all calf entries resulted from births within the study farms. Purchased calves during the study period were not included in this study due to lack of complete calf information. Female and male calves contributed 89 (63.6%) and 51(36.4%) of the entries over the observation period, respectively. They contributed a total of 23972 calf days at risk, which is also equivalent to 133 calf six months at risk.

The dynamics of the study cohort is shown here under in Table 2. A total of 15 calves out of 140, which contributed to the follow ups exited due to deaths and

Table 1: The household and dairy performance characteristics of smallholder respondents

Herd level Variables	Parameters	Frequency	Percent
sex of house hold	Female	14	22.2%
	male	49	77.8%
Age of house hold	≤ 45 years	23	36.5%
	>45 years	40	63.5%
Educational status of house hold	Illiterate	6	9.5%
	elementary	22	34.9%
	high school	26	41.3%
	professional	9	14.3%
Experience calf caretaker	≤ 5 years	28	44.5%
	>5 years	35	55.5%
Location of farm	Urban	29	46.0%
	Per urban	34	54.0%
Duration of farm	< 5 years	11	17.5%
	5-10 years	30	47.6%
	>10	22	34.9%
Calving facilities	Present	44	69.8%
	absent	19	30.2%
Awareness to colostrum feed	Yes	42	66.7%
	no	21	33.3%
Time of first colostrum feeding	≤ 6 hours	42	66.7%
	> 6 hours	21	33.3%
Mode of feeding	free grazing	8	12.7%
	stall feeding	40	63.5%
	Partial grazing	15	23.8%
Source of water	tap water	40	63.5%
	river	20	31.7%
	open well	3	4.8%
Bedding	Present	58	92.1%
	absent	5	7.9%

Table 2: Number of calves monitored and reasons of withdrawals from the longitudinal cohort

		Withdrawals		
Visit at monthly basis	Number of calves	Deaths	Sales	Total
First Visit	91	-	-	-
January	33	4	1	5
February	16	4	0	4
March		3	1	4
April		0	0	0
May		2	0	2
June		0	0	0
July		0	0	0
Total	140	13	2	15

sales from the study before the termination of the cohort period. The total exit rate was 10.7% of which 9 (6.4%) and 6 (4.3%) were females and males, respectively.

Estimates of Morbidity and Mortality

Incidence of the Morbidity: The crude morbidity and cumulative incidences of various disease conditions/ syndromes recorded in the study is presented in table 3.The incidence risk of morbidity was 41.7%. From disease conditions encountered during the follow up period, calf diarrhea was the leading cause of calf morbidity with incidence risk of 14.8%, followed by septicemic conditions 11.3%, pneumonia 10.4%. The incidences of other calf hood diseases were relatively low.

Incidence of Mortality: The incidence of calf mortality associated with different diseases is shown in Table 4. The calf mortality risk in the present study was 9.5%.

Table 3: Incidence (true rate and risk rate) of crude morbidity and specific disease conditions in Kembata Tembaro zone

				Incidence	
Disease condition	N	Calf days at risk	Calf six months at risk	True rate (6Calf months at risk)	Risk rate (%)
Diarrhea	21	23374	130	0.16	14.8
Pneumonia	14	24198	134	0.11	10.4
Septicemic conditions	16	23918	133	0.12	11.3
Naval ill	3	24585	137	0.02	2.2
Miscellaneous cases	5	24740	137	0.04	3.6
Non specific	2	24859	138	0.02	1.5
Crude morbidity rate	61	20475	114	0.54	41.7

Risk rate = 1-e-$^{\text{true rate}}$ N= number of cases

Table 4: Incidence (true rate and risk rate) of crude mortality and specific disease conditions in Kembata Tembaro zone

				Incidence	
Disease condition	N	Calf days at risk	Calf six months at risk	True rate	Risk rate (%)
Diarrhea	5	24516	136	0.04	3.9
Pneumonia	2	24865	138	0.02	1.5
Septicemic conditions	4	24815	138	0.03	2.9
Non specific	2	24933	139	0.01	1.4
Crude mortality rate	13	23972	133	0.1	9.5

Risk rate = 1-e-$^{\text{true rate}}$ N= number of cases

Table 5: Potential risk variables significantly associated with the incidence of crude morbidity based on univariable analysis using cox regression

