ADDIS ABABA UNIVERSITY

FACULTY OF VETERINARY MEDICINE

CALF MORBIDITY AND MORTALITY IN DAIRY FARMS IN DEBRE ZEIT AND ITS ENVIRONS, ETHIOPIA

A thesis submitted to Faculty of Veterinary Medicine, Addis Ababa University in partial fulfillment of the requirements for the Degree of Master of Science in Tropical Veterinary Epidemiology

BY

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JUNE, 2004

DEBRE ZEIT, ETHIOPIA

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LIST OF ABBREVIATIONS

^0C	Degree Celsius
AAU	Addis Ababa University
BPLS	Brilliant green phenol red lactose sucrose
BVD	Bovine virus diarrhea
CI	Confidence interval
CSA	Central Statistical Authority
DVM	Doctor of Veterinary Medicine
DZARC	Debre Zeit Agricultural Research Center
ELISA	Enzyme linked immunosorbent assay
ESLCE	Ethiopian School Leaving Certificate Examination
ETEC	Enterotoxigenic *E. coli*
FAO	Food and Agriculture Organization
FPT	Failure of passive transfer
FVM	Faculty of Veterinary Medicine
HIV	Human immunodeficiency virus
HR	Hazard ratio
i.e.	That is
Ig	Immunoglobulin
ILRI	International Livestock Research Institute
ISO	International Organization for Standardization
Kg	Kilogram
Km	Kilometer
LT	Labile toxin
mm	Millimeter
MOSH	Market oriented smallholder
MSc	Master
OIE	Office International des Epizooties
Plc.	Private limited company
ST	Stable toxin
TSI	Triple sugar iron
XLD	Xylose-lysine-desoxycholate
ZST	Zinc sulfate turbidity

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ABSTRACT

A longitudinal prospective observational study on calf morbidity and mortality in dairy farms in Debre Zeit and its environs was conducted from October 11, 2003 to April 8, 2004 with the objective of describing incidence of calf morbidity and mortality, investigating potential risk factors related to calf morbidity and mortality and identification of some pathogens associated with calf diarrhea. A total of 236 calves, 51 from three large dairy farms and a random sample of 185 calves from market oriented smallholder dairy farms in Debre Zeit and its surrounding were included in the study. Each calf was individually identified and regularly monitored for clinical health problems up to an age of six months. Information on different potential risk factors were collected by personal observation during the regular visit to farms and from questionnaire survey conducted during the study. Fecal samples were also collected from diarrheic calves for laboratory examination to detect entropathogens involved.

The overall incidences of crude morbidity and crude mortality found in this study were 61.5% and 18.0%, respectively. Disease conditions/syndromes that were diagnosed in calves included diarrhea, pneumonia, navel ill, joint ill, septicemic conditions, congenital problems and other miscellaneous cases. The most frequent disease syndrome was calf diarrhea with the incidence of 42.9% followed by pneumonia (4.9%). The incidence of calf diarrhea and crude morbidity were apparently higher in large dairy farms than in the market oriented smallholder farms. However, the mortality was higher in the latter.

A total of 20 potential risk factors were investigated for their association with the risk of crude calf morbidity, crude calf mortality and calf diarrhea using Cox's proportional hazard model. Age was the only factor that was found significantly associated with risk of crude calf mortality (HR= 0.04, P= 0.001). Older calves above three months age were at lower risk of mortality than younger calves under three months of age. When weaned calves were considered, weaning age and age at first colostrum feeding were additional risk factors.

Among the risk factors examined, those found significantly associated with the incidence of crude morbidity were age of the calves, age at first colostrum ingestion and cleanness of the calf house. Older calves were at lower risk of crude morbidity (HR=0.42, P = 0.001) than younger calves. Higher risk of crude morbidity were observed in calves that ingested their first colostrum meal later than 6 hours of age as compared with those that ingested before 6 hours (HR = 2.24, P = 0.001). Similarly calves housed at unclean house were at higher risk of crude morbidity than those housed in clean house (HR = 1.75, P = 0.024).

Risk factors with significant association to calf diarrhea were age, condition of birth and cleanness of calf house. Older age was again associated with low risk of diarrhea as compared with younger age (HR = 0.24, P = 0.000). Calves from prolonged labor or dystocia (HR = 3.01, P = 0.002) and housed at unclean house (HR = 2.34, P = 0.011) were at greater risk of diarrhea than those calves from normal delivery and in clean house, respectively.

Based on laboratory examination, *Salmonella* and *Cryptosporidium* were detected from diarrheic calves at rate of 2/55(3.6%) and 4/55(7.2%), respectively. The serotypes of *Salmonella* identified were *Salmonella* Typhimurium and *Salmonella* Heidelberg both of which were susceptible to commonly used antibiotics.

In conclusion, the incidence of calf morbidity and mortality found in this study were high and could affect the productivity of the dairy farms through mainly decreasing the availability of replacement stock. Among the management risk factors investigated, time of first colostrum ingestion and cleanness of the calf house were found very important; incidentally, these two aspects of calf management are easy for observation and carrying out appropriate interventions. Implementation of good calf management in these areas could contribute in the reduction of the high calf disease problems seen in this study. *Salmonella* and *Cryptosporidium* were found in diarrheic calves and these pathogens in addition to their role in calf diarrhea, are potent zoonotics. Individuals particularly very young, elderly and immunocompromised, in contact with calves are at a potential risk of infection and therefore, efforts should be mounted to avoid such risks.

Keywords: Calf, *Cryptosporidium*, dairy farms, diarrhea, incidence, longitudinal study, morbidity, mortality, risk factors, *Salmonella*

1. INTRODUCTION

The Ethiopian society in the coming few decades is characterized by an increased total population and accelerated urbanization. This demands a parallel increase in food production of which animal products are very important. Presently the per capita milk consumption in Ethiopia is only 20kg per year, which is lower than the average for sub Saharan Africa (Tegegne and Gebrewold, 1998). Considering FAO's recommendation of 200 liter per head per year (Kyomo, 1997), the significance of the deficit can easily be appreciated. To fill this gap the traditional subsistence production is no more a feasible option. Currently a number of urban and peri-urban dairy farms are the major suppliers of milk and milk products to the urban consumers (Tegegne and Gebrewold, 1998) and continue to be in the future.

The substantial demand-supply variance in milk and milk products for the major urban centers in Ethiopia is a great opportunity for the development and flourishing of peri-urban dairy farms. Large commercial and market oriented smallholder urban and peri-urban dairy production systems have tremendous potential for development and could play significant role in mitigating the acute shortage of dairy products in urban centers. For these systems to develop and flourish, and to ensure their sustainability, the constraints with the systems need to be addressed.

The major constraints for the development of peri-urban dairying and the development of livestock industry in general have been summarized as policy, socioeconomic, institutional, technical and technological (Tegegne and Gebrewold, 1998). Animal diseases are among the technical and technological constraints for the peri-urban and urban dairy production systems (Tegegne and Gebrewold, 1998; Belihu, 2002).

Peri-urban and urban dairies are intensive production systems, which keep high-grade cows and have improved management practices. This is usually associated with increased susceptibility to disease, poor survival rate and poor reproductive performance (Eneyew *et al.*, 2000). Reproductive inefficiency, young mortality and some cattle diseases like mastitis, lameness, pneumonia and ketosis are the major health problems in intensive dairy production (ILCA, 1994). In developed countries, an increase of 10-40% for mastitis, 10-20 % for calf mortality and 5-15% for lameness was observed to be associated with intensification of dairy production (ILCA, 1994). Similarly, a three-fold increase in mastitis, calf mortality and lameness was observed from less intensive to more intensive groups in dairy production systems of Addis Ababa milk shed (ILRI, 1996).

The future of any dairy production depends among other things, on the successful program of raising calves and heifers for replacement. Under most conditions, 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). This makes the cost of raising dairy replacement heifer substantial and only next to feed (Heinrichs and Radstits, 2001). Nevertheless, calf replacement should be given appropriate attention since the availability of heifer replacements for a dairy herd markedly influences the ability of a dairyman to increase production by allowing him to practice elective culling of low producing cows.

Among other factors, calf diseases that cause morbidity and mortality are the major problems faced in raising replacement stock. High incidence of calf morbidity and mortality incurs great economic loss to dairy producers. This arises from death loss, treatment cost, decreased lifetime productivity and survivorship (Waltner-Toews *et al.*, 1986a). It also causes the loss of genetic material for herd improvement and decreases the number of dairy heifers available for herd replacement and expansion. Calf morbidity and mortality are perennial problems for dairy producers worldwide. Calf mortality shows wide variation ranging from 1 to 30 %(Heinrichs and Radostits, 2001). According to ILCA (1994), based on producers' response to questionnaire, calf morbidity and mortality were ranked as next to mastitis problem for the different settings of dairy production in Addis Ababa milk shed in Ethiopia.

Calf diseases that cause morbidity and mortality are the results of complex interaction of the management practices and environment, infectious agents and the calf itself. Scours in neonatal period and pneumonia in older calves are known to be responsible for most of calfhood morbidity and mortality (Olsson *et al.*, 1993; Debanth *et al.*, 1995; Sivula *et al.*, 1996b). Similar findings were reported from Ethiopia (Hussen, 1998; Amoki, 2001; Lemma *et al.*, 2001; Shiferaw *et al.*, 2002). Several environmental and managemerial factors act as risk factors for the occurrence of calf morbidity and mortality (Waltner-Toews *et al.*, 1986b; Lance *et al.*, 1992a; Bruning-Fann and Keneene, 1992).

It is an established fact that development of urban and peri-urban dairy production requires above all a sound knowledge of the magnitude, the causes and predisposing factors of diseases of intensification to institute appropriate intervention. Debre Zeit town is one of the urban centers where market oriented smallholder farms are flourishing rapidly with 100% increase in number of dairy farms in the last five years (Kassaye, 2002). There are some studies in different parts of Ethiopia, which show high calf mortality ranging from 7 to 25% (ILRI, 1996; Hussen, 1998; Amoki, 2001; Shiferaw *et al.*, 2002). In a study that included still-birth and abortion, mortality rate was reported as high as 67% (Gryseels and de Boodet, 1986). These studies were mostly done on government and research centers and are less relevant to the smallholder setup, which is a predominant system in the country including Debre Ziet. The present study was, therefore, initiated with this background and has the following objectives:-

1. describing the incidence of calf morbidity and mortality,
2. investigating the potential management and host factors related to the risk of calf morbidity and mortality and
3. identifying the infectious agents involved in causing calf diarrhea.

2. LITERATURE REVIEW

2.1. The Calf

Calf refers to the age group of young cattle from birth to six or nine month of age (West, 1995). Elsewhere it was defined as cattle up to six month of age after which in natural circumstances, it might be expected to be self-sufficient (Webster, 1984). The term calf, in less intensive system of production, may generally include cattle older than the age indicated in the above definitions. The proportion of calves weaned before six months of age increases from less intensive to more intensive systems of production (ILRI, 1996).

Calves have some special features in their body system that have relevance in disease occurrence and accordingly require special attention in management. Those that have particular importance are the poorly developed defense mechanism and a dynamic digestive system that has to evolve from milk digestion to a solid feed digestion. These make calves particularly susceptible to disease.

A newborn calf has poorly developed defense mechanism. The normal flora is not well established and unlike to newborn of primates, they are born with no circulating antibodies to combat infection (Bath *et al.,* 1985). Yet the calf must survive in highly contaminated environment.

In the digestive system of newborn calves, there are certain alterations. There is delay in acid secretion from stomach and in the development of pancreatic function; thus acid and trypsin digestion of protein is not started. The newborn calves have also specialized intestinal epithelium capable of engulfing soluble protein, which will disappear within 24 hours after birth (Cunningham, 1992). All these help calves to absorb intact immunoglobulin from colostrum. Pre-weaned calves have physiologically monogastric type stomach. The liquid feed flows through the closed esophageal groove directly into the abomasum thus bypassing the fore-stomach. For the newborn calves, it is most important that closure occur prior to feeding, so that the liquid feed will be prevented from entering the rumen and causing digestive disturbance (Blowey, 1990). Other chemical and physical components of digestive system develop with age as the calf starts feeding on different feeds (Heinrichs and Radostits, 2001).

2.2. Colostrum and its Role in Neonatal Calf Management

The less developed immune system and lack of previous exposure to infection make newborn animals susceptible to infectious diseases. To compensate this, neonates possess mechanism to acquire maternally derived immune factors. The mode of passive transfer in neonates varies with the type of placentation and in the case of neonatal calves; it is based on an immediate postpartum ingestion of antibody rich colostrum (Tizard, 1995).

Colostrum, the first milk produced by the cow at calving, has two important properties: source of immunity and highly nutritious balanced diet for newborn calves. The immunity obtained from colostrum is composed of maternal immunoglobulin, immunoactive substances and active immune responsive cells (Garry *et al.*, 1993). Providing the newborn calves with sufficient quantity and good quality of colostrum at the right time is the most important aspect of calf management. For maximum protection against infection, newborn calves should receive colostrum amounting up to 6% of their body weight within six hours after birth. The highest absorption of immunoglobulin occurs during this period and by 24 hours most of absorption capability is lost (Bath *et al.*, 1985). Colostrum feeding should continue in the second and third day after birth. The immunoglobulin during this period, though not absorbed, will provide some local protective action against bacteria and other organism in the digestive tract.

