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Original Article

Cross-Breed Neonatal Calf Mortality and Health Problems in Small-Scale Dairy Production in and Around Bishoftu Town, Oromia

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Abstract *- Calf mortality is a perennial problem for dairy producers worldwide and impairs appropriate heifer replacement. However, limited study has been reported on calf mortality in the study area. Hence, a Longitudinal prospective observational study was conducted between November 2016 to April 2017 in urban and peri-urban smallholder dairy farms of Bishoftu town on 158 live-born calves selected from 60 dairy farms to identify the risk factors associated with calf mortality. A questionnaire tool was used to collect information on the risk factors of calf mortality. Calf diarrhea was the leading cause of calf mortality, with a case-specific mortality rate of 3.1% among the causes of death recorded. The total cumulative incidence of mortality found in this study was 8.2 %. The association of 8 potential risk factors with dairy calf mortality was investigated. Of these factors, among others, delivery condition (OR=5.9, P=0.018), amount of colostrum (2L) (OR =0.17, P = 0.039), age of calf (OR=6.5, P=0.046), and farm size≥8 (OR = 12.9, P = 0.007), were the risk factors found to be significantly associated with the death of calves. The present study suggested that the existence of high mortality in small dairy farms might be due to poor farm and calf management. Hence, special emphasis should be given to the amount of colostrum feeding; proper management as the farm size increases and especially care management of the first week age of calves was found important. Moreover, further investigation is suggested to identify the specific causative agents incriminating for calf mortality in dairy farms of the study area.*

Keywords *- Bishoftu, Calves, Mortality, Risk factors, Smallholder dairy farms.*

1. Introduction

In many developing countries, raising livestock is one of the main ways to raise people's living standards. Livestock is essential to the national economy and the livelihood of rural inhabitants in sub-Saharan African nations (ILCA, 1998). However, this sector is growing relatively slowly in sub-Saharan African nations. In particular, the tropics are not ideal for calf rearing due to the high temperature and humidity, which introduce many potential disease problems to milk-fed calves (Moran, 2011), impairing appropriate heifer replacement. Calf morbidity and mortality are ongoing issues for dairy producers worldwide (Heinrichs and Radostits, 2001). By enabling dairy farmers to undertake selective culling of underproductive heifers, heifer replacement significantly influences dairy farmers' capacity to raise productivity (Moran, 2011).

Although other illnesses such as navel illness (Kasari, 1993), arthritis, bloat, septicemia, arthropod parasites, and nutritional diseases are also reported, the two primary diseases are diarrhea and pneumonia (Virtala *et al*., 1996), which are the most prevalent in young calves and pre-weaned calves, respectively. The development of dairy farms in Ethiopia can substantially impact poverty reduction and nutrition improvement in the nation due to the significant potential for smallholder income and employment production from high-value dairy products. However, the percentage of calf crop survival determines the success of any breeding program as well as the future of smallholder dairy farms. Therefore, calf mortality and morbidity are of major concern (Heinrichs and Radostits, 2001).

Because most deaths occur within the first two weeks of life, the neonatal period (0-28 days) is crucial (Wells *et al.*, 1997). Calves frequently endure episodes of diarrhea during the first few weeks of life when they are routinely fed whole milk or milk substitutes. These episodes are frequently brought on by infectious agents such as Rotavirus, Escherichia coli, Cryptosporidium parvum, or Salmonella spp (Ambrosim *et al*., 2002; Quigley, 2007). Cattle ranchers around the world suffer significant financial losses as a result of calf loss (Lundborg, 2004). Not only are there financial losses connected with death, but there are also losses of genetic material, intervention costs,

performance losses, and reduced output later in life (Wells *et al.*,.1997; Lundborg, 2004).

Mortality-causing calf diseases are the result of complicated interactions between the calf, its environment, its management practices, and its microbial pathogens. To reduce extreme calf disease problems, it is strongly advised that appropriate calf management practices be implemented (Wudu *et al.*, 2008). Although there have been some studies on the issue of calf illness and mortality in the study region, they have tended to concentrate on large and research-oriented dairy farms. Since the number of small-scale dairy farms is rapidly expanding and calf mortality is a widespread issue, the current study's primary focus was on these farms. Its objectives were to:

- To evaluate neonatal calf mortality rate in small-scale dairy farms in urban and peri-urban areas of Bishoftu town and
- To assess potential management risk factors associated with calf mortality.

