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ORIGINAL PAPER

Calf morbidity and mortality in smallholder dairy farms in Ada'a Liben district of Oromia, Ethiopia

T. Wudu · B. Kelay · H. M. Mekonnen · K. Tesfu

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Abstract A longitudinal observational study on calf morbidity and mortality was conducted in smallholder dairy farms in Ada'a Liben district of Oromia, Ethiopia. A total of 185 calves from 112 market oriented smallholder dairy farms were selected randomly and regularly monitored for clinical health problems up to six months of age. Information on potential risk factors was collected by personal observation during the regular visit to farms and from questionnaire survey conducted during the study period.

The overall incidences of crude morbidity and crude mortality were 62 % and 22%, respectively. The most frequent disease syndrome was calf diarrhea with the incidence of 39% followed by joint ill 6%. The other disease conditions/syndromes diagnosed include navel ill, pneumonia, septicemic conditions, congenital problems and miscellaneous cases. Age of the calves, age at first colostrum ingestion and cleanness of the calf barns significantly influenced morbidity. Older calves (greater than three months of age) were at lower risk of crude morbidity than younger calves (less than three months of age) (HR=0.42, P=0.001). Higher risk of crude morbidity was observed in calves that ingested their first colostrum meal later than 6 hours of age compared to those that ingested colostrum earlier (HR=2.24, P=0.001). Similarly, calves housed in unclean barns were at higher risk of morbidity than calves housed in clean barns (HR=1.75, P=0.024). Of the 20 potential risk factors investigated, age was the only factor that was found significantly associated with mortality (HR=0.04, P=0.001). Calves older than three months of age were at lower risk of mortality than younger calves.

Keywords Smallholder · Dairy calf · Morbidity · Mortality · Risk factors · Ethiopia

T. Wudu (✉)
Faculty of Veterinary Medicine, University of Gondar,
P.O. Box 196, Gondar, Ethiopia
e-mail: temesgenha@yahoo.com

B. Kelay · H. M. Mekonnen
Faculty of Veterinary Medicine, Addis Ababa University,
P.O. Box 34, Debre-Zeit, Ethiopia

K. Tesfu
Akililu Lemma Institute of Pathobiology,
Addis Ababa University,
P.O. Box 1176, Addis Ababa, Ethiopia

Introduction

The future of any dairy production depends, among other things, on the successful raising of calves and heifers for replacement. Under modern dairy production in the developed world, the average length of time a cow stays in a milking herd is about four years and, therefore, 25% of the milking herd must be replaced each year (Bath et al. 1985). Generally calf diseases result from complex interaction of the

environment, infectious agents and the calf itself, and are the major constraints for raising replacement stock. The impacts of calf diseases could be direct (causing calf deaths) and indirect through increased treatment expenses and decreased lifetime productivity and survivorship (Waltner-Toews et al. 1986a). Calf mortality shows wide variations worldwide ranging from 1 to 30 % (Heinrichs and Radostits 2001). The few studies on calf mortality conducted in Ethiopia show mortality that range from 7 to 25 % (ILRI 1996; Hussien 1998; Amoki 2001; Shiferaw et al. 2002). Calf health problems cause loss of genetic material for herd improvement and decrease the number of dairy heifers available for herd replacement and/or expansion. Environmental and managerial factors are considered major determinants influencing the occurrence of calf morbidity and/or mortality (Lance et al. 1992; Bruning-Fann and Kaneene 1992).

In developing parts of the world including Ethiopia there is a growing trend in the development of market-oriented urban and peri-urban dairy farming which is becoming an important supplier of milk and milk products to urban centers. However, studies conducted on problems of calf morbidity and mortality particularly on market oriented smallholder farms in Ethiopia are very few.

The present study was, therefore, conducted to determine the incidence of calf morbidity and mortality and identify potential management and host related risk factors in dairy farms representative of the smallholder system.

Materials and methods

Study area and population

The study was conducted from October 11, 2003 to April 8, 2004 in the Ada'a Liben district of the Oromyia regional state (45 km south east of Addis Ababa). The area has an altitude of 1900 m and enjoys an average annual rainfall of 1150 mm in a bimodal distribution with short (March to May) and long (June to September) rainy seasons. The average maximum and minimum temperature of the area are 30.7°c and 8.5°c, respectively (National Meteorological Service Agency 2000). In the study area, there were more than 600 market oriented smallholder (MOSH) dairy farms with an average herd size of around three cows. The majority of MOSH dairy farms were organized under one dairy cooperative called Ada'a Liben Milk and Milk Products Marketing Cooperative. All farms were keeping crossbreed dairy cows (*B. taurus* × *B. indicus*).