Many studies have demonstrated the importance of high level of serum immunoglobulin in reducing risk of morbidity and mortality in calves (Bakheit, 1981; Hancock, 1985; White and Andrew, 1986; Virtala *et al.*, 1999; Amoki, 2001). There are also some studies which failed to demonstrate strong association between immunoglobulin status and morbidity and mortality (Cadlow, 1988; Sivula *et al.*, 1996a). Based on convincing evidences of previous studies it has been concluded that total serum protein or immunoglobulin has strong relationship with low incidence of calf morbidity and mortality in herds with higher disease incidences. This relationship was less pronounced in herds with low disease incidence. Passive acquisition of immunity can be compromised by colostral deficiencies, ingestion failure, absorption failure or a combination thereof. Each one of these are influenced by a range of diverse calf and dam, and environmental and management factors (Aldridge *et al.*, 1992).

2.3. Morbidity and Mortality in Dairy Calves

2.3.1. Economic Importance

Calf morbidity and mortality are of great economic importance to all dairy producers. Calfhood morbidity cause direct cost for treatment and nursing, affects days at first calving, affects dairy herd survivorship and future productivity (Waltner-Toews *et al.*, 1986a; Curtis *et al.*, 1989). In Waltner- Toews *et al.* (1986a) study, heifers that have been treated for pneumonia during the first 3 months of life were 2.5 times more likely to die after 90 days of age than other heifers and heifers that had been treated for diarrhea were 2.9 times more likely to calve after 900 days of age than other heifers. Correa *et al.* (1988) on their study in Holstein heifer calves on several New York dairy farms observed that heifers without respiratory illness during calfhood life were twice as likely to calve 6 months earlier compared with those which experienced respiratory illness during calfhood. Britney *et al.* (1984) were also similarly demonstrated the effect of navel- joint illness on future survivalship of calves. In this study calves with navel-joint illness within the first 4 months of life exhibited significantly poor survival distribution pattern than the remaining cohorts including having respiratory illness, gastrointestinal, septicemic and other diseases.

Calf death also causes a loss of genetic material for herd improvement and decreases the number of dairy heifers available for herd replacement and expansion. Economic losses resulting from calfhood mortality and morbidity can be easily recognized, but the effect of morbidity on future health and performance, which may constitute a loss of even greater importance, is difficult to estimate. A dairy farm management system should employ a strategy that will reduce calf mortality and improve calf performance by controlling diseases. In a good management practices, annual mortality of calves under one months of age can be reduced to below 3-5% and first calving age at around 24 months (Heinrichs and Radostits, 2001).

2.3.2. Major Causes of Morbidity and Mortality in Calves

2.3.2.1. Calf Diarrhea

Calf diarrhea is the commonest disease in young calves and is the greatest single cause of death (Gitau *et al.*, 1994; Sivula *et al.*, 1996a; Busato *et al.*, 1997; Heinrichs and Radostits, 2001). It accounts for approximately 75% of the mortality of dairy calves under three weeks of age (Blowey, 1990). It is also a complex syndrome of great etiological complexity. In addition to the influence of varied environmental, managemental and nutritional factors, the infectious agents capable of causing diarrhea in calves are numerous. The most important causes of diarrhea in calves include enterotoxigenic *Esherichia coli*, *Salmonella*, Rotavirus, Coronavirus, *Cryptosporidia* and *Emeria Spp*. (Waltner_Toews *et al.,* 1986e; Reynolds *et al*, 1986; Snodgrass *et al.*, 1986; Abraham *et al.*, 1992). Failure of passive immunity transfer and overwhelming pathogen exposure are the main precipitating factors for calf diarrhea (Hunt, 1993). Four mechanisms have been demonstrated to be important in occurrence of diarrhea in calves. Hypersecretion of ions and water into the bowl, increased osmotic pressure from maldigestion – malabsorption disease caused by damage to enterocytes, increased mucosal permeability due to inflammation, and the last and less important mechanism is alteration of intestinal motility (Hunt, 1993).

Enterotoxigenic *Escherichia coli* (ETEC)

Escherichia coli causes two common diseases of newborn calves. Coli septicemia in which the bacteria invade the systemic circulation and internal organs, and enteric collibacillosis in which the bacterial are localized in the lumen and mucosal surface of the small intestine. The serotypes of *E. coli* that cause these diseases differ. Each type possesses unique attributes of virulence that differentiate it from each other as well as from non-pathogenic serotypes of *E. coli* that are normal digestive flora of healthy calves (Acres, 1985).

The types of *E. coli* that cause diarrhea commonly are enterotoxigenic *E. coli* (ETEC). These types of *E. coli* possess two characteristics of virulence that play role in their pathogenicities. These include their ability to produce entertoxins, which stimulate fluid secretion from the intestine and presence of pilli (fimbriae), which allow the bacteria to adhere to epithelial cells of small intestine. *E coli* serotypes that have the ability to adhere to wall of small intestine of calves possess K99 fimbrial antigen. With their fimbriae they attach to the wall of the calf intestine and produce enterotoxins. These toxins stimulate the calf to produce excessive quantities of intestinal secretions, thus leading to severe diarrhea. ETEC usually interact positively with other pathogens like rotavirus and *Cryptosporidium* to cause diarrhea in calves (Snodgrass *et al.*, 1982; Runnel *et al.*, 1986). Most of the time ETEC cause diarrhea in calves of less than one week of age (Acres, 1985; Reynolds *et al.*, 1986; Abraham *et al.*, 1992).

In diagnosing E. coli as a cause of diarrhea, demonstration of fimbrial antigens (K99 in case of calves) or the enterotoxins is necessary (Quinn *et al.*, 1994). Fimbrial antigens can be detected by immunological tests like latex agglutination test or ELISA either directly from fecal samples or from culture of *E. coli* in special media that support expression of fimbrial antigens. Fluorescent antibody technique using conjugates prepared against colonizing antigens can be used on smears made from scraping from the ileum of fresh carcass. The most sensitive of the methods being developed for heat labile (LT) and heat stable (ST) toxins is ELISA, which employs monoclonal antibodies. LT has been assayed in legated loops and its effect on adrenal and Vero cells monolayer. STa enterotoxin(this is the enterotoxin produced by ETEC isolated from calves) can be assayed in suckling mice and STb toxin in weaned pig and rabbit intestinal loops.

Rotavirus

Rotavirus belongs to the family *Reoviridae*. There are six groups of the genus Rotavirus. Of these groups, Group A Rotavirus is the most prevalent and clinically important and containing several serotypes of differing virulence (Murphy *et al*., 1999). Rotavirus has been shown to be the most common cause of scouring in calves during their first week of life (Snodgrass *et al*., 1982; Reynolds *et al*., 1986; Hunt, 1993). Rotavirus is present in all dairy herds but only under certain condition like, poor hygiene and/or a heavy challenge does it cause disease. Rotavirus replicates in the mature absorptive and enzyme producing enterocytes on the villi of small intestine, leading to rupture and sloughing of the enterocytes with release of virus to infect adjacent cells. With virulent strains of rotavirus, the loss of enterocytes exceeds the ability of the intestinal crypts to replace them; hence, the villi height is reduced, with a consequent decrease in intestinal absorptive area and intestinal digestive enzyme activity leading to scouring (Aiello, 1998).

Many diagnostic techniques for rotavirus have been developed with the objective of having reliable, sensitive and rapid technique. Electron microscopy is a rapid method of diagnosis of rotavirus. Use of immunelectron microscopy improves the detection ability. ELISA is a more practical and most sensitive method for detection of rotavirus infection from feces (Murphy *et al*., 1999).

Bovine coronavirus

Bovine coronaviruses belongs to the family of *Coronaviridae*. They are second to rotavirus as a cause of calf diarrhea (Murphy *et al*., 1999). It was the predominant pathogen detected from diarrheic calves in one study in Ethiopia (Abraham *et al.,* 1992). It replicates in the epithelium of upper respiratory tract and in the enterocytes of the intestine where it produces similar lesion to rotavirus. It cause diarrhea in young calves of few weeks age. Diagnosis of bovine coronavirus is made by electron microscopy from feces or viral isolation (Murphy *et al.*, 1999). Antigen detection ELISA can also be used in detecting coronavirus from feces (Quinn *et al.*, 1994).

Cryptosporidiosis

Cryptosporidium parvum is coccidian parasite that affect domestic animals and man. It was reported as one of the most common cause of diarrhea in calves (Ongerth and Stibbs, 1989; McDonough *et al.*, 1994; Quitez *et al.*, 1996). The parasite does not invade but adheres to the apical surface of enterocytes in the distal small intestine and the colon. This result in the loss of microvilli, decreased mucosal enzyme activity with villus blunting and fusion (leading to reduced villus absorptive area) and inflammatory changes in the submucosa. The organism is endemic in all cattle herds and as with rotavirus and coronavirus, most calves are at high risk of infection between birth and weaning, and poor ventilation and filthy barn predisposes to infection (Mohammed *et al.*, 1999).

Diagnosis of *Cryptosporidium* is usually done with acid-fast stain of fecal flotation smears. Commercially available ELISA tests have been also developed that have higher sensitivity and specificity than stained fecal floatation smears (Hendrix, 1998).

Salmonellosis

The genus *Salmonella* contains a single species with more than 2000 serologic variants. *Salmonella* serotypes especially *Salmonella* Typhimurium and *Salmonella* Dublin and occasionally others cause diarrhea in calves of 2-12 weeks of age. The commonest serotype is *Salmonella* Typhimurium. This organism produces enterotoxin but also is invasive and produces change within the intestine. The disease is seen as profuse diarrhea with septicemia and death may occur within 24 hours. Chronic form of the disease is also common, in which the affected calf simply has pasty dung and unthriftness. At the far end of the spectrum, some calves may carry the infection without suffering any adverse effects (Aiello, 1998).

Cultural isolation of the organism from feces sample is the usual method of Diagnosing of *Salmonella* from diarrheic calves. This involves inoculation of feces to selective enrichment broths. After overnight incubation in selective enrichment, it will be transferred to selective plating media. Colonies showing characteristics of *Salmonella* will then be tested biochemically and seroptyped (Quinn *et al.*, 1994).

2.3.2.2. Calf Pneumonia (Enzootic Pneumonia)

Although it can affect pre-weaned calves, this is the most common of all the diseases of the weaned calves and causes the highest loss in this age group, both in terms of mortality and reduced growth rates and accounts for about 15% of calf mortality from birth to 6 month of age (Heinrichs and Radostits, 2001). Calf pneumonia is a multiple etiology syndrome, that is caused by one or more of a whole range of organisms, including bacteria (like *Pasteurella multocida*, *P. haemolytica*, *Hemophilus somnus*, *Actinomyces pyogenes*), virus (like Respiratory syncytial virus, Parainfulenza virus type 3 etc.) and *Mycoplasma* (*M. bovis*, *M. dispar*) (Sivula *et al.*, 1996a; Virtala *et al.*, 1996a). Environmental factors like inadequate ventilation are extremely important in the occurrence of calf pneumonia. The disease is characterized by clear nasal discharge and raised temperature in early stage and coughing and faster breathing rate later. Some acute outbreaks can occur with fatalities before any significant coughing has been heard (Blowey, 1990).

2.3.2.3. Navel Ill (omphalitis)

Localized inflammation or infection of the contents of the umbilical cord external to the body wall is referred to navel ill (omphalitis). Omphalophlebitis, omphaloarthritis, and urachitis are terms used further describe the extension of inflammation or infection from the external umbilicus to the intra-abdominal segment of the umbilical vein, umbilical arteries, and urachus respectively (Kasari, 1993). The most frequently isolated pathogen from navel ill is *Actinomyces pyogens* in mixed infection with other bacteria usually *E .coli* (Kasari, 1993).

Survey on the incidence of umbilical infection showed that the age of calves for its occurrence is usually in the first week of life (Virtala *et al.*, 1996b). According to some studies, it is one of the disease conditions which has serious effect on future survival and productivity of calves (Britney *et al.*, 1984).

2.3.2.4. Other Causes of Morbidity and Mortality

Other diseases in calves including arthritis, bloat, parasitic gastroenteritis, and parasitic pneumonia in grazing calves; arthropod parasites and nutritional diseases (like inadequate intake of energy, protein, vitamins, and minerals) are also reported (Heinrichs and Radostits, 2001).

2.3.3. Epidemiology of Dairy Calf Morbidity and Mortality

2.3.3.1. Morbidity and Mortality Rates

Most of the time, morbidity statistics of dairy calf are not available, when available are not as reliable as those in mortality because they depend on the producers' diagnosis, amount of time spent observing the animal, degree of illness expressed by the animal, and tendency of producers not to record every illness event (Bruning-Fann and Keneene, 1992). This created wide variations of morbidity rates reported in different studies.