2. Materials and Methods

2.1. Study Area

The study was conducted in Bishoftu Town. Bishoftu Town is located 45 km South East of Addis Ababa, the capital of Ethiopia. It lays 9^0N latitude and 40^0E longitude at an altitude of 1850m above sea level. The rainfall is bimodal. It receives an annual rainfall of 1151.6mm, of which 84% is received during the long rainy season covering June to September and the remaining in the short rainy season extending from March to May. The dry season extends from October to February. The mean maximum and minimum temperature of the area is 36^0C and 14^0C, respectively, and the mean relative humidity is 61.3% (NMSA, 2004).

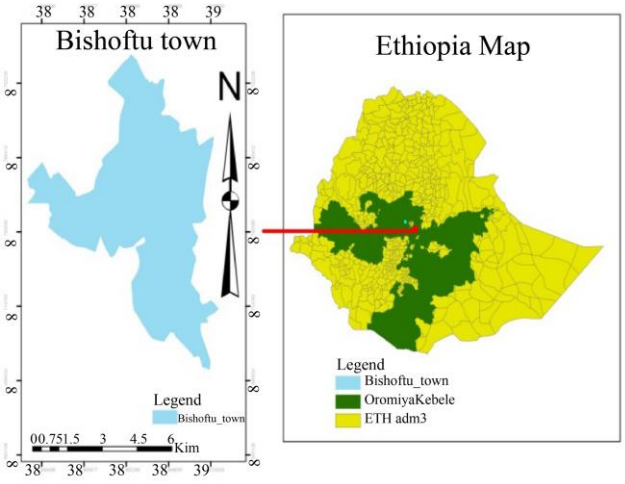

Fig. 1 The map of Ethiopia and location of the study site, Bishoftu town, in East Shoa (source: GIS)

2.2. Study Population

The sampling units for the study were cross-breed dairy calves of up to six months of age. All calves from smallholder dairy farms managed under intensive and semi-intensive systems in urban and peri-urban constituted the study population. There were 150 smallholder dairy farms with a herd size of eleven cows on average registered in the urban agricultural office of Bishoftu town.

2.3. Study Design

The study was a longitudinal prospective observational study that extended for six months from November 2016 to April 2017. The sampling units (calves) were identified individually and observed throughout the study period in a two-week interval.

2.4. Sampling Procedure and Sample Size

First, dairy cattle were sampled by cluster sampling technique from all dairy farms in the town. A sampling frame, i.e., the list of dairy farms, was acquired from the urban agricultural development office of Bishoftu town at the beginning of the study. Dairy farms were selected from the list using a random sampling procedure to ensure the selection of proportional and representative sampling of dairy farms from both urban and per-urban sectors. Accordingly, 60 smallholder dairy farms were visited on a cluster basis. In these selected farms, all calves less than two months and pregnant cows>seven months were included in the observation. Initially, the sample size using a simple random sampling method was determined at 11.6% expected calf mortality rate for Bishoftu (Gebremedhin, 2014) for large dairy farms, 95% confidence level, and 5% required absolute precision by using a mathematical formula (Martin *et al.*, 1987). The adjustment for cluster sampling using cluster size and intra-cluster correlation was made as follows.

$$N = n[1 + ((m - 1) * p)]$$

Where,
N=sample size for cluster sampling
n= sample size for simple random sampling
m=average cluster size
p= intra cluster correlation

However, in this particular case, as the average herd (cluster) sizes (calves per small-scale dairy farm) were small, the effect of intra-cluster correlation would be small and "N" will be very close to "n". So the sample size determined by simple random sampling was taken to be the sample size for the study (Martin *et al.*, 1978).

$$n = \frac{(Z\alpha/2)^2(p(1-p))^2}{\Delta^2}$$

n = sample size
Zα/2= confidence level
P= expected prevalence
Δ= precision level

Accordingly, data on 158 calves newborn and born two months before the start of the study were included. When a selected farm did not have a calf or calves (having calves under two months of age, a pregnant caw > seven months, or the owner is not interested eligible for the study, another farm replaced it.

2.5. Method of Data Collection

Observation of dairy farms for calf mortality was carried out for four months. For this study, the calf was defined as young cattle less than six months of age and mortality was defined as the death of calves above the age of 24 hours. For the observation, all calves in the selected farms under two months of age at the beginning of the follow-up period and those born in the subsequent months of follow-up were included. This way, each calf was observed for four months unless censured due to death.