Selection of study farms

At the start of the study the Ada'a Liben Milk and Milk Products Marketing Cooperative had 614 registered market oriented smallholders, nearly all market oriented smallholder farmers in the area. The list of members of Ada'a Liben Milk and Milk Products Marketing Cooperative was used as a sampling frame. Initially, the sample size using simple random sampling method was determined at 15% expected incidence of calf mortality(ILRI 1996), 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 intraculster correlation was made as follows.

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

Where,

- n' sample size for cluster sampling
- n sample size calculated for simple random sampling
- m average cluster size
- p intraculster correlation

However, in this particular case, as the average herd (cluster) size (calves per MOSH dairy farm) was only 1.6, the effect of intracluster correlation would be small and "n' "would be very close to "n". So the sample size determined for simple random sampling was taken to be the sample size for the study. Accordingly, a sample size of 196 calves from 112 smallholders was determined. Selection was done by generating random numbers using a calculator and taking the corresponding farm from the sampling frame until 196 calves are included. When a selected farm did not have an eligible calf or calves, it was replaced by another farm selected again randomly. In this study, calf was defined as young cattle less than six months of age. Calves over three months of age at the start of the study, or those that would not attain at least three months of age at the en of the follow-up period were not considered for the study. The total number of calves initially selected was 196, of which

11 withdrew later, most of them being male and sold for veal.

Data collection

In this study, calf morbidity is defined as any sickness that has a recognizable clinical manifestation, and mortality as death of calves above the age of 24 hours. Morbidity and mortality data were collected through questionnaire survey and by monitoring dairy farms for 6 months period (October 11, 2003 to April 8, 2004).

Questionnaire survey

In each farm, a cross-sectional questionnaire survey was conducted by way of personal interview to determine farm characteristics, calf management techniques including peri-parturient care, feeding and housing and previous history of calf diseases. The questionnaire was closed type for its major part and administered by the investigator. the questionnaire was pre-tested and re-adjusted accordingly.

Longitudinal study

Calves were individually identified and calf cards were prepared to record genealogy of the calf, events surrounding the birth of the calf, routine management practices applied to the calf and health problems. The calves were visited fortnightly up to three months of age and then on monthly basis thereafter. Emergency visits were also paid in response to calls from farms for calf health problems. When calves complete their 6 months of age, they were withdrawn from the follow-up group. The main activities accomplished during the regular visits were clinical examination of calves for any health problem, observation of different calf management aspects like cleanness of the calf barn and feeding practices, asking calf attendants the occurrence of ill health cases between visits and recording of the information.

Data management and analysis

As animals in this longitudinal study were recruited at different times and were followed for different periods of time, incident density (true rate) was used to determine morbidity and mortality rates. Incident density was calculated by dividing the number of diseases cases or deaths to the number of calf days at risk. Number of calf days at risk was found by adding the number of days that each calf stayed in the study group. Prevalence rate was calculated instead of incidence rate for congenital health problems, as these were time independent for individual animal and recorded only in the first visits of individual calves.

In the calculation to determine crude morbidity rate, a calf recovered from an illness was considered to be at risk for another illness and even to the same type of illness if it occurred after complete recovery (complete disappearance of clinical signs) of the clinical sign of the first occurrence. Similarly, two or more cases of the same disease condition were considered as different cases in calculating the incidence rate of disease condition/syndromes as far as the second occurred after the disappearance of the clinical sign of the first. In this case the days in which the calf stayed ill were not counted as days at risk for the second occurrence.

Investigation of risk factors

Investigation of risk factors related to calf health problems were done by considering a total of 20 potential risk variables (explanatory variables) (Table 1). The responses of all variables were dichotomised to facilitate analysis and interpretation of results. While dichotomising, care was taken to make the cut-off points reasonable. In the analysis, only the first occurrence of cases was considered. Congenital problems were not considered in the analysis of the effect of risk factors, since it was assumed that risk factors associated with them are different from the factors considered in the analysis.