In a survey of dairy calf morbidity and mortality in Holstein dairy herds, 20% of live-born calves were treated for diarrhea and 15% treated for pneumonia before weaning (Waltner-Toews *et al*., 1986b). In one study in Swedish dairy herds a morbidity rate of 7% was found. In this study, enteritis and pneumonia occurred with frequency of 7.2% and 0.8% respectively (Olsson *et al*., 1993). In Holleta dairy farm in Ethiopia, among the crosses and Boran breeds, a 6-month cumulative incidence of 42% and 38% was recorded for respiratory disease and calf scour respectively (Shiferaw *et al*., 2002).

Available literatures on dairy calf mortality from birth to weaning indicate a wide variation from about 1 to 30% and even higher (Heinrichs and Radostits, 2001). In a typical commercial dairy herds of 50-200 lactating cows in North America, the population mortality rate of all live born calves from birth to weaning ranges from 5 to 10% from year to year and varies from 3 to 30% among individual herds from year to year (Heinrichs and Radostits, 2001). A survey on morbidity and mortality of cattle in smallholder dairy farmers in Zimbabwe indicated a mortality rate of 35% in calves of less one-year of age, which was five times higher than adults (French *et al*., 2001). Similarly, a study on large-scale dairy farms in Tanzania showed mortality rate of up to 20% (Kifaro and Temba, 1991).

2.3.3.2. Determinants of Dairy Calf Morbidity and Mortality

Major diseases in dairy calves have multi-factorial etiology, resulting from interactions between the calf, infectious agent, management and environmental factors.

2.3.3.2.1. Calf Factors

Breed

Differences in susceptibility of calves to diseases is often observed among different breeds. Taurine breeds and their crosses are generally more susceptible to diseases in tropical climates. In one study in Ethiopian highlands, a higher mortality rate (62%) was recorded in 87% Friesian x Boran crosses than 75% Friesian x Boran crosses (32%) (Gryseels and de Boodet, 1986). Hailemariam *et al.* (1993a) also found higher calf mortality in exotic breeds than locals. Mortality and morbidity also differ among calves of temperate dairy breeds (Olsson *et al.*, 1993; Agerholm *et al.*, 1993).

Vigor and Health of the Calf at Birth

The vigor and health of the calf at birth is highly correlated to morbidity and mortality (Heinrichs and Radostits, 2001). Several factors affect the health and vigor of calves immediately afterbirth. Calves born from dams with inadequate nutrition at late pregnancy or affected with prolonged anorexia, fever, or septicemia may be weak. Dystocia or prolonged parturition affects the calf's survival (Sivula *et al.*, 1996b). Research findings have indicated that metabolic, respiratory and mixed acidosis develop frequently at birth in calves, as a result of prolonged or difficult labor and dystocia. This acidosis at birth may have detrimental effect on colostral immunoglobulin absorption (Besser *et al.*, 1990; Drewry *et al.*, 1999). Bendali *et al.* (1999) also found dystocia associated with risk of neonatal diarrhea.

Age of the Calf

The age of the calf is the most important factor affecting morbidity and mortality. Approximately 75% of the mortality, in dairy animals under one year of age, occurs in the first month of their life (Heinrichs and Radostits, 2001). In a three-month study on Swedish dairy farms, 70% of the mortality occurred in the first month of the calves' age and the first week of age is with higher risk of dying than any other time there after (Waltner-Toews *et al*, 1986c; Olsson *et al*., 1993). Similarly, Virtala *et al.* (1996b) in their 3 months study reported the peak occurrence of crude mortality and diarrhea at the second week of life. In a study on smallholder dairying in Debre Zeit, 15% of the mortality rate was reported in the first month as compared to 8% mortality rate in 1 to 3 month of life (Gryseels and de Boodet, 1986). What all these studies showed was that young age is the critical age for calves and producers need special attention for young calves.

2.3.3.2.2. Environmental and Managemental Risk Factors

Farm Personnel

There is a marked influence of who feeds and cares for calves on calf's health. Fewer death losses were observed on farms where the owner managed the calves than on farms where employees performed the duties (Britney *et al.*, 1984). This suggests that owners might be motivated sufficiently to provide the care necessary to insure high survival. Similarly, low calf mortality was seen in herds owned by older and more experienced managers (Heinrichs and Radostits, 2001).

Feeding Management

Feed and feeding methods are important risk factors in morbidity and mortality of dairy calves. Feeding starts with colostrum soon after birth and involves feeding liquid feeds to pre-weaned calves and solid feeds to weaned calves (Bath *et al.*, 1985).

- Colostrum Feeding

Ingestion and absorption of enough quantity and quality of colostrum is a critical determinant for the health and survival of neonatal calves. Calves, which do not received adequate colostrum, are shown to have higher overall death rate, specially from septicemia and joint ill, and are more likely to develop scouring and pneumonia, even at two to three months old; for details see Table 1 (Blowey 1990). Wittum *et al.* (1994) found that calves with inadequate blood colostral immunoglobulin concentration in 24 hours of birth were at greater risk of neonatal morbidity and mortality, preweaning morbidity and morbidity and respiratory problems while in feedlot. Several reports have shown the importance of colostrum in relation to the risk of calf mortality and morbidity (Edwards *et al.*, 1982; Waltner-Toews *et al.*, 1986d; Aldridge *et al.*, 1992; le Rousie *et al.*, 2000).

Table 1. Percent of mortality, general illness (including scouring) and pneumonia in relation to colostral status (n = 1050 calves).

	Colostrum status(ZST[a]) units		
	0 - 10	10 - 20	20 and above
% of calves	18	32	50
% of mortality	9.8	4.1	3.2
% of illness	36.1	23	15
%pneumonia	5.2	3.2	1.4

[a] ZST(zinc sulphate turbidity): a test used to measure the amount of immunoglobulins absorbed to calf's blood stream.

Source: Blowey (1990).

The passive transfer of colostral immunity from dam to the neonatal calf is believed to be affected by several factors including age at first feeding, volume and concentration of the immunoglobulin in the colostrum fed, birth weight, method of feeding, seasonal influence, stress, use of colostral supplements, etc.(Aldridge *et al.*, 1992; Drewry *et al.*, 1999).

Time between birth and the first feeding is the prime factor for the failure of passive transfer of colostral immunity. Studies showed that calf mortality is significantly higher in calves that got colostrum late after birth than those that got colostrum soon after birth (Bruning-Fann and Kaneene, 1992; Wells *et al.*, 1996). In one study, it was found that each hour of delay within the range of 1 to 12 hours after birth increased the risk of illness by 10% (Olsson *et al.*, 1993).

The concentration of immunoglobulin is also important factor in colostral immunity. This is again affected by the dry period of the dam and genetic line of cattle. In a study by Besser *et al.* (1991) it was reported that a minimum of 40 days and a maximum of 90 dry days resulted in best quality colostrum and dry cows that leaked milk prior to parturition have lost the best colostrum. Generally, some cattle are prone to low immunoglobulin level in their colostrum. For example, beef cattle breeds have higher immunoglobulin concentration than Holsteins and among dairy breeds, it is higher in Holstein than in Guerency (Rebhun *et al*, 1995; Tyler *et al.*, 1999). Although colostrum from first lactating heifers usually was thought to be insufficient, some studies showed that it is adequate (Tayler *et al*, 1999).

The volume of colostrum and method of feeding are important factors to achieve the desired level of colostral immunity (Besser *et al.*, 1991). According to this study the method of feeding was more important factor for failure of passive immunity in calves than other management factors like the use of previously frozen colostrum and from cows with long lactating interval. Again in the same study, it was observed that failure to passive transfer immunity was less frequent in dairies that used artificial feeding (nipple bottle-feeding and tube feeding), than in dairies that allow calves to suckle. In the later case, the prevalence of failure to passive transfer was greater than 50% even among calves nursed by cows with above average colostral IgG concentration. Similarly, another study indicated improvement of the passive transfer when suckling was supplemented with bottle feeding (Bringole and Stott, 1980). This is suggested to be due to inability of calves to ingest enough volume of colostrum by suckling.

Passive immunity transfer in calves is also influenced by season. A study showed that the level of colostral immunoglobulin in calves' serum was higher during summer than winter (Gay *et al.*, 1983). This seasonal variation could be probably due to variations in immunoglobulin concentration in colostrum or ability to absorb immunoglobulin from colostrum in different seasons. There is also evidence that mastitis during dry period of cows decreases the concentration of IgG, particularly IgG1 in the colostrum of the next lactation (Komine *et al.*, 2000).

- Feeding after colostrum

Pre-weaned calves in modern dairy herds are fed with milk or milk replacer. The quality of feed and the method of feeding require great care. The feeding method and time of feeding for pre-weaned calves that fail to insure the closure of oesophageal groove, leads the feed to rumen and causes digestive upset (Blowey, 1990). Method of feeding was also associated with some contagious diseases (Wilson *et al.*, 1998). In this study, the proportion of calves infected with ETEC on the farm was positively associated with the use of regular pails for feeding calves (as opposed to nipple bottles or nipples pails).

A transition from liquid pre-weaned feed to solid weaned calf feed is also a critical time in feeding calves. If this is not done carefully, the calf will get dietary stress and be susceptible for different diseases (Blowey, 1990; Cry *et al.*, 1998).

Housing

On most dairy farms, calves are taken from the maternity area soon after birth and placed in the calf-rearing barn. Calves raised for herd replacement are commonly maintained in facilities that range from total confinement to open pastures. The greater the confinement, the more the calves environment is under the control of the producer and the less calves are able to make behavioural response to that environment. Morbidity and mortality rates are usually higher in calves housed indoors than outdoors. The increased illness and mortality in calves that are reared indoors is often attributed to a combination of inadequate control of thermal environment, poor air quality, undesirable relative humidity, inadequate exchange of air and poor sanitation (Blowey, 1990).

Different calf housing types have been associated with different rates of calf morbidity and mortality. In one study, producers who housed in calf hutch experienced lower calf mortality than producers who used any other type of housing, and housing calves in a group pens significantly increased risk of calf morbidity and mortality (Lance *et al.*, 1992a). Another study by Olsson *et al.* (1993) also indicated that keeping calves in single pen decreased incidence of enteritis as compared to group pens.

Herd Size

A marked increase in population density commonly results in an increase in the incidence of infectious diseases. Different studies reported significantly lower calf mortality in dairies having small herds than large or medium herd size (Bruning-Fann and Kaneene, 1992). Garber *et al.* (1994) found higher prevalence of *Cryptosporidium* associated with larger herd size in dairy farms. Herd size by itself has not a biological effect on the calf health; rather, it may be a measurement of other factors like time available to observe and care for calves. Other possible reason for the apparent association between herd size and calf mortality could be that in case of small herd sizes enough time may elapse between successive births, which will reduce the concentration of infectious agents in the calf-rearing environment.

Season of the Year

Season is important in areas where the climate goes to either extremity. In areas where winter temperature is very cold there will be more mortality of calves that are born in this season

(Aiello, 1998). According to review on calf morbidity and mortality by Bruning-Fann and Keneene (1992), calves suffer morbidity and mortality and show less performance during winter than other seasons. This seasonal influence could be due to cold temperature itself or due to long period of housing which may lead to the increase of infection pressure and poor ventilation. In tropical areas high mortality was reported in hot dry season (Hailemariam *et al.*, 1993b) which could arise from shortage of feed in dry season.

Other Risk Factors

Other environmental and managemental risk factors suspected to affect calf morbidity and mortality include: dam preventive practices by vaccination, the sanitation of calving area, perinatal care, grazing level (whether zero grazing, partial grazing or total grazing), level of herd production, practice of prophylactic antibiotics, weaning age, separation or mixing of calves etc. (Brunning- and Kanene, 1992; Lance *et al.*, 1992a; Olsson *et al.*, 1993).

2.4. Status of Calf Morbidity and Mortality in Ethiopia

The information on calf morbidity and mortality in Ethiopia is scarce. Those available are mostly from research and institutional herds, which do not properly represent the predominant smallholder production system existing in the country.

2.4.1. Causes

Most frequently reported causes of morbidity and mortality in dairy calves in Ethiopia include calf diarrhea, calf pneumonia, gastrointestinal parasites, skin disease, etc. (Gryseels and de Boodet, 1986; Hassen and Brannag, 1996; Amoki, 2001; Lemma *et al.*, 2001; Shiferaw *et al.*, 2002). These studies also showed that calf diarrhea and calf pneumonia as leading causes in younger calves and gastrointestinal parasites in older calves that when on pasture.

There are very few studies done to identify specific agents involved in disease syndromes such as the ones mentioned above. Abraham *et al.* (1992) tried to identify specific infectious agents associated with neonatal diarrhea in Ethiopian dairy calves. They found bovine enteric coronavirus, group A rotavirus and K99 Enterotoxogenic *E. coli* independently or in combination in diarrheic calves. Bovine enteric coronavirus was the most frequently detected pathogen followed by rotavirus. *Salmonella* was detected in diarrheic calves and was responsible for the death of calves in different parts of the country (Pergram *et al.*, 1981).