Variables	Categories	HR	95% CI for HR	P- value
Condition of birth	Easy *vs* assisted	0.6	0.4 -0.9	0.001
Site of birth	In door *vs* out door	0.8	0.2 -0.9	0.035
Floor of birth place	Concrete *vs* Mud	0.4	0.07-0.6	0.001
Time of first colostrum ingestion	<6 hours *vs* > 6 hour	0.6	0.2-0.9	0.032
Parity of dam	Prim parous *vs* multiparous	1.7	1.2-7.0	0.001
Source of breeding service	AI *vs* bull	0.5	0.2-0. 8	0.012

HR= Hazard ratio (which has similar meaning to relative risk), CI= confidence interval

Table 6: Potential risk variables significantly associated with the incidence of crude morbidity based on multivariable analysis using cox regression

Variables	Categories	HR	95% CI for HR	P- value
Condition of birth	Easy *vs* assisted	0.6	0.3- 0. 7	0.001
Site of birth	In door *vs* out door	0.7	0.3- 0.8	0.008
Floor of birth place	Concrete *vs* mud	0.4	0.3- 0.7	0.001
Time of first colostrum ingestion	<6 hours *vs* >6hours	0.6	0.1- 0.7	0.009
Party of dam	Prim parous *vs* multiparous	1.6	1.4- 2.9	0.011
Source of breeding service	AI *vs* bull	0.6	0.4- 0. 9	0.001
breed	Cross *vs* local	1.5	1.1- 11.3	0.038

HR= Hazard ratio (which has similar meaning to relative risk), CI= confidence interval

In this study the main cause of calve mortality was calve diarrhea (scouring) either watery or bloody, which is evidenced by 5 death records among overall 13 dead calves. Next to calf's diarrhea Septicemic conditions was the main cause for calve mortality, which was 4 death records among overall 13 dead calves. Two calves died of Pneumonia and the other two calves died of non-specific cause which includes sudden death.

Association of Explanatory Variables with Morbidity and Mortality

Risk Factors of Crude Morbidity: According to univariable Cox-regression six risk factors were found significantly associated with calf morbidity (P<0.05; Table 5).

In the multivariable analysis a model was fitted for morbidity by stepwise backward elimination of insignificant variables (P>0.05). However, after multivariable modelling at P<0.05, Condition of birth, Site of birth, Floor of birth place, Time of first colostrum ingestion, Parity of dam, breed and Source of breeding service were found significantly associated with crude morbidity (Table 6).

According to the model, holding the effect of other variables constant, the relative hazard of morbidity in those calves born easy was 0.6 times compared to calves born by assisted, the relative hazard of morbidity in those calves born indoor was 0.7 times compared to calves born outdoor, the relative hazard of morbidity in those calves born on Concrete was 0.4times compared to calves born

Table 7: Explanatory variables significantly associated with the incidence of crude mortality based on univariable analysis using cox regression

Variables	Categories	HR	95% CI for HR	P- value
Condition of birth	Easy *vs* assisted	0.5	0.06-0.8	0.0016
Time of first colostrum ingestion	<6 hoursss *vs* >6 hourss	0.3	0.04-0. 8	0.024
Parity of dam	Prim parous *vs* multiparous	1.7	1.3-3.7	0.001

HR= Hazard ratio (which has similar meaning to relative risk), CI= confidence interval

Table 8: Potential risk factors significantly associated with the incidence of crude mortality based on multivariable analysis using cox regression

Variables	Categories	HR	95% CI for HR	P- value
Condition of birth	Easy *vs* assisted	0.6	0.3-1.0	0.047
Time of first colostrum ingestion	<6 hoursss *vs* >6 hourss	0.4	0.04-1.0	0.039
Parity of dam	Prim parous *vs* multiparous	1.5	1.2-3.4	0.001

HR= Hazard ratio (which has similar meaning to relative risk), CI= confidence interval

on mud, the relative hazard of morbidity in those calve ingestion colostrum for first time in <6 hours was 0.6 times compared to those calves ingestion colostrum for first time in >6 hours, the relative hazard of morbidity in those calves born from Prim parous dam was 1.6 times compared to those calves born from multiparous dam, the relative hazard of morbidity in those calves born from AI was 0.6 times compared to those calves born from bull and the relative hazard of morbidity in those calves with cross breed was 1.6times compared to those calves with local breed.

Risk Factors of Crude Mortality: Only three explanatory variables significantly (P<0.05) associated with mortality by univariable Cox-regression modelling (Table 7).