Statistical analysis

Microsoft excel (2002) was used to calculate the descriptive statistics. Statistical analyses on the associations between risk factors (explanatory variables) and outcome variables (status variables) were done by Cox's proportional hazard model (Cox regression). First individual risk factor were screened in terms of their simple (crude) association with an outcome variable by univariate Cox regression. Those variables significantly associated with the outcome variable at 5% significance level in the univariate analysis were selected for multivariable analysis using

Table 1 Potential risk variables considered in the analyses and their categories

Variables	Description of category and codes
Calf factors	
Birth time	0 = born in day time
	1 = born in night time
Birth condition	0 = normal delivery
	1 = assisted delivery
Sex	0 = male
	1 = female
Age	0 = ≤50% follow up days below 3 month of age (younger)
	1 = >50% follow up days above 3 months of age (older)
Parity of the dam	0 = calves from first calving dams
	1 = calves from multiparous calving
Management factors	
Age at first colostrum ingestion	0 = ≤6 hours
	1 = >6 hours
Method of colostrum feeding	0 = suckling from its dam
	1 = hand feeding
Time of introduction of additional feed	0 = before or on 3 weeks of age
	1 = after 3 weeks of age
Amount of milk fed daily	0 = <4 liter
	1 = ≥4 liter
Weaning age	0 = <3 months of age
	1= ≥ 3 months of age
Housing condition	0 = separate calf pen
	1 = in the same barn with cows
House cleanness	0 = clean
	1 = unclean
Farm attributes	
Owners education level	0 = primary and below
	1 = secondary and above
Age of the farm	0 = ≤5 years
	1 = >5 years
Farm as source of income	0 = primary source of income
	1 = secondary source of income
Ownership of the calf caretaker	0 = owner
	1= hired
Sex of calf caretaker	0 = male
	1 = female
Experience calf caretaker	0 = ≤5 years experience
	1 = >5 years experience
Knowledge about the importance of colostrum	0 = yes
	1 = no
Knowledge on the optimum age to feed colostrum	0 = yes
	1 = no

Cox regression to see their independent effect. In the multivariable analysis, a model was fitted for each outcome (status) variable by stepwise backward elimination of non-significant variables ($P>0.05$). SPSS statistical software (SPSS for Windows, Release 11.5, 2002) was used to run Cox regression.

Results

Morbidity and mortality

The results of this study revealed that the incidence of crude morbidity and crude mortality in the first 6 months of calfhood were 62%[1] and 22% respectively. Among disease conditions/syndromes diagnosed during the monitoring period, calf diarrhea was the leading factor associated with calf morbidity (39%). The risk rate for pneumonia, joint ill (arthritis), navel ill (omphalitis) and septicemic condition were all between 4% and 6%. The incidence rate of the disease conditions is presented in Table 2.

Prevalence rate of congenital problems recorded during the study period was 6.5%. Eighty three percent of the congenital problems were congenital loss of sight. Of the clinical syndromes lumped to the miscellaneous category, unthriftness, bloody urine and hair loss on the different parts of the body occurred relatively more frequently than the others.

The principal disease syndrome associated with calf death was again diarrhea, directly accounting for the 13 cases out of the 29 total deaths. Other causes of death recorded included sudden death (2), pneumonia (2), grain engorgement (1), navel ill complication (1), water toxicity (1) and septicemia of unidentified causes (4). Cause of death was not identified in 5 cases.

The average ages of calves for the occurrence of morbidity and mortality were six and nine weeks, respectively. Proportionally, the highest morbidity (13%) and mortality (19%) incidents occurred in the first week of life. Again, 36% and 32% of the total cases of crude morbidity and crude mortality, respectively, occurred in the first month of age and 84% and 77% of the total cases of crude morbidity and crude

[1] Although the morbidity and mortalities were originally calculated as incidence density (true rate), here they are derived and put as risk rate to facilitate the comparison of results with other works.

Table 2 Disease conditions/syndromes, crude morbidity and mortality rates in claves (112 smallholder dairy farms; 2003–2004)

Disease condition/ syndrome	Number of cases	Calf days at risk	Incidence rate	
			True rate/6 calf months at risk	Risk rate (in %)[a]
Diarrhea	58	20661	0.50	39
Pneumonia	5	21191	0.04	4
Joint ill (arthritis)	7	21171	0.06	6
Navel ill (Omphalitis)_	5	21191	0.04	4
Septicemic condition	6	21181	0.05	5
Congenital problems	12	[b]185	[c]6.5	–
Miscellaneous cases	23	21241	0.19	17
Crude morbidity	116	21241	0.98	62
Crude mortality	29	21241	0.25	22

a = derived by the formula, Risk rate=1-e-$^{true\ rate}$ (Martin et al. 1987)

b = number of calves,
c = prevalence

mortality, respectively, occurred in the first three months of age.