Hussien (1998) and Simachew (1998) have also isolated *E. coli* from diarrheic calves, but this did tell little about the significance of the isolated bacteria to the causation of the disease. This is because most *E. coli* strains are normal flora of gastrointestinal tract of mammals and the strain causing with ability of causing disease should be identified before incriminating them as the causes.

2.4.2. Mortality and Morbidity Rates

Most studies on calves, reported mortalities. Morbidity rates have not usually been reported; this may be due to unreliability of farm records on illnesses. Nevertheless, the reports on mortality are considered to show more generally the disease status in those herds.

Calf mortality rates reported in Ethiopia range from 7 to 25% in pre-weaned calves (Sisay and Ebro, 1998; Shiferaw *et al*., 2002). Hassen and Brannag (1996) reported a mortality rate of 53% from three years record of Ada Berga dairy farm that keeps Danish Jersey breeds. A mortality rate (including abortion and stillbirths) as high as 67% was found in Friesian-Zebu crosses up to two years of age (Gryseals and de Boodet, 1986). Mortality rates reported from different studies are summarized in Table 2.

Table 2. Calf mortality rates compiled from different studies in Ethiopia

Productions system	Breed of calves	Age of calf Considered	Mortality Rates (%)	Referances
Semi-intensive	Friesian x Boran and Jersey x Boran	Preweaning (3 months)	7	Shiferaw *et al*., (2002)
Intensive and extensive	Friesian x Boran, Jersey x Boran and Borans	Preweaning	14.2	Amoki (2001)
Semi-intensive	Borans	preweaning	25	Sisay and Ebro, (1998)
Semi-intensive	Crosses of Friesian and local breeds	preweaning	15	ILRI (1996)
Semi-intensive	Jersey	-	53	Hassen and Brannang (1996)
-	Crosses of Friesian, Jersey and Simmental with local breed animals	Up to 6 months	17.5	Hussien (1998)
Intensive and extensive	87% Friesian Crosses and local zebu	2 years	67	Gryseels and de Boodet (1986)

2.4.3. Risk Factors Assessed

Different studies tried to assess different risk factors for calf morbidity and mortality. Younger age and higher level of Taurus blood of calves was found to be associated with higher calf mortality (Gryseels and de Boodet, 1986; Hialemariam *et al.*, 1993a; Shiferaw *et al.*, 2002). Different managemental and environmental factors were reported to significantly affect calf morbidity and mortality. These include: colostral feeding, housing, calving assistance, production system, herd size, hygiene of micro-environment, season, etc. (Hailemariam *et al.*, 1993b; ILRI, 1996; Simachew, 1998; Amoki, 2001; Shiferaw *et al.*, 2002). The importance of colostrum status of the calves as a risk factor for mortality has been indicated in Table 3.

Table 3. Passive immune status with 16 ZST units as a cut off point in 28 cases of mortality in dairy calves in Holleta area, Ethiopia

Passive Immune Status	Mortality	
	No of calves died	% of calves died
Normal	9	32.1
Complete failure	19	67.9

Source: Amoki (2002)

3. MATERIALS AND METHODS

3.1. Study Area

This study was carried out in dairy farms found in Debre Zeit and the surrounding areas. Debre Zeit town is located some 45 km South East of Addis Ababa and has total human population of 95 000 (CSA, 2001). The area has an altitude of 1850 meter above sea level and experiences a bimodal rainfall pattern with a long rainy season from June to October and a short rainy season from March to May. The average annual rainfall and average maximum and minimum temperature for the area are 800mm, and 27.7°C and 12.3°C, respectively (CSA, 2001).

3.2. Study Population

The sampling units for the study were crossbred dairy calves of up to 6 months of age. All calves from dairy farms in Debre Ziet and its surrounding constituted the study population. There were few relatively large dairy farms with milking herd size of greater than 30 and a lot of market oriented smallholder (MOSH) dairy farms with herd size of around three cows. The majority of MOSH dairy farms were organized under one dairy cooperative called Ada Liben Milk and Milk Products Marketing Cooperative, plc. The cooperative comprised about 614 member farms. Both large and MOSH dairy farms kept crosses of Holstein and local breed animals.

3.3. Study Design

The study was longitudinal prospective observational study that extended for six months from beginning of October 2003 to the beginning of April 2004. The sampling units (calves) were identified individually and monitored throughout the study period. The questionnaire survey was also conducted during the study period.

3.3.1. Sampling Procedure and Sample Size

All calves from the three large dairy farms namely; Debre Zeit Dairy Farm, Gensis Dairy Farm and Debre Zeit Agricultural Research Center (DZARC) Dairy Farm, and a representative random sample of calves from market oriented smallholder (MOSH) dairy farms were selected for the study. Considering individual MOSH dairy farms as a cluster,

cluster sampling method was used to select calves from MOSH dairy farms. In the actual sampling procedure, the list of members of Ada-Liben Milk and Milk Products Marketing Cooperative was used as a sampling frame. Sample size for cluster sampling was determined by adjusting the sample size calculated for simple random sampling. The adjustment is the function of average cluster size and intraculster correlation, and mathematically expressed as:-

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

where

n' = sample size for cluster sampling

n = sample size calculated for simple random sampling

m = average cluster size

ρ = intracluster correlation

In this particular case the average herd (cluster) size (calves per MOSH dairy farm) was only 1.6. With this small clustering, the effect of intracluster correlation would be small and n' would approximate n. So the sample size calculated for random sampling was taken directly to be the sample size for this study as far as MOSH farms were concerned.

The sample size for estimating disease problems using simple random sampling methods was calculated according to Martin *et al.* (1987).

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

n = sample size

$Z\alpha/2$ = confidence level

P = expected prevalence

Δ = precision level

Using expected calf mortality of 15% (reported by ILRI, 1996 for Addis Ababa milk-shed), confidence level of 95% and required absolute precision of 5%; a sample size of 196 calves was determined for MOSH farms. Selection was done by lottery system from the sampling frame until 196 calves were included. When a selected farm did not have calf or calves eligible for the study (having calves under three months of age or pregnant cows with due calving date in the next three months), it was replaced by another farm mostly from neighboring. Totally 236 calves, 51 from the three large dairy farms and 185 calves from 112 MOSH farms were used for the study.

3.4. Data Collection

3.4.1. Longitudinal Study

Monitoring of dairy farms for calf morbidity and mortality was carried out for 6 months from October 11, 2003 to April 8, 2004. For the purpose of this study, calf was defined as young cattle under six months of age, morbidity as any sickness that has recognizable clinical manifestation and mortality as death of calves above the age of 24 hours. For the monitoring, all claves in the selected farms that were under three months of age at the beginning of the follow up period and those born in the subsequent three months were individually identified and monitored by the investigator throughout the follow up period. The calves were withdrawn from the follow up when they completed their 6 months of age. In this way, each calf was monitored at least for three months unless censured due to deaths.

Individual records were prepared (Annex 1) when a calf joined the study cohort. These were used to record genealogy of the calf, events surrounding the birth of the calf, routine management practices applied to the calf and health problem incidents that were observed during the monitoring.

In the actual monitoring work, calves under three months of age were regularly visited every two weeks and monthly thereafter by the investigator. The main activities accomplished during the regular visits were:

- 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 abnormality was suspected
- Observation on different calf management aspects like cleanness of the calf house and feeding practices
- Asking calf attendants the occurrence of calf health problem incidents between the visits and recording of the history of the calf health problem that would enable the investigator infer the possible cause and thus assist diagnosis
- Collecting faecal samples from active cases of diarrhoea in calves

In addition to regular visits, emergency visits were paid in response to calls from farms for calf health problems.

Calf morbidities encountered during the monitoring period were categorized in six disease conditions/syndromes based on their clinical signs. These were:

Diarrhoea: Any condition characterised by passing of lose or watery feces with increased frequency, which could or could not be accompanied by other systemic signs like dehydration, decreased appetite or fever.

Pneumonia: When frequent coughing observed with or with out respiratory discharges and fever.

Septicaemic condition: Any condition characterised by depression, anorexia and fever with out any distinct involvement of specific body system.

Navel ill (omphalitis): Swelling of umbilical cord which is painful when palpated and with or without abscess formation

Joint ill (arthritis): Enlargement of joints usually with abscess formation in any one or all limbs, which could or could not be preceded by other disease condition.

Congenital problems: Any problems that was acquired inborn.

Miscellaneous cases: Different health problems that could not be grouped in any one of the other groups mentioned before and diagnosed relatively less frequently.

3.4.2. Cross-sectional Study Based on Questionnaire

A well structured questionnaire was administered to 112 MOSH dairy farmers by one visit interview. The questionnaire was designed to collect information on farm characteristics, calf management techniques including periparturient care, feeding and housing, and previous history of calf diseases. The sample of questionnaire format is shown in Annex 2.

3.5. Identification of Infectious Agents Associated with Calf Diarrhea

3.5.1. Sample Collection

Fecal samples were collected from untreated diarrheic calves preferably soon after onset of diarrhea. About ten grams of feces was collected from rectum in separate sterile container, kept at an ice cold condition and transported to laboratory. The samples were processed as soon as possible after collection. The samples were collected with the intention of examining them for the presence of rotavirus, bovine coronavirus, *Escherichia coli* strain K99, *Salmonella* and *Cryptosporidium*. But due to the problem encountered to secure the ELISA kit for detection of rotavirus, bovine coronavirus and *E. coli* strain K99, laboratory examination of fecal samples was done only for *Salmonella* and *Cryptosporidium*.

3.5.2. Detection of *Salmonella*

Isolation and identification of *Salmonella* was carried out based on procedures made available by international organization for standardization (ISO, 1998) and Carter (1984). About 5-10% of the quantity of feces was inoculated into selenite cycitene (Merck, Germany) and 1% into Rappaport Vassiliadis (Sifini, Germany) broths which were incubated at 37°C and 42°C for 24 hours, respectively. From selective enrichments, subculture were made at 24 hours to selective plate media BPLS (Sifin, Germany) and XLD (Sifin, Germany) and incubated at 37°C for 24- 48 hours. Suspicious colonies were further subcultured in nutrient media (Oxoid, England) for biochemical tests.

The suspected pure colonies from nutrient agar were inoculated in TSI slant (Merck, Germany), citrate slant (Difico, USA), lysine decarboxylase broth (Difico, USA) and urea broths (Merck, Germany). Red (alkaline) slant, yellow (acid) butt, H_2S positive/negative in TSI and lysine positive and urease negative were identified as *Salmonella*. These isolates were sent to OIE *Salmonella* reference laboratory of health Canada in Guelph, Ontario, Canada, for stereotyping and antimicrobial susceptibility test.

3.5.3. Detection of *Cryptosporidium*

Fecal samples were also examined for the presence of *Cryptosporidium*. This was done by modified Zeihl-Nelson staining technique as described by Kaufmann (1996).

The outline of the Procedure was:

- Thin fecal smear was prepared, air dried and pass quickly through flame
- Stained with 0. 5% of carbon fuchsine for two minutes
- Rinsed for few seconds within acid alcohol (3% hydrochloric acid &70 % of ethanol
- Rinsed again within tap water
- Counterstained with brilliant green for two minutes
- Observed under high power microscope for the presence of bright red granules (oocysts) on blue green background.

Identification of oocysts from smears was made by comparing with the slide photograph in Kaufmann (1996). A smear was considered positive when one or more oocysts were observed.

3.6. Data Management and Analysis

3.6.1. Describing Morbidity and 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 diseases occurrences. Incident density was calculated by dividing the number of cases of interest to the number of calf days at risk. Cases here are referred to one of the disease conditions/syndromes defined previously or death of calves. Number of calf days at risk was found by adding the number of days at risk of obtaining a new case in each calf in the study period.

Prevalence rate was calculated instead of incidence rate to describe congenital health problems, since these problems were time independent for individual calves, i.e. recorded only in the first visit of individual calves.

Incidences were calculated for crude morbidity, crude mortality and for each disease condition/ syndromes mentioned before. In the calculation to describe 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 as far as it occurred after complete recovery (complete disappearance of clinical signs) of the preceding one. Similarly, two or more cases of the same disease condition were considered as different cases in calculating the incidence of that disease condition/syndromes as far as the second occurred after the disappearance of the clinical sign of the first. Nevertheless, in this case the days in which the calf stayed ill were not counted as days at risk.

3.6.2. Investigation of Risk Factors for Morbidity and Mortality

In investigating risk factors, the data was analysed at calf level. As the calves in the same herd in case of large dairy farms lack independency from each other they were excluded from the analysis. Therefore, investigation of risk factors related to calf health problems were done only for smallholder farms.

A total of 33 potential risk variables (explanatory variables) of which seven calf factors, 18 management factors and eight farm attributes were considered to analyze their effect on calf morbidity, calf mortality and calf diarrhea (Table 4, Annex 3). However, analyses were made only using 20 of the potential risk variables (Table 4). The rest of the variables could not be used for analyses because either they had very small observations per category or similar responses were recorded for all subjects (calves).