Individual records were prepared when a calf joined the study cohort. These were used to record the genealogy of the calf, events surrounding the birth of the calf, routine management practices applied to the calf, and health problem incidents that happened during the observation. In the actual observation work, calves were regularly visited every two weeks. During this period, observations and in-depth interviews with farm owners or workers were made on different aspects associated with calf health problems and potential animal and management risk factors, including calf barn, sex and age of the calf, time of colostrum provision, milk supplementation after separation, naval disinfection, veterinary service, the amount of colostrum provision, age of separation from the dam, occurrence of calf mortalities and the general herd management aspect of the farm.

2.6. Data Management and Analysis

2.6.1. Describing Mortality Problems

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 death occurrence. Incident density was calculated by dividing the number of deaths by the number of calf weeks at risk. The number of calf weeks at risk was found by adding the number of weeks at risk of obtaining a new death in each calf in the study period.

2.6.2. Statistical Analysis

Questionnaire data were recorded on Microsoft Excel sheets and analyzed using SPSS version 20. Descriptive statistics were employed to determine the calf mortality rate. First, the association of individual risk factors with a death variable was screened by univariable logistic regression. Those variables with a p-value of less than 0.25 were selected forward for multivariable logistic regression. For all factors, a P-value of less than 0.05 was set to indicate association with calves' death.

3. Results

3.1. Incident Rate

The results of this study revealed that the cumulative mortality proportion in the first 6 months of calf hood was 8.2%. Among the causes of calf death recorded in this study, calf diarrhea was the leading cause of calf mortality, with a cause-specific mortality proportion of 3.2%, followed by septicemia (1.3%), pneumonia (1.3%) and nonspecific causes (1.3%) (Table 1). The mortality proportion of other causes of death (bloat and accident) recorded in this study was equivalent to a cause-specific mortality proportion of (0.63%). The calf death rate or incident rate was 0.0055/calf week.

The average occurrence of mortality incidents was 10 weeks. Proportionally, the highest mortality incidents occurred in the first week of life, in which 61.5% of the total mortality cases occurred. Again, 76.9 per cent of the total cases of crude mortality occurred in the first month of age, and 100% of the total cases of crude mortality occurred in the first three months of age.

Table 1. Causes of mortality in dairy calves (N = 158) and crude mortality

Health problems	Mortality cases	Crude mortality (%)
Diarrhea	5	3.1
Pneumonia	2	1.3
Septicemia	2	1.3
Bloat	1	0.6
Nonspecific causes	2	1.3
Accident	1	0.6
Death rate	13	0.0055calf-weeks
Total (NO=158)	**13**	**8.2**

3.2. Association of Potential Risk Variables with Incidence of Calf Mortality

A total of eleven different potential risk factors (sex, age, navel disinfection, time of colostrum ingestion, milk supplementation after separation from the dam, delivery condition, amount of colostrum ingestion, age of separation from the dam, calf barn, and farm size and management system of the farm) were investigated for their potential association with the occurrence of crude calf mortality. Among the risk factors assessed, the age of the calf (OR=6.5, P= 0.046), delivery condition (OR=5.9, P=0.018), the amount of colostrum ingestion (OR=0.17, P = 0.039) and farm size (OR = 12.9, P = 0.007) were found to be significantly associated with the death of calves while the other risk factors; separation of calf house from the farm and sex were not found to be significantly associated to the death of calves (table 2).

3.3. Description of Household and Livelihood Characteristics of the Farmers Based on Questionnaires and Observation

The farm owners were male (61.7%), and the rest (38.3%) were female. 48.7% of the age of the owners was between 31-50 years, while 26.6%, 16.7%, and 8.3% were above 51 years, 25-30 years, and less than 25 years, respectively. As far as household literacy is concerned; (16.7%), of the farm owners were illiterate, 30% attended primary school, 33.3% completed secondary school and diploma, and 20% were college graduates. The average herd size per household of the dairy cattle in the study area was 11 and ranged from 5 to 17 heads of cattle.

The average number of cross-breed calves per household was 2. About 61.7% of the owners had farm experience of more than ten years, while the rest, 28.3% and 10%, had 5-10 years and less than 5 years, respectively.

About 86.7% of the farm owners have no calving pen. All owners use artificial insemination (A.I.) for breeding, and 81.7% of the owners use dairy farms as a secondary source of income, whereas 18.3% of the owners mainly depend on the farm for livelihood. As the owner replied that hypocalcaemia (36.7%), mastitis disease (33.3%), bloat (15%), pasteurellosis (10%), and others (5%) were the common diseases affecting dairy farms.