Association of risk factors with incidence of morbidity and mortality

The results of univariate Cox regression analysis for crude morbidity revealed that six risk factors (condition of birth ($p<0.01$), age of calves ($p<0.001$), age at first colostrum ingestion ($p<0.001$), amount of milk fed daily ($p<0.01$), barn cleanness ($p<0.05$) and weaning age ($p<0.01$)) had significant effects. Among these factors (excluding weaning age) which were fitted into a multivariable Cox regression model, only three (age of the calves ($p<0.01$), age at first colostrum ingestion ($p<0.01$) and cleanness of the calf barns ($p<0.05$)) were found to be significantly associated with the risk of crude morbidity (Table 3). Keeping the effect of other factors constant, the hazard of morbidity in older calves was only 42% of that of younger calves. The hazard of morbidity was 2.2 times higher for calves, which ingested their first colostrum meal later than 6 hours after birth than those ingested within 6 hours after birth. The hazard of morbidity in calves which were housed in unclean barns was 1.75 times higher than those housed in clean barns. When a similar analysis was carried out only for weaned calves with the inclusion of weaning age as a potential risk factor, the same factors contributed to the model (Table 3).

Of the 20 risk factors considered for analysis, only four (age of claves ($p<0.01$), age at first colostrum ingestion ($p<0.05$), amount of milk fed daily ($p<0.05$) and weaning age ($p<0.01$) were found to be significantly associated with crude calf mortality in a univariate Cox regression (Table 4). Further analysis of the four risk factors using multivariable Cox regression indicated that only age of calves was significantly associated with the risk of crude mortality (HR=0.04, P=0.001). According to the model, keeping the effect of other factors constant, the hazard of mortality in older calves was only 4% of the hazard in younger calves. When the same procedure was applied to weaned calves only, weaning age ($p<0.01$) and age at first colostrum ingestion ($p<0.01$) were additional risk factors associated with mortality (Table 4).

Table 3 Potential risk variables significantly associated ($p<0.05$) with the incidence of crude calf morbidity based on univariate and multivariable analysis using Cox regression (112 Smallholder dairy farms; 2003–2004)

Methods of analysis and Variables	**HR***	**95 % CI for HR**	**P value**
Univariate analysis			
Condition of birth	2.34	1.26–4.34	0.007
Age	0.39	0.24–0.62	0.000
Age at 1st colostrum ingestion	2.51	1.56–4.03	0.000
Amount of milk fed daily	0.50	0.32–0.79	0.004
Weaning age	0.54	0.31–0.94	0.029
Cleanness of calf barn	1.69	1.06–2.73	0.029
Multivariate analyses			
Age	0.42	0.26–0.69	0.001
Age at 1st colostrum ingestion	2.24	1.38–3.62	0.001
Cleanness of calf barn	1.75	1.08–2.84	0.024
Multivariate analyses (weaned calves)			
Age	0.46	0.28–0.76	0.003
Age at 1st colostrum ingestion	2.61	1.55–4.40	0.000
Cleanness of barn	1.81	1.06–3.02	0.030

*Hazard ratio (which has similar meaning to relative risk)

Table 4 Potential risk variables significantly associated ($p<0.05$) with the incidence of crude mortality based on univariate and multivarible analysis using Cox regression (112 small holder dairy farms; 2003–2004)

Methods of analysis and Variables	HR	95 % CI for HR	P value
Univariate analysis			
Age	0.03	0.004–0.24	0.001
Age at 1st colostrum ingestion	2.58	1.23–5.39	0.012
Amount of milk fed daily	0.44	0.19–0.98	0.045
Weaning age	0.23	0.08–0.63	0.004
Multivariate analysis (weaned calves)			
Age	0.05	0.01–0.41	0.005
Age at 1st colostrum ingestion	5.02	1.7–14.34	0.003
Weaning age	0.19	0.06–0.55	0.002

Discussion

Morbidity and mortality

The morbidity rate determined in the present study (62%) was higher than many previous reports which reported morbidity less than 30% (Gitau et al. 1994; Sivula et al. 1996). On the other hand, it was comparable to the findings of Virtala et al. (1996) and Debanth et al. (1990) who have indicated 52% crude morbidity in calves.