The responses of all variables were dichotomised to facilitate analysis and interpretation of results. While dichotomising continuous variables and those categorical variables with response of more than two levels, care was taken to make the cutoff points sensible.

The incidence of specific diseases other than calf diarrhoea was small and doing separate analysis for risk factors was not found important.

In the analysis of risk factors only the first occurrence of cases was considered since subsequent cases would not be independent of the preceding one, which is required for most statistical analysis. Congenital problems and specific epidemic infectious disease were not considered in the analysis of management factors on the assumption that they are more or less not affected by calf management (but it does not mean that they are not affected by dairy management in general).

3.6.3. Statistical Analyses

Processing of data was done by computer software. Microsoft excel (2002) was used to calculate the descriptive part. Statistical analyses of the associations between risk factors (explanatory variables) and outcome variables (status variables) were done by Cox regression (Cox's proportional hazard model); a statistical method used to model survival data. First, the association of individual risk factor with an outcome variable was screened by univariate Cox regression. Those variables significantly associated with the outcome variable at 5% significance level in the univariate analysis were selected for multivariate analysis using multiple Cox regression to see their independent effect. In the multivariate analysis a model was fitted for each outcome (status) variable by stepwise backward elimination of nonsignificant variables (P>0.05). SPSS statistical software (SPSS for Windows, Release 11.5, 2002) was used to run Cox regression.

Table 4. 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 bellow 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 bellow 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

4. RESULTS

4.1. Morbidity and Mortality

Monitoring of 236 dairy calves for clinical health problems was conducted for 6 months to determine the incidence of morbidity and mortality rates. The results of this study revealed that the incidence of crude morbidity and crude mortality in the first 6 months of calfhood were 61.5% and 18.0%, respectively. From disease conditions/syndromes diagnosed during the monitoring, calf diarrhea was the leading infectious cause of calf morbidity with incidence rate of 42.9%, followed by pneumonia (4.9%). The incidence of other disease conditions was low (Table 5).

Table 5. The incidence (true rate and risk rate) of different disease conditions/syndromes, crude morbidity and crude mortality

Disease condition/syndromes	N	Calf days at risk	Incident rate	
			True rate/6 calf months at risk	Risk rate (%)[a]
Diarrhea	85	27562	0.56	42.9
Pneumonia	8	28332	0.05	4.9
Joint ill (arthritis)	7	28342	0.04	3.9
Navel ill (omphalitis)	6	28352	0.038	3.7
Septicemic condition	7	28342	0.04	3.9
Specific infec. epidemic diseases	7	28342	0.04	3.9
Congenital problems	12	236[b]	5%[c]	-
Miscellaneous cases	24	28412	0.15	13.8
Crude morbidity	152	28412	0.96	61.5
Crude mortality	31	28412	0.2	18.0

N= number of cases, a = derived by the formula, Risk rate = $1\text{-}e^{-\text{true rate}}$ (Martin *et al.*, 1987)
b = number of calves, c = prevalence

A 5% prevalence of congenital problems was recorded in this study, of which 10 of the 12 cases were congenital loss of sight. The cases recorded as specific infectious epidemic disease were that of foot and mouth disease which occurred due to an outbreak in one of the large dairy farms. Of the clinical syndromes lumped to the miscellaneous category, unthriftness, bloody urine (associated with excess intake of water) and hair loss on the different part of the body (which had a characteristic of mange or ring worm) occurred relatively more frequently than the others.

The principal cause of death was again diarrhea directly accounting for the 13 cases of the total 31 deaths. However, only two of these calves were dead showing the classical pattern of acute calf diarrhea (dehydration and depression). Four calves died of unthriftness after recovering from diarrhea attack. The other three calves died very acutely showing signs of abdominal discomfort suggesting clostridial enterotoxaemia. Other causes of death recorded include sudden death (2), pneumonia (2), grain engorgement (1), navel ill complication (1), water toxicity (1) and septicemia of unidentified causes (4).

The average age for the occurrence of crude morbidity, crude mortality and diarrhea were six, nine and six weeks, respectively. Proportionally the highest morbidity, mortality and diarrhea incidents occurred in the first week of life. Some 13% of the total cases of morbidity and diarrhea and 19% of the total cases of mortality occurred in the first week of life. Again 36, 32 and 40 percent of the total cases of crude morbidity, crude mortality, and calf diarrhea, respectively occurred in the first month of age and 84, 77 and 91 percent of the total cases of crude morbidity, crude mortality and diarrhea, respectively occurred in the first three months of age.

When calf health problems were compared by farm types, the incidence of crude morbidity and calf diarrhea were apparently higher in large farms than MOSH farms while the incidence of calf mortality was higher in MOSH (Figure 1).

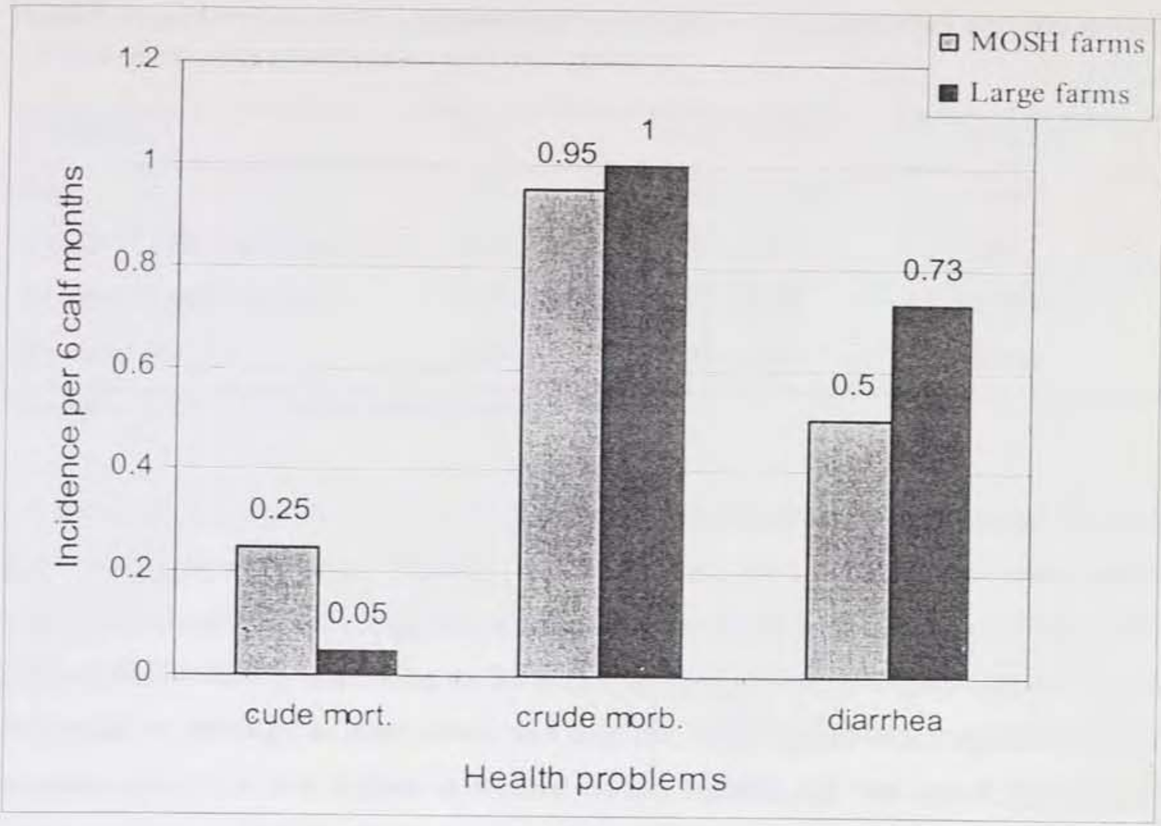

Figure 1. Incidence of different health problems by farm types

4.2. Association of Potential Risk Variables with Incidence of Morbidity and Mortality

A total of 20 different potential risk factors were investigated for their association with the occurrence of crude morbidity and mortality in smallholder farms. Such an analysis was also done for calf diarrhea as it was the leading cause of morbidity and mortality. Of the 20 factors considered for analysis, only four factors were found significantly ($P<0.05$) associated with crude calf mortality in a univariate analysis using Cox regression. These include age of the calves, age at first colostrum feeding, amount of milk given daily and weaning age (Table 6). The result of statistical analysis for all factors tested is indicated in Annex 4.

Table 6. Potential risk variables significantly associated with the incidence of crude mortality based on univariate analysis using Cox regression

Variables	HR*	95 % CI for HR	P value
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

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

Further analysis using Cox regression by fitting into the model only the potential risk factors with significant association ($P<0.05$) with crude calf mortality after univariate analyses 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, weaning age and age at first colostrum ingestion were additional risk factors associated with mortality, the weaning age being the most significant (Table 7).

Table 7. Potential risk variables that were significantly associated with the incidence of crude calf mortality in weaned calves based on multivariate analyses using Cox regression

Variables	HR	95 % CI for HR	P value
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

The difference in hazard of crude mortality between early weaning and late weaning in calves is displayed in Figure 2.

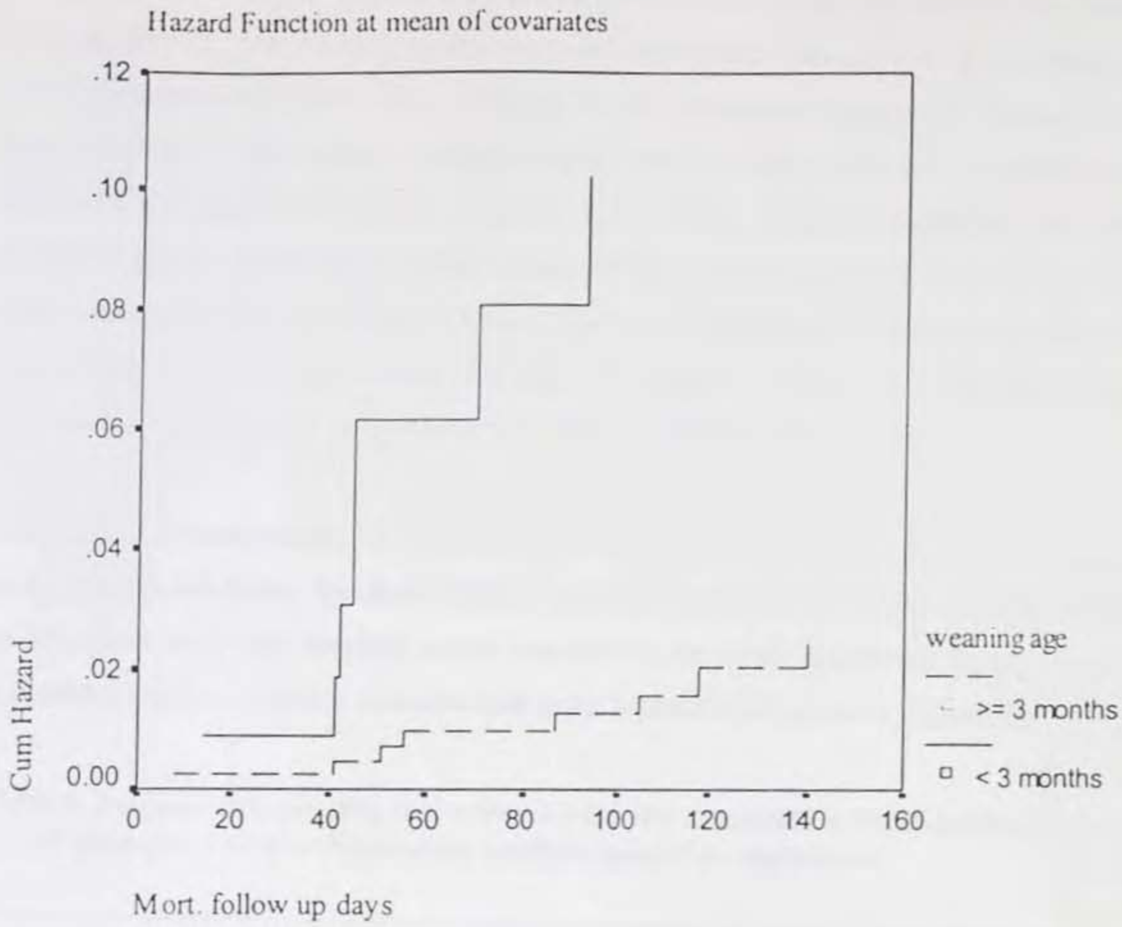

Figure 2. The hazard for crude calf mortality compared by weaning age of calves

When similar analysis to crude mortality was done for crude morbidity, condition of birth, age of calves, age at first colostrum ingestion, amount of milk fed daily, house cleanness and weaning age were found with significant association($P<0.05$) in the univariate Cox regression (Table 8, Annex 5).

Table 8. Potential risk variables significantly associated with the incidence of crude calf morbidity based on univariate analysis using Cox regression

Variables	HR	95 % CI for HR	P value
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 house	1.69	1.06 – 2.73	0.029

Among the six variables significantly associated with crude calf morbidity in the univariate analysis, five of them (excluding weaning age) were fitted into a model to run multivariate Cox regression. After the analysis, only age at first colostrum ingestion, cleanness of the calf house and age of the calves contributed significantly to the model at 5% significant level (Table 9). Keeping the effect of other factors constant, 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. Similarly, the hazard of morbidity in older calves was 42% of that of younger calves. The hazard of morbidity in calves which were housed in unclean houses were 1.75 times higher than those housed in clean houses.

When a similar analysis was carried out for weaned calves with the inclusion of weaning age as a potential risk factor, the same factors contributed to the model (Table 10). The difference in hazard of morbidity between calves grouped by the most significant factor, age at first colostrum feeding, is clearly demonstrated in the hazard function curve (Figure 3).

Table 9. Potential risk variables that were significantly associated with the incidence of crude calf morbidity based on multivariate analyses using Cox regression

Variables	HR	95 % CI for HR	P value
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 house	1.75	1.08 – 2.84	0.024

Table 10. Potential risk variables that were significantly associated with the incidence of crude calf morbidity in weaned calves based on multivariate analyses using Cox regression

Variables	HR	95% CI for HR	P value
Age	0.46	0.28 – 0.76	0.003
Age at 1st colostrum ingestion	2.61	1.55 – 4.40	0.000
Cleanness of house	1.81	1.06 – 3.02	0.030

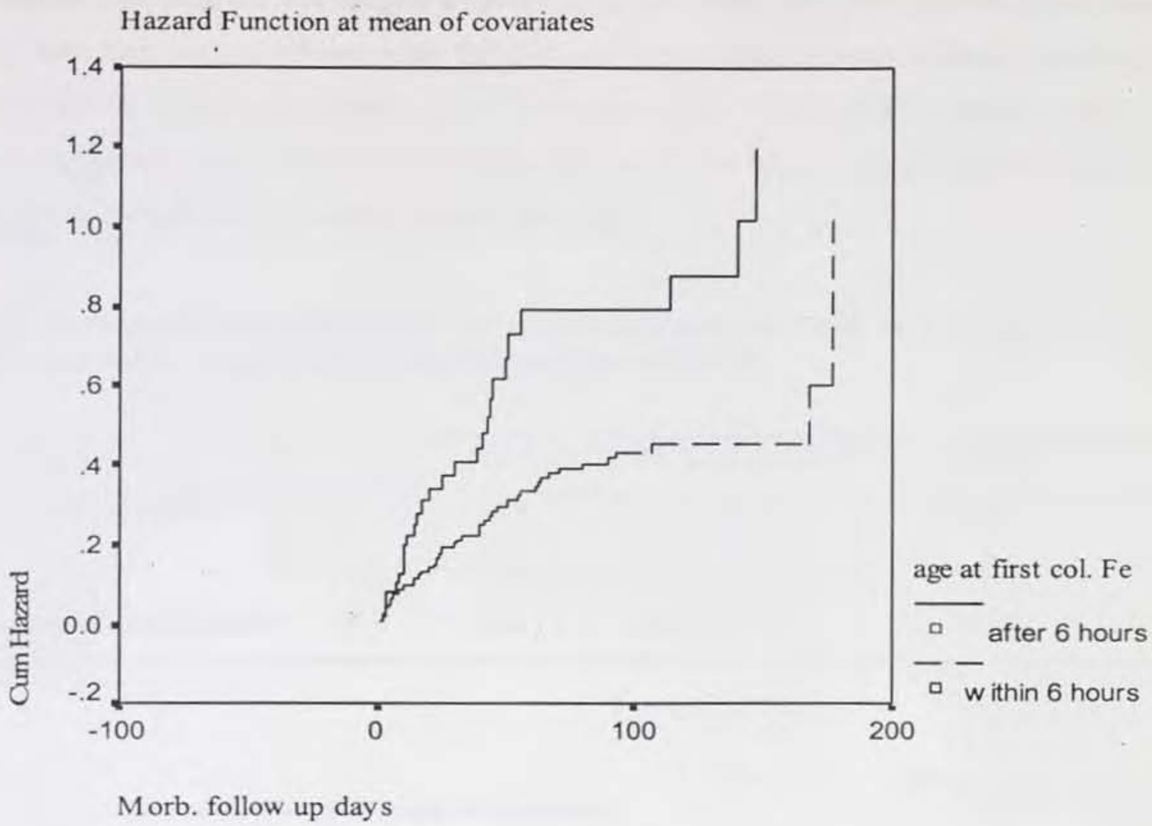

Figure 3. The hazard for morbidity compared by ages of first colostrum ingestion

Four potential risk factors were found significantly associated with risk of calf diarrhea when tested separately using univariate Cox regression. These included condition of birth, age of calves, age at first colostrum ingestion and cleanness of calf house (Table 11). The result of statistical analysis for all tested factors is indicated in Annex 6.

Table 11. Potential risk variables significantly associated with the incidence of calf diarrhea based on univariate analysis using Cox regression

Variables	HR	95 % CI for HR	P value
Condition of birth	3.10	1.54 - 6.24	0.002
Age	0.26	0.13 – 0.48	0.000
Age at 1st colostrum ingestion	2.32	1.28 - 4.2	0.005
Cleanness of calf house	2.48	1.29 – 4.78	0.006

When the potential risk factors having significant association with calf diarrhea after univariate analyses were fitted in multivariate model to run Cox regression, condition of birth, age and house cleanness contributed significantly to the model. According to the model, the hazard for calf diarrhea was around 3 times higher for calves born with difficult birth than those born from normal delivery when the effects of other factors are kept constant. Similarly, the hazard for experiencing diarrhea for calves whose house was rated as unclean was 2.5 times higher than those housed in clean house (Figure 4). The hazard of calf diarrhea for older calves was 25% of that of younger calves (Table 12).

Table 12. Potential risk variables that were significantly associated with the incidence of calf diarrhea based on multivariate analyses using Cox regression

Variables	HR	95 % CI for HR	P value
Condition of birth	3.01	1.52 – 6.21	0.002
Age	0.24	0.12 – 0.47	0.000
Cleanness of calf house	2.34	1.21 – 4.50	0.011

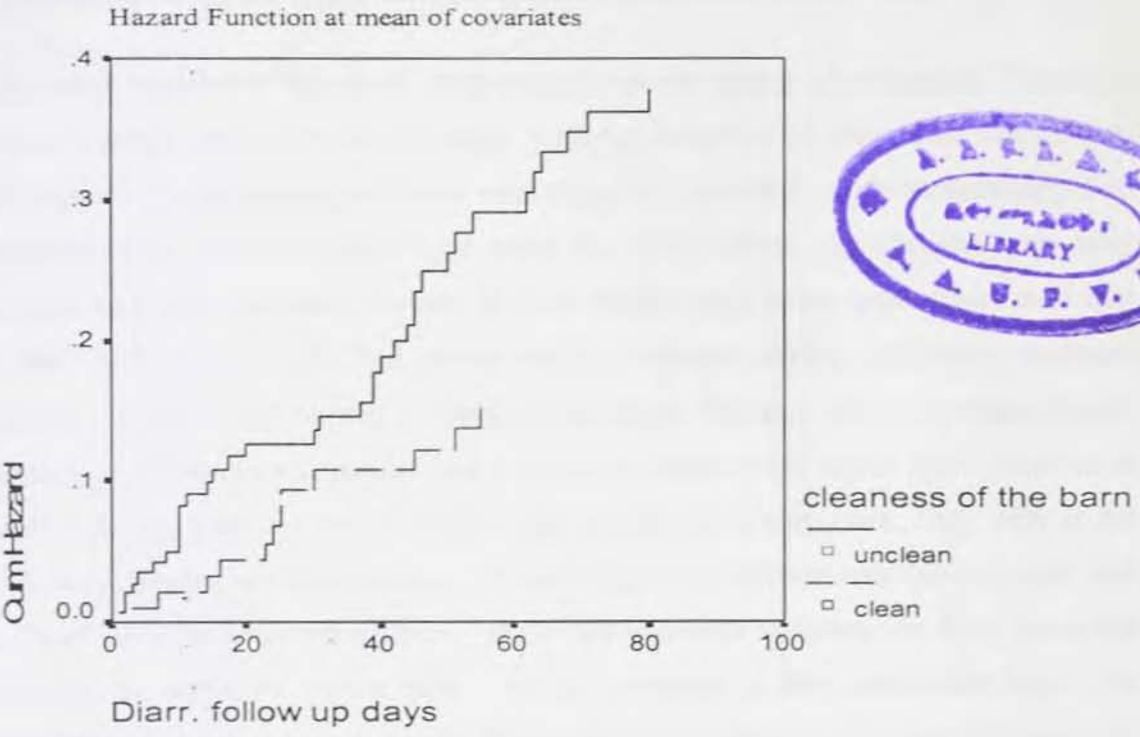

Figure 4. Hazard for calf diarrhea compared by the hygienic status of calf houses

4.3. Agents Associated with Calf Diarrhea

Laboratory examination of 55 fecal samples from 85 cases of diarrhea that occurred during the study period was done to identify pathogens associated with calf diarrhea. Examination of samples was done only for *Salmonella* and *Cryptosporidium*.

Of the 55 samples examined for *Salmonella*, only two (3.6%) samples were positive. Both isolates were from calves that were 2 weeks of old suffering from acute diarrhea, one from large dairy farm and other from MOSH dairy farms. The serotype of these salmonellae were *Salmonella enterica* serovar typhimurium (*Salmonella* Typhimurium) and *Salmonella enterica* serovar heidelberg (*Salmonella* Heidelberg). Both these serotypes were sensitive for drugs that are commonly used in treatment of man and animals such as streptomycin, amipicillin, amoxicillin, tetracyclines, chlramphenicol and sulfa drugs.

Fecal smears were made from all 55 samples to detect the presence of *Cryptosporidium* oocysts. Only four (6.7%) samples were positive. The age of calves from which *Cryptosporidium* was detected ranged from 20 to 90 days. These positive calves also were from both large and MOSH dairy farms.

4.4. Description of Farms Based on Questionnaire Result and Observation

All the farms included in this study were under intensive system of production. They kept crossbred animals (Holstein x local breeds). With the exception of Debre Zeit Dairy Farm, which exercises partial grazing, all farms were completely stall-fed. All farms raise their own replacement stock. Debre Zeit Dairy Farm raises only heifer calves. The other two large dairy farms raise both male and female calves. In Most MOSH dairy farms, male calves were sold soon after birth. Only DZARC had calving facility (separate calving pen). Navel treatment during birth of calves was practiced in none of the farms. The knowledge of immunological importance of colostrum was present and a deliberate effort to fed calves with colostrum at the right time was practiced only in Debre Zeit and DZARC Dairy Farm. Only 44% of the MOSH dairy farmers had knowledge of the advantage of colostrum over ordinary milk and only 7% of them did know the optimum time to fed colostrum to calves. All study farms fed whole milk for calves two times daily with the exception of few smallholder farms. No special starter feed was used in any of the farms rather same feed given to cows were used for calves. These include straw, hay and concentrate mixture (wheat bran and Nug cake (*Guizoitia abyssinica*)). Age to introduce non-milk feed and weaning age varied from farms to farms. Genesis and DZARC dairy farms and the majority of MOSH (60%) farms wean their calves at three months of age. Most of the remaining MOSH and Debre Zeit Dairy Farm wean the calves at 4 months. The weaning age was lower for male calves mostly under three months. DZARC and Debre Zeit Dairy Farms used individual calf pen and Genesis Dairy Farm used calf hutch for housing calves until 6 months of age. MOSH dairy farms either house their calves in cow barns, in a separate calf house or in groups when calves are more than one. Bedding was provided for calves in all large dairy farms and in none of the MOSH dairy farms.

In all large dairy farms, there were vet personnel (veterinarian and/or animal health technician) either as fully employed or part time employed to deal with health aspects of the farms. MOSH dairy farms call private veterinary practitioners, whenever facing health problem of animals. None of the farms practiced dam vaccination or any other measures to protect future calf morbidity and mortality. Of the 112 MOSH dairy farmers interviewed 64 (57.1%) of them mentioned calf morbidity and mortality as one of the health problems in their farms. For 11 (9.8%) MOSH dairy farms, calf mortality was number one problem (for the rest of the farms either reproductive problem or mastitis was the first complaint). Forty (35.7%) MOSH dairy farms had experienced the death of at least one calf in the past year. From farmers that mentioned calf health problems as a problem in dairy production the majority of them (53.1%) complained diarrhea as a major cause of morbidity and mortality. For large dairy farms, calf health problem was a second complaint next to mastitis.