In the multivariate analysis a model was fitted for mortality by stepwise backward elimination of insignificant variables (P>0.05). However, after multivariable modelling at P<0.05, Condition of birth, Time of first colostrum ingestion and Parity of dam were found significantly associated with crude mortality (Table 8).

According to the model, holding the effect of other variables constant, the relative hazard of mortality in those calves born from Prim parous dam was 1.5 times compared to those calves born from multiparous dam, the relative hazard of mortality in those calves born easy was 0.6 times compared to calves born by assisted and the relative hazard of mortality in those calves ingestion colostrum for first time in <6 hourss was 0.4 times compared to those calves ingestion colostrum for first time in >6 hours. Thus, higher risk of mortality related to delayed intake of first colostrum meal could be associated with failure of passive transfer of colostral immunity.

DISCUSSION

This study was conducted to determine the incidence rate of calf morbidity and mortality and to investigate the associated risk factors of calf morbidity and mortality in small holder dairy farms in Kembata Tembaro zone. The study was designed to meet the intended objectives through herd level questionaries and calf level longitudinal observations.

Herd Level Findings Based on Semi-structured Questionnaire and Observation: The involvement of women in dairy farming (owners) in the study area was found to be high (22.22%), when compared to the previous reports of 11% women ownership of small holder dairy farms of Debre Ziet [25]. This indicates that smallholder dairy farming provides self-employment to women and, therefore, contributes to the alleviation of poverty in this particular group. A reason for this could be the results of women supportive by current local government.

The study revealed that the majority 66.7% of the farmers does have awareness about colostrum, but 33.3% of the dairy owners don't know about the right time to feed colostrum to calves. In this study 66.7% of the owners practiced feeding of colostrum to the new born with <6 hoursss after birth. This was considered by different researchers as a good practice of ensuring enough colostrum to the calves in the early hours to keep the animals health and protect liability to some neonatal diseases and mortality [10, 26, 27].

Morbidity and Mortality: In the present study, calf morbidity risk and mortality risk of 41.7% and 9.5% were recorded respectively, which is considered as high. This finding was higher than 3 to 5% calf mortality risk that can be achieved through good calf management and above the economically tolerable level [23, 28].

The magnitude of calf mortality rate found in this study has considerably congruent with other findings reported in Hawassa town [29]. Conversely, the present mortality rate finding was relatively higher when compared to some previous reports in Ethiopia [30-33]. This report was also found relatively lower than that of some earlier reports in Ethiopia [10, 34-37].

The discrepancy between the present and previous reports in Ethiopia might be attributed to variations in many calf and herd-level risk factors, management practices, age of the calf considered, breed of study calves, agro-ecology and the method they used to measure mortality (incidence rate/risk or prevalence).

In general, most of the times, morbidity statistics is unavailable in many farms and difficult to make comparisons, unlike mortality. If available, variations are wide; this might be partly due to lack of reliable morbidity records by dairy producers and the different methods used in diagnosis. For instance, some authors report calf morbidity based on producer diagnosis and treatments, while others depended on veterinarian diagnosis [22]. The present morbidity rate finding was relatively higher when compared to some previous reports in Ethiopia [29, 33] who reported 29.3% and 30.9%, respectively and the present morbidity rate finding was relatively lower when compared to some previous reports in Ethiopia [10, 26, 39] who reported 62%, 58.4% and 47.3%, respectively.

Cause Specific Morbidity and Mortality: In the present study, calf diarrhea was found to be the predominant calf health problem with incidence risk of 14.8% followed by Septicemic conditions (11.3%) and pneumonia (10.4%). The risk of calf diarrhea in this study was higher from some previous studies in Ethiopia [29,33,36] who reported 10%, 10.4% and 10.43%, respectively. In contrary, the present outcome was less than from some previous studies in Ethiopia [10, 17, 26] who reported 34%, 25.2% and 42.9% respectively. This finding has also been supported by other studies [10, 26] who documented the calf diarrhea as the commonest disease. Nonetheless, calf diarrhea as a prominent health problem in growing dairy calves, the lower incidence in this study suggests the significance of hygienic handling of feeding utensils and calf house observed during the study. Besides, based on interview and observation, most of the smallholder farmers were aware of the optimal time for colostrum feeding and this could greatly contribute to the lower incidence of calf diarrhea.