The incidence of crude calf mortality (22%) observed in the present study was much higher than reports made in other countries (Roy 1990; Heinrichs and Radostits 2001). The latter indicated 3% to 5% calf mortality under conditions of good calf management. However, the mortality rate was in agreement with other reports in Ethiopia (Hussien 1998; Amoki 2001), but still higher than the 12% mortality reported for sub-Saharan Africa (Otte and Chilonda 2000).

Our finding that calf diarrhea is the most important disease syndrome that affects calf health in the study herds is in agreement with other reports worldwide (Sivula et al. 1996; Lemma et al. 2001). Poor hygienic condition of feeding utensils and calf barns observed during the study might be responsible for the high incidence of calf diarrhea. The relatively lower incidence of pneumonia in this study might be due to the small herd size of farms. Large herd size has strong positive correlation with environmental stress that exposes calves to respiratory problems; a 50% decrease in stocking density was found to increase the ventilation rate by 20 times there by decreasing the risk of pneumonia (Blowey 1990). The high incidence of congenital loss of sight (90% of the congenital problems), which was not associated with any gross anatomical abnormality on the globe of the eye or any other part of body, was difficult to explain and warrants further study.

Risk factors

Among a range of putative risk factors tested for their association with crude morbidity and mortality, age was found to be the most important calf factor affecting both crude morbidity and mortality. It was the only risk factor significantly associated with risk of mortality in all age groups (weaned and unweaned). In this study, younger calves under three months of age were at higher risk of morbidity and mortality. Similar age pattern of morbidity and mortality has been reported by previous studies (Waltner-Toews et al. 1986b; Virtala et al. 1996). On the other hand, there are also studies, which indicated higher mortality in older calves than younger ones (Gitau et al. 1994) and mortality rates unrelated to age (Debanth et al. 1990). The relatively higher risk of mortality in young calves observed in this study suggests the need of more careful management for very young calves.

Delayed first colostrum feeding (later than 6 hours of age) was associated higher risk of mortality in weaned calves, but this was not the case when calves of all age groups taken together. This seems unsound, as the colostral immunity is more important in very young age when calves' own immunity is weak; and the age at which it is ingested should matter more in young calves. However, we urge caution in interpreting the results relating to weaned calves as the calves that died after weaning was smaller than the sample size recommended for survival analysis (Altman 1991). As to the association of delayed first colostrum feeding with morbidity, our results are in agreement with other reports. Several previous studies have shown that the first six hours of life is the period in which maximum absorption of colostral immunoglobulin takes place (Matte et al. 1982; Bath et al. 1985) and higher risk of morbidity was related to failure of passive transfer of colostral immunity during this period (Wittum and Perino 1995; le Rousie et al. 2000).

Early weaning (before 3 months of age) was also found to be a risk factor statistically associated with

risk of mortality. Based on literature, under good management, dairy calves can be safely weaned as early as 7–8 weeks of age (Bath et al. 1985; Heinrichs and Radostits 2001). Based on this fact, the age considered early and found out to be risky for calves in the present study was within the range of the optimum age for weaning. Therefore, what seemed to operate as risk factor in the study calves is the practice (procedure) of weaning calves rather than of the actual age of weaning.

Cleanness of calf barns was the most important factor that had significant association with calf morbidity. Other studies (Bendali et al. 1999; Shiferaw et al. 2002) also documented the existence of significant association between higher risk of morbidity and dirtiness of calf barn. As most infectious agents are acquired by calves from the immediate environment, the high risk of calf morbidity in unclean barns observed in the present study is logically supported.

Among the variables that were grouped under farm attributes, most of which explain about personal characteristics of people caring for calves, none of them were associated with any of health events considered. In a study on a dairy farm it had been reported that such factors affect farm performance to greater or equal degree to other management variables (Tarabla and Dodd 1990). Jenney et al. (1981) found lower calf mortality when owners care for calves instead of hired labor. In the present study, the failure to detect significant difference may be due to the fact that the activities of hired caregivers were under close supervision of the owners.

Conclusions

The present study has shown that calf morbidity and mortality rates were higher than previous reports, be it for Ethiopia or sub-Saharan Africa. The leading disease condition associated with morbidity and mortality was found to be diarrhea. We have also found that age of calves, age of first colostrum feeding and barn cleanness were important risk factors associated with calf morbidity while age of calves, age of first colostrum feeding and weaning age were the most important determinants of calf mortality. Given the fact that the study farms raise their own replacement stock and have small herd size, special emphasis should be given to the time of colostrum feeding, proper timing and management of weaning calves and the hygiene of calf barns as these aspects of calf management were found important and are, relatively, easy to manage.

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