To summarize the major findings of the whole study in brief, the incidence of crude calf morbidity and mortality was 61.5% and 18.0%, respectively, in the study herds. Among the different disease conditions diagnosed, calf diarrhea was the predominant calf health problem followed by pneumonia. From a number of putative risk factors analyzed for their association with incidence of calf morbidity and mortality, age of the calves, age at first colostrum ingestion and house cleanness were found most important in affecting the occurrence of calf health problems. The Laboratory work revealed the role of *Salmonella* and *Cryptosporidium* in causing calf diarrhea. From personal observation and farmers interview, inadequacy was found in some of calf management techniques.

5. DISCUSSION

In the present study, an attempt has been made to find the incidence of calf morbidity and mortality, establish the role and magnitude of the associated predisposing factors and also identify some of the infectious agents involved in calf diarrhea. Unlike previous studies on the subject in Ethiopia, which addressed mainly state farms and research herds, the focus of the present study was on market oriented smallholder dairy farms especially in the case of investigation of risk factors. So the findings are judged to contribute invaluable information in the area of calf management in the rapidly expanding smallholder dairying in the major urban centers of the country. On the whole, the study was based on all calves in the large dairy farms and representative sample of calves from smallholders. Moreover, all the outcomes and most explanatory variables tested for their association with disease outcomes were recorded from direct observations; these apparently make the internal and external validity of the results acceptable. However, due to small number of death events which lower the power of the test in survival analysis, the results for that outcome might need cautious considerations. The small number of fecal samples collected (55 samples from a total of 85 diarrheic cases recorded), due to problem of getting diarrheic calves especially from MOSH farms on time for sampling, might have influenced the prevalence of pathogens looked for.

5.1. Mortality and Morbidity

In the present investigation, in Debre Zeit town and its environs, crude calf morbidity of 61.5% and crude calf mortality of 18.0% were recorded and this is considered among the highest incidence reported on the subject so far. These findings are much higher than the 3 to 5% calf mortality that can be achieved through good calf management and above the economically tolerable level at least by the standard of the western production systems (Heinrichs and Radostits, 200; Roy, 1990).

Generally, Comparisons of the present results with that of other studies have faced inherent difficulties. Regarding calf morbidity and mortality, incidence reports varied with the period covered during the follow up, the methods used in measuring rates (incidence density (true rate) or cumulative incidence (risk rate)) and the unit of study used (herd or calf). Although the disease conditions/syndromes diagnosed in this study were originally calculated as true rates, they were derived into risk rates to facilitate the comparison of results with other studies.

In this study, the mortality rate found for 6 months has considerably agreed with the mortality rates reported for similar period by different studies in Ethiopia (Hussien, 1998; Amoki, 2001). However, it was higher than the 12% mean calf mortality rate in smallholder dairy production in sub-Saharan Africa (Otte and Chilonda, 2002) and even much higher than those from western world which were reported in the ranges of 9 to 13 % for Europe and 6.3% for USA(Heinrichs and Radostits , 2001). On the other hand, the present finding was lower than the 25% and 50% reported by Sisay and Ebro (1998) and Hassan (1996), respectively.

Concerning the morbidity and mortality of calves, most previous reports from Ethiopia were based on studies in research stations and state farms with large herd sizes and usually holding high exotic blood level animals, apparently these are associated with increased risk of calf disease occurrence. In the present study, the number of calves per farm was small and the farmers can easily monitor calves and take measures to avoid calf health problems. This could be one of reasons to find relatively lower mortality rate than those large herd size farms mentioned above. It was higher than reports from developed countries where there is a well developed management system. In addition, the tropical environment for which temperate breeds are not well adapted might have been an additional stress to increase the risks of health problems.

Generally, morbidity rate reports showed wide variability due to the different methods used in diagnosis. Some authors reported calf morbidity based on producer diagnosis and treatments while others depended on veterinarian diagnosis. Nevertheless, the morbidity rates determined in the present study were higher specially those due to diarrhea than similar reports. Crude calf morbidity rates of less than 30% were reported by many authors in different parts of the world (Waltner-Toews *et al.*, 1986b; Olsson *et* al., 1993; Gitau *et al.*, 1994; Sivila *et al.*, 1996a). Comparable morbidity rates to the present study were reported by Virtala *et al.* (1996b) and Debnath *et al.* (1990) who reported 52% crude morbidity in calves.

In the present investigation, calf diarrhea was found to be the predominant calf health problem with incidence rate of 42.9% followed by pneumonia (4.9%). Diarrhea was also the leading cause of mortality in the study herds. These findings are in agreement with reports of Lemma *et al.* (2001) and Hussein (1998) in Ethiopia and many other studies elsewhere, which reported diarrhea and pneumonia as the first and second important disease complexes that affect calf health (Olsson *et al.*, 1993; Debanth *et al.*, 1995; Sivula *et al.*, 1996a). On the other hand, there are studies which found pneumonia as the leading cause of calf mortality (Rao and Nagarcenkar, 1980; Agerholm *et al.*, 1993; Shiferaw *et al.*, 2002). Nonetheless calf diarrhea as a leading health problem in growing dairy calves is a common finding, the high incidence in this study suggests the significance of poor hygienic handling of feeding utensils and calf house observed during the study. In addition, based on the present study , only a very small percentage of farms were aware of the optimal time for colostrum feeding and this could greatly contributed to the high incidence of calf diarrhea in those herds. This finding is consistent with the work in the central highland of Ethiopia by Amoki (2001) indicating a high percentage of failure of passive transfer of immunity in market oriented smallholder dairy farms. On the other hand, the relatively lower incidence of pneumonia in this study might be due to the small herd size of farms. Large herd size has strong correlation with environmental stress that exposes calves to respiratory problems; it was observed that a 50% decrease in stocking density was increasing the ventilation rate by 20 times there by decreasing the risk of pneumonia (Blowey, 1990).

The occurrence of other health problems of calves diagnosed less frequently were navel ill (3.7%), joint ill (3.9%), septicemic conditions (3.9%), congenital problems (5%) and other miscellaneous cases. In agreement with these findings, there are similar reports of lower incidences of these disease conditions than diarrhea and pneumonia (Britney *et al.*, 1984; Olsson *et al.*, 1993; Virtala *et al.*, 1996b; Shiferaw *et al.*, 2002). The 5% prevalence found for congenital problems in this study was difficult to explain. Ninety percent of the congenital problems recorded was the congenital loss of sight with no gross anatomical abnormality either on the globe of the eye or any other part of body. No previous observation of such a problem has been reported. There are some toxins and infection like bovine virus diarrhea (BVD) virus which cause congenital cataract with consequences of blindness (Blowey, 1990). Nevertheless the frequency of this problem in the study herds was so high that a well-designed further investigation is suggested.

Although it was not possible to statistically compare calf health problems between farm types due to the sampling method and level of analyses used, crude morbidity and calf diarrhea were apparently higher in large dairy farms than smallholder farms. On the opposite, mortality was higher in smallholders. Amoki (2001) also similarly found higher mortality of calves in market oriented smallholder farms as compared to large dairy farms and mixed subsistence farms in Holleta area, Ethiopia. The higher morbidity in large farms can be due to the large herd size which demand for more calf rearing facilities and the indiscriminate and continuous use of the resources for different calves. This condition allows a build up of infectious agents in the calf rearing environment and hence increases the risk of calf diseases. The relatively higher mortality rate while morbidity was lower in smallholder farms indicates poor management of sick calves, which could arise from lack of easy access to animal health professionals for smallholders as observed during the monitoring work.

5.2. Risk Factors

A range of putative risk factors were tested for their association with crude mortality and crude morbidity in smallholder farms. Age was the important calf (host) factor found to affect crude mortality, morbidity and calf diarrhea. It was the only risk factor significantly associated with risk of mortality in all calves (weaned and unweaned). In all cases (mortality, morbidity and calf diarrhea), younger calves under three months of age were at higher risk as compared to older calves. In the six months period, the mode age for all outcomes was the first week of life within which 19% of crude mortality and 13% of crude morbidity and calf diarrhea had occurred. Forty, 36 and 32 % and 91, 84 and 77% of crude mortality, morbidity and calf diarrhea had occurred within one and three months of age, respectively. Similar age pattern of mortality and morbidity have been reported by several previous studies. Olsson *et al.* (1993) reported that 65% and 75% of morbidity and mortality in three months of life occurred in the first month of age. Waltner-Toews *et al.* (1986c) also found that 60% of all deaths occurred in the first months of life over a period of four months. Virtala *et al.* (1996b) in their three months study showed the peak occurrence of crude mortality and diarrhea at the second week of life, which decreased sharply thereafter. There are also studies, which reported either higher mortality in older calves than younger calves (Gitau *et al.*, 1994) or unrelated to age (Rao and Nagarcenkar, 1980; Debanth *et al.*, 1990) in studies that covered a year period.

Briefly, the present study lies between the two groups of study mentioned above in terms of the age distribution of health events. Similar to the first group, the present finding showed that the younger age was the critical age for calf health. On the other hand, unlike the first group and similar to the second group, the health events in the present study were less concentrated in the first few weeks of life and declined gradually. These imply that besides the undeveloped inherent immunity in very young calves, other factors like malnutrition in older calves were important in calf health management in the study herds. The relatively higher risk of mortality in young calves obsereved in this study suggests the need of more careful management for very young calves as compared to older ones.

In addition to younger age, early weaning (before 3 months of age) and delayed first colostrum feeding were found statistically associated with risk of mortality in weaned calves. Early weaning was reported to increase risk of mortality by Jenny *et al.* (1981) who found 50% higher mortality in calves that were weaned at 3-4 weeks as compared to those weaned at 7 or more weeks. 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). The age considered early and found out to be risky for calves in the present study was optimum age for weaning in the literatures. Therefore, what seemed to operate in the study calves is the management practice of weaning calves instead of the actual age of weaning. In most of the study farms, calves stayed without being introduced to dry feed up to 6 weeks and no special starter feed was given; when weaned in this condition, they fail to adjust to dry feed quickly and efficiently that leads to malnutrition and susceptibility to diseases.

In literature, the association between delayed intake of first colostrum meal and risk of calf disease have been widely reported. One thing unexpected in this respect was the significance of this factor as risk for mortality in weaned calves while it was not for calves of all age groups. As the colostral immunity is more important in very young age, the age at which it is ingested should matter more in young calves. This contradictory result may be probably due to the few number of calves died (n=15) after weaning which is unsuitable for survival analysis. In survival analysis like the one used in this study, the power of the test is directly related to the number of events (death in this case) than the actual sample size (Altman, 1990). Therefore, the finding in this case would be less reliable and further investigation along this line is warranted.

In the present work, the factors found statistically associated with crude morbidity were age, age at first colostrum feeding and cleanness of the calf house. Younger age, delay in first colostrum feeding and unclean calf house were associated with higher risk of morbidity. The finding that delayed colostrum intake (latter than 6 hours of age) associated with high risk of morbidity agrees with other reports. Olsson *et al.* (1993) found that each hour of delay in colostrum ingestion in the first 12 hours of age increased the chance of a calf becoming ill by 10%. Matte *et al.* (1982) found that 61% of colostral immunoglobulin containing 80mg/ml of

IgG is absorbed in six hours and decreases sharply thereafter. This indicates that the first six hours are the period in which maximum absorption of colostral immunoglobulin takes place (Bath *et al.*, 1985). The higher risk of morbidity related to delayed intake of first colostrum meal could be associated with failure of passive transfer (FPT) of colostral immunity. The role of FPT on subsequent health and production of neonatal calves was well documented by many researchers. According to Wittum and Perino. (1995), calves with inadequate colostral immunoglobulin concentration within 24 hours of birth were at greater risk of neonatal morbidity and mortality, preweaning morbidity and morbidity and respiratory morbidity while in feedlot. There are many other similar studies which proved FPT to be a risk for calf mortality and morbidity (Edwards *et al.*, 1982; Aldridge *et al.*, 1992; Amoki, 2001; le Rousie *et al.*, 2000). Perez *et al.* (1990) found no difference in terms of morbidity between those ingested first colostrum before 3 hours and after three hours of age. This showed that colostrum can be still efficiently absorbed after three hours and could not contradict the finding of the present study or other similar findings.

Based on the findings of analysis of risk factors, cleanness of the calf house was the other variable found to significantly affect crude morbidity in calves. The higher risk of morbidity associated with dirtiness of calf house seen in this study agrees with Shiferaw *et al.* (2002) who reported the effect of hygiene of the microenvironment of calves in the occurrence of calf mortality and morbidity in Holleta, Ethiopia. Bendali *et al.* (1999) also reported unclean calf houses associated with higher risk of calf scour. Increased risk of morbidity in calves associated with irregular change of bedding and poor housing condition was also reported by Perez *et al.* (1990). As most of infectious agents are acquired by calves from the immediate environment, the high risk of calf morbidity in unclean houses observed in the present study is logically supported. On the other hand, a study which considered cleanness of calf house and feeding utensils as potential risk variable on calf morbidity and mortality failed to show significant association between cleanness and calf health problems (Lance *et al.*, 1992a). This can happen from subjective nature of assessment of cleanness. The same factors that affect crude morbidity in all calves remain significant risk factors also in weaned calves. This shows that these risk factors are important throughout calfhood period.