Table 2. Multivariable logistic regression model output for potential risk factors of calf mortality

Risk factors	Group	Live births(n)	Death	Mortality rate %	OR	95.0%CI	P-value
Sex	Male	55	6	10.91	0.58	0.093-3.572	0.553
	Female	103	7	6.80	Ref*		
Age	≤1week	41	8	19.5	6.5	1.032-41.09	0.046*
	>1week	117	5	4.3	Ref*		
Delivery condition	Assisted	29	8	27.59	5.9	1.359-25.3	0.018*
	Normal	129	5	3.88	Ref*		
Amount of colostrum ingestion	Measured(2L)	101	3	2.97	0.17	0.03-0.915	0.039*
	Unmeasured	57	10	17.54	Ref*		
Calf barn	Separated	87	3	3.45	0.69	0.126-3.748	0.665
	Un separated	71	10	14.08	Ref*		
Farm size	≥8	81	11	13.6	12.9	2.02-81.3	0.007*
	<8	77	2	2.60	Ref*		

OR=Odd Ratio, CI=Confidence Interval, Ref*=Reference, *=Significant

The majority of the farmers (88%) had knowledge of the advantage of colostrum over ordinary milk. All of them did know the optimum time to feed colostrum to calves and provide milk supplementation after separation from the dam. However, the majority of them did not know the amount of colostrum needed for the newborn calf within 24 hours. None of them practices naval disinfection, and all of them call private veterinary practitioners whenever facing health problems with animals. Of farmers that mentioned calf health problems as a problem in dairy production, the majority of them (50%) complained that diarrhea is a major cause of calf morbidity and mortality. The majority of the owners sold male calves at a young age while they kept female calves for production purposes. The housing systems of the major dairy owners were loose, and no separation between calf and cattle houses. Most owners employ a person who keeps their cattle and cares for their calves.

4. Discussion

In the present observation, the overall mortality percentage of live-born calves up to four months of age on smallholder dairy farms is found to be 8.2%, which is considered high. Different authors reported a wider range of calf mortality rates in Ethiopia. Reported calf mortality varies widely depending on many factors, some of which may be specific to the particular population being studied. The finding of the present study is in agreement with the 9.3% and 10.2% mortality proportions reported by (Bekele *et al*., 2009) and (Assen *et al*., 2014). In contrast, the present finding was lower than the previous mortality reports in different parts of the country; 18.0% in Debrezeit (Wudu *et al*., 2008), 16-22% (up to 6 months age) in Wolaita Sodo (Assefa *et al*., 2014), and 30.7% in Bahir Dar and Gozamen districts of Amhara Region (Ferede *et al.,* 2014). The relatively less mortality rate in this study compared with the findings of (Wudu *et al*., 2008) in Debrezeit is probably due to the current better access to veterinary services in towns and their suburbs. In addition, the time elapsed for this investigation was lower than the previous one.

In the present study, the major causes of calf mortality identified were diarrhea, pneumonia, septicemia, bloat, accident, and nonspecific causes. However, calf diarrhea was found to be the dominant cause of calf mortality, with a cause-specific mortality percentage of 3.1%. This finding is in agreement with the reports of (Lemma *et al*., 2001), Habtamu (2007), (Wudu *et al*., 2008), (Bekele *et al*., 2009), (Konjit *et al*., 2013) and (Assefa *et al*., 2014) in Ethiopia, and many other studies elsewhere, which reported diarrhea as the first most important health problems causing calf death (Olsson *et al*., 1993; Debnath *et al*., 1995 and Sivula *et al.,* 1996; Torsein *et al*., 2011). Calf diarrhea, as a leading health problem in growing dairy calves, is a common finding. The high incidence of mortality in this study suggests the significant improvement of farm management and failure of adequate immunoglobulin due to the majority of the farm owners having the wrong perception that feeding a large amount of colostrum causes diarrhea in calves.

The lower mortality rate recorded for pneumonia in this study is with the studies conducted by Rao and Nagarecenkar (1980), (Agerholm *et al*., 1993), (Shiferaw *et al*., 2002) and (Gitau *et al*., 2010), which found pneumonia as the leading cause of calf mortality. The lower mortality incidence rate recorded for pneumonia in this study could be due to most of the owners using loose housing systems which provide good ventilation. This is supported by Blowey (1990), who indicated that low calf mortality due to

pneumonia has occurred in calves kept in good-ventilated houses. A well-designed study needs a high proportion of mortality due to unknown causes characterized by sudden death.