The next dominant calf health problem in this study was septicemic conditions with incidence rate of 11.3% and this was different from some studies which was pneumonia next to calf diarrhea [17, 26, 33, 35, 36]. The relatively lower incidence of pneumonia in this study might be due to the small -herd size of farms. The incidence rates of other calf health problems were found lower.

Determinants of Calf Morbidity and Mortality: About 27 hypothesized explanatory variables were tested for their association with crude mortality and morbidity in small-holder dairy farms located in Kembata Tembaro zone. However, procedurally these variables were examined stringently through univariable and multivariable analysis by using Cox-regression. In the final model (multivariate Cox regression), Condition of birth, time of first colostrum ingestion and party of dam were investigated as risk factors of calf mortality. Site of birth, condition of birth, floor of birth place, time of first colostrum ingestion, source of breeding service, breed and parity of dam were also the proven determinant factors of calf morbidity.

Condition of birth was found significantly associated with calf mortality and morbidity. Those calves with history of born with assisted were at higher risk of mortality and morbidity than those calves born with easily. These findings were agreed with other finding [26, 33]. Time of first colostrum ingestion was found significantly associated with calf mortality and morbidity. Calf ingested their first colostrum later than 6 hours after birth was at higher risk of mortality and morbidity than those ingested within 6 hours after birth. These findings agree with other finding [10, 26, 33, 36]. The first six hours of calf life is the period in which maximum absorption of colostral immunoglobulin takes place and higher risk of mortality and morbidity was related to failure of passive transfer of colostral immunity during this period [37]. Parity of dam was found significantly associated with calf mortality and morbidity. Calf born from primparous dam was at higher risk of mortality and morbidity than those born from multiparous dam. These finding agree with similar reports [26, 33, 36]. These finding were disagreed with Assefa and Ashenafi, [17]. The immune status is better in calves from multiparous than prim parous dams; this could be due to insufficient or lower concentration of colostrum from first lactating heifers. Older cows tend to have more IgGs than first calf heifers, as they have been exposed to a greater number of pathogens during their lifetimes [38].

The other factor significantly associated with calf morbidity was breed. The local breed was higher resistant for diseases than cross breed. This finding was agreed with other finding [22, 26]. The effect of exotic genetic influence under the tropics environment on calf morbidity has been widely addressed. The effect of breed on mortality and morbidity has been detailed by many researchers. In general, the higher morbidity in crossbred calves might be associated with the susceptibility of *Bos Taurus* breeds to climatic and disease stress in tropical

environments [21, 40]. Thus, it is important to reconsider the recommendation of Yahya *et al.* [41], which suggested that keeping crossbred dairy cows of the intermediate exotic blood (62.5%-75%, Friesian inheritance) is better for health and production in the tropics. Site of birth was significantly associated with calf morbidity. The calves born outdoor were higher risk of morbidity than calves born indoor. This finding was agreed with other finding [17]. This was the difficulty of handling outdoor environmental condition. The floor of birth place was significantly associated with calf morbidity. Calves kept on mud floored farm were sick compared to calves kept on concrete floor. This finding was agreed with other finding [17, 42]. This might be because of difficulty in keeping mud floors clean and dry. Muddy, wet conditions have proven to be the source of increased morbidity because disease causing bacteria can grow rapidly [42].

CONCLUSION AND RECOMMENDATIONS

The incidence rate of calf morbidity and mortality was found to be relatively high in the studied area (Kembata Tembaro zone) with overall incidences risk of morbidity and mortality 41.7% and 9.5%, respectively. This morbidity and mortality magnitude is found higher than economically tolerable level. Thus, these higher rates of calf morbidity and mortality will be suppressing growth rate of the calves decrease their replacement capacity of the herd and ultimately hinders the success of small-holder dairy business. Calf diarrhea was the predominant calf health problem responsible for the majority of calf illnesses and deaths. This study has identified important risk factors that are significantly associated with calf morbidity and mortality. Calves born easy than assisted, indoor, in concrete place, those which ingest colostrum with in six hour after birth and local breed ones had lower risk of morbidity. Calves which ingest colostrum with in six hours after birth, born easy than assisted and with multiparous dams had also lower risk of mortality. Therefore, based on the above conclusion, the following points were forwarded as recommendation:

- Making tailor-made interventions against these determinant factors can certainly improve calf health status and production performances.
- Emphasis should be given to feeding complete colostrum as early as possible within 6 hours of birth through sustained awareness creation and rising.
- Emphasis should be given to continuous training of dairy farmers to raise their awareness towards calf health management practices.

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