Furthermore, analysis of the potential risk factors were done for calf diarrhea and age of the calf, condition of birth and cleanness of the calf house were the factors found with significant statistical association to calf diarrhea in all and weaned calves. Similar to the effect on crude morbidity, younger age and uncleanness of the calf house positively affected the occurrence of diarrhea. This was in agreement with the finding that calf diarrhea was the major contributor to calf morbidity. Any thing that affect occurrence of diarrhea will likely affect crude morbidity and the explanation given for crude morbidity applies to diarrhea as well. Similarly, calves from dystocia or prolonged labor were found at higher risk for diarrhea than those born from normal delivery. Other studies also demonstrated higher risk of calf morbidity (which can also apply to diarrhea) in calves of beef herds with high rate of dystocia than those herds with low dystocia rate (Wittum *et al.*, 1994; Bendali *et al.*, 1999; Sanderson and Dargatz, 2000). The higher risk of diarrhea in calves of difficult birth could be due to inadequate passive transfer of colostral immunity. Such calves either would lack vigor to suckle on time or will fail to absorb even if they managed to suckle. Calves from prolonged labor develop respiratory acidosis, which interferes with absorption of colostral immunoglobulin (Besser *et al.*, 1990; Drewry *et al.*, 1999).

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 a greater or equal degree to other management variables (Tarabla and Dodd, 1990). There are also studies which found lower calf mortality when owners care for calves instead of hired labor (Jenny *et al*,. 1981). Waltner-Toews *et al.* (1986d) found the effect of 'who care for calves' to be different by season. In the present study, the failure to detect significant difference may be due to the fact that the activities of hired care givers were under close supervision and their personal attitudes were not reflected on the management.

5.3. Detection of Infectious Agents Associated with Diarrhea

Identification of infectious agents causing calf diarrhea was one of the major tasks of the present investigation. Apart from the influence of varied environmental and managerial factors, the infectious agents involved in causing diarrhea are numerous. Therefore, laboratory investigation to find out the cause of diarrhea should involve testing to all potential enteropathogens which could cause diarrhea in interaction or independently. Although the plan in this study were to look for known implicated pathogens for calf diarrhea, only *Salmonella* and *Cryptosporidium* were examined because of some inconveniences in securing the needed diagnostic material. Both *Salmonella* and *Cryptosporidium* were detected from diarrheic calves in the study herds. These pathogens are isolated from calves by many other authors in different parts of the world (Reynolds *et al.*, 1986; Ongerth and Stibbs, 1989; de la

Fuente *et al.*, 1999). Although these pathogens can be isolated from healthy calves as well, the excretion rate is higher in diarrheic calves indicating their role as a cause of calf diarrhea (Reynolds *et al.*, 1986).

In the present study *Salmonella* was isolated at rate of 2.6 %(2/55). This is in agreement with other studies which reported low prevalence of *Salmonella* from diarrheic calves (McDonough *et al.*, 1994; Reynolds *et al.*, 1986). Other workers, for instance Bulgin *et al.* (1982) reported *Salmonella* as the most dominant isolate from diarrheic calves. Pergram *et al.* (1981) diagnosed *Salmonella* as an important cause of calf diarrhea in dairy farms of Ethiopia. On the other hand, Abraham *et al.* (1992), in their relatively comprehensive work on calf diarrhea in dairy farms of the central highlands of Ethiopia, could not detect *Salmonella* in diarrheic calves. The detection of *Salmonella* in diarrheic calves in the present study in relatively small sample size demonstrated its potential role in calf diarrhea at least in the study herds.

From *Salmonella* serotypes identified in this study, *Salmonella* Typhimurium is among the most frequent serotype isolated from diarrheic calves in many studies on the subject (Pergram *et al.*, 1981; Waltner-Toews *et al.*, 1986e; Lance *et al.*, 1992b; Warnick *et al.*, 2001). The other serotype *Salmonella* Heidelberg is not commonly reported in connection with calf diarrhea. Antimicrobial susceptibility test for commonly used antimicrobials on these serotypes proved their susceptibility. This could be due to less frequency of treating diarrheic calves in the study herds especially in smallholder farms.

Similarly, *Cryptosporidium* was detected on 7.2% (4/55) samples collected during the study. Due to lack of positive control to confirm the positive smears and absence of *Cryptosporidium* report in the country from previous work on calf diarrhea (Abraham *et al.*, 1992), a conservative approach was followed in deciding positivity of slides upon microscopic examination. This added to the less sensitive nature of the test, the rate reported here might have been underestimated. *Cryptosporidium* was reported by many studies worldwide as cause of diarrhea independently or concurrently with other enteric pathogens. de la Fuente *et al.* (1999) found *Cryptosporidium* as the only pathogen detected on 52.6% of diarrheic calves and concurrently with other pathogens in 47.4% of diarrheic calves. Intestinal Cryptosporidiosis was reported as a cause in an outbreak of calf diarrhea in one region of Germany (Aurich *et al.*, 1990). Though the *Cryptosporidium* infection prevalence found in

the present study was relatively lower than reports from other countries, it indicated the importance of the pathogen as a cause of calf diarrhea in Ethiopian dairy farms as well.
In addition to their role in calf diarrhea complex, *Salmonella* and *Cryptosporidium* are potential zoontic pathogens. With widespread HIV virus infection in this country, their role as public health hazard could be significant.

5.4. Interview Findings

From the interview of dairy producers, it was learned that calf morbidity and mortality were among the priority problems usually next to mastitis in large dairy farms and next to breeding problem (repeat breeding) in majority of MOSH farms in the study area. For some of MOSH farms, calf mortality stands number one problem. Thirty six percent of MOSH experienced death of at least one calf during the last one year only. This agrees with finding from the monitoring work which determined a higher calf mortality in MOSH farms. Previous studies similarly reported reproductive inefficiency, young mortality and some cattle diseases like mastitis, lameness, pneumonia and ketosis as major health problems in intensive dairy production (ILCA, 1994).

Basic knowledge on dairy production process and calf management is crucial for the ultimate success and increased productivity of the dairy business. The fact that only below half of the dairy producer know about the importance of colostrum to calves and very few know when to feed it to calves found in this study, show lack of basic calf management techniques in dairy producers. However, only 19% of the calves failed to ingest colostrum (irrespective of the quantity) before 6 hours of age in the study calves. This probably happened because colostrum is not used for any other purposes by humans and thus the calves have the opportunity to get çolostum freely. Occasions in which this opportunity would be lost was when owners wrongly believe that colostrum cause diarrhea in calves and restricted them from having access to enough colostrum as observed during the study. With exception of one large farm, cows were made to calve in the same cow barn that could increase the chance of infection of calves.

In brief, in the present investigation 61.5% morbidity and 18.0% mortality were found in dairy calves in Debre Zeit and its environs. This high calf health problem in the study herds could seriously affect the productivity of dairy farms through decreasing the availability of replacement stock. Among the potential risk factors, investigated age of the calf from calf factors, and time of first colostrum feeding and house hygiene from management factors were significantly associated with calf health problems. Incidentally these risk factors especially colostrum feeding and house hygiene are amenable to intervention, therefore, there is more room to improve the present scenario through management intervention. In the laboratory examination to identify some of the pathogens involved in causing diarrhea, *Salmonella* and *Cryptosporidium* were detected. Though these pathogens were detected at low rate, their potential role as cause of diarrhea in Ethiopian diary herds is demonstrated in this study.

6. CONCLUSIONS AND RECOMMENDATIONS

The calf morbidity and mortality rates found in this study were higher than economically tolerable and that can be achieved through good management. Given the fact that the study farms raise their own replacement stock and have small herd size, higher rates calf morbidity and mortality will be great hindrance to improve productivity of dairy production through selection. It has also been found that factors including colostrum feeding, house cleanness and the age of calves were the most important determinants of calf health problems. Therefore, implementation of improved calf management practices is greatly suggested to reduce the high level of calf disease problems in the study herds and also in other areas with similar management system. Special emphasis should be given to the time of colostrums feeding and the hygiene of calf house.

The present study also showed that calf diarrhea was the predominant calf health problem responsible for the majority of calf illnesses and deaths. *Salmonella* and *Cryptosporidium* were the only pathogens detected with the available laboratory facility. However, calf diarrhea is a syndrome of great etiological complexity and hence a more comprehensive study should be conducted to identify the major infectious causes involved. As the pathogens detected from diarrheic calves in this study are also pathogenic to human, individuals in contact with calves specially that are very young, elderly and immunocompromised, should take the necessary care to avoid the risk of zoonotic infection.

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8. ANNEXES

Annexe1. Sample of Questionnaire Format

1. Farm identification

Owners' name: ....

Address: Kebele................ House no....................... Tel. no.............

1. Farm description

2.1. Owner/manager educational status

a) Illiterate

b) Read and write

c) Elementary school

d) High school graduate

e) Professional

If professional	Related to animal production	
	Unrelated to animal production	
2.2. Herd size	cows.......	Male calves...........
	Bulls.........	female calves..........
	Heifers.......	

2.3. Breed and age of animals kept

2.4. Age of the farm

2.5. The farm as a source of income a) primary b) secondary

3. Management data

3.1. Calf caretaker (attendant)

3.1.1. Ownership	a) owner (family member)		b) hired
3.1.2. Sex	a) male		b) female
3.1.3. Experience	a) <= 5 years		b) >5 years

3.2. Periparturlent care

3.2.1. Calving facilities	a) calving pen		b) the same barn
3.2.2. Navel treatment	a) practiced		b) not practiced

3.2.3. Awareness of importance of colostum to neonates a) yes b) no

If yes, method of feeding	a) suckling		b) hand feeding
Time of first feeding	a) 6 hours	b) 6-24 hours	c) > 24 hours
Duration of feeding	a) for 24 hour	b) 24 hour-4 days	c) > 4 days

If hand feeding source of feeding a) dam b) another cow

3.3. Feeding

3.3.1. Type of feed a) milk b) milkreplacer

3.3.2. Amount of milk/milk replacer given daily per unit of body weight........

3.3.3. Frequency a) once/day b) twice/day c) thrice/day

3.3.4. Time of introducing feed other than milk or milk replacer ....

3.3.4. Type of supplementary feed and quantity given per unit of body weight

a) grazing (hours of grazing)

b) concentrates

c) hay

3.3.5. Weaning age

4. Housing

4.1. Housing a) separate pen

b) together with cows in the cow barn

c) other

If separate pen, a) individual pen b) group pen

4.2. Bedding a) present b) absent

If present what is the bedding material and how frequently is it changed

a) > once/week b) once/week c) <once/week

5. Experience on calf health problems and prevention and control of the problems

5.1. major health problem for the farm..................................

5.2 Number of calves the farm lost during the last one year........................

5.3. Disease or disease syndrome responsible for sickness and death of calves in order of importance. 1. ....2. ....

5.4. Measures taken to treat sick calves...............................

3.5. Measures taken to prevent disease problems.......................

Annex 2. Sample of Calf Card Format

1. Geneaology and periparturient care

1.1. Date of birth	month..........,	day	
1.2. Time of birth	a) night	b) day	
1.3. Site of birth	a) the same cow barn	b) calving pen	
1.4. Condition of birth	a) normal delivery	b) dystocia	
1.5. Sex	a) male	b) female	
1.6. Parity of the dam	a) first parity	b) second parity and above	
1.7. Exotic blood level	a) <=50%	b) 50-75%	c)>=75%
1.8. Navel disinfected	a) yes	b) no	

1.9. Chemical used in navel disinfection

1.10. Time of colostrum ingestion a) before 6 hr b) 6-12hr c) >24hr

1.11. Method of colostrum feeding a) hand feeding b) suckling

1.12. The number if days the calf stayed with the dam

1.13. Total amount of colostrum ingested in liter.

2. Feeding and housing

2.1. Type of liquid feed given to calves a) milk b) milk replacer

2.2. Time introduction of extra diet

2.3. Type of extra feed

2.4. Amount of liquid diet before introduction of extra feed

2.5. Frequency of feeding

2.6. Weaning age

2.7. Access to water	a) free access	b) limited access
2.8. Housing type	a) the same cow barn	b) separate calf pen
2.9. Grouping in house	a) housed in-group	b) individual calf pen
2.10. Bedding	a) used	b) not used
2.11. Cleanness of the calf house	a) clean	b) unclean

3. Case incidence record

3.1. Date of appearance of clinical symptoms

3.2. Major clinical symptoms

Diagnosis

Treatment ...... Treatment outcome ....

Annex 3. Variable considered in risk factor investigation for which analysis was not done

- Breed
- Health status of the dam during pregnancy
- Number of open days preceding parturition
- Calving facility
- Navel disinfection practice
- Duration of colostrum feeding
- Total amount of colostrum fed
- Type of preweaning liquid diet
- Frequency of feeding
- Type of extra feed
- Water access
- Grouping per pen/house
- Bedding

Annex 4. Result of univairiate