This investigation showed that mortality was higher during the first week of birth (OR=6.5; P≤0.046) and decreased with increasing age. Age was found to be the most important calf factor affecting their mortality. Among dead calves, 61.5% of deaths occurred at the age of less than 1 week. In this study, younger calves under the first months of age were at higher mortality risk. A similar age pattern of mortality has been reported by previous studies (Wudu *et al.*, 2008, Bekele *et al*., 2009). The higher risk of mortality in young calves observed in this study suggests the need for more careful management for very young calves.

Other risk factors were assessed to determine the magnitude of their association with the occurrence of dairy calf mortality delivery conditions. Mortality in calves delivered by assisting was higher compared to calves delivered normally (OR=5.9, p=0.018). The odds ratio (5.9), we estimated that the odds of death for cross-bred calves born assisted were around 6 times higher than calves delivered normally. When calves are suffering from pain after calving assistance, they become weak to stand and suckle. Murray *et al.* (2014) found that calves born following dystocia were more acidotic and took longer to attain sternal recumbence and stand compared to calves born normally, and Uigley (1997) noted that newborn calves stressed due to dystocia are weak enough to adapt to life in the external environment. This stress on the calves probably reduced the immunoglobulin absorption efficiency and delayed or decreased colostrum intake. Hence, the longer the calves are without adequate colostrum Ig, the more opportunity for the pathogens that provoke diarrhea to invade the gut.

The logistic regression analysis of mortality in dairy calves with respect to the amount of colostrum ingestion revealed that the highest mortality rate was observed in calves that took inadequate and unmeasured colostrum (OR=0.17; p=0.039). Hence, this study agrees with the theory which says that absorption of enough quantity and quality of colostrum is a critical determinant for the health and survival of neonatal calves. Calves that did not receive adequate colostrum are shown to have higher overall death rates. 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).

In this study, significantly (OR=12.9, P=0.007) high mortality of dairy calves occurred in farms where greater than eight animals were kept. This finding is supported by (Frank and Kaneene 1993, Schouten, 2003, and Bekele *et al*., 2009). Herd size has been positively associated with an increased incidence of calf diarrhea, one of the leading causes of mortality. This may be due to overstocking, or this difference might be that owners who kept less than eight animals have given sufficient time for nursing the sick calves, which might be the reason for lower mortality. Against the present finding, other studies conducted in Waliata Sodo town on dairy calf morbidity and mortality (Assefa *et al.*, 2014) revealed that calf mortalities were high in dairy farms when less than ten animals were kept.

5. Conclusion and Recommendation

The present study has estimated that the calf mortality proportion of 8.2% is higher than the economically tolerable level in dairy cattle. Mortality was higher at the lower age of calves in the first months of life. It has also found that the age of calves, unmeasured amount of colostrum, feeding and delivery condition, and farm size were important risk factors associated with calf mortality. This is a great hindrance to improving smallholder dairy production and productivity in the study area. The leading disease condition associated with mortality was found to be diarrhea. Known fact that the observed farms raise their own replacement stock and have small herd sizes, it is recommended that special emphasis should be given to naval disinfection of newborn calves, having confinement pens and paddocks used as parturition areas, the amount of colostrum feeding, implementation of proper management as the farm size increases and especial care management of first week age of calves were found important to minimize calf mortality. Moreover, further investigation is suggested to identify the specific causative agents incriminating for calf mortality in dairy farms of the study area.

Declaration

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Ethical Considerations

Since the research was undertaken by collecting data using questionnaires, it did not abuse animal welfare protocols. All procedure of data collection was carried out in accordance with relevant guidelines. This research studies comply with international guidelines, so we would like to firmly endorse that no ethical approval was required for this research article.

Limitations of the Study

This research was mainly focused on evaluating neonatal calf mortality rate and assessing potential management risk factors associated with calf mortality in small-scale dairy farms. Therefore, this research could not address the isolation, identification, and molecular characterization of major causative agents of calf mortality, and it will not reveal information about the antimicrobial resistance pattern of the causative agents within the study area, which is supposed to aid the effective prescription of antimicrobial drugs to reduce the problems of drug resistance developments. Since the study was conducted on small-

scale dairy farms, the finding of this research will not be extrapolated to the entire population.

Availability of Data and Materials

Since we want to work with the scientific and research community, the data underlying the findings of a paper should be publicly available wherever possible and as open as possible. We therefore firmly support and endorse the Findability, Reusability, and Accessibility of this article. So, we prefer to deposit the data in a public repository that meets appropriate standards of archiving, citation, and curation.

Funding

We write this to inform you that we are from a lower-income economy country and do not have any supporting body (Funding Institution) that makes the payment for the Article processing charge (APC). Hence, I would like to ask for the cancellation of APC and the publishing of this article without any fee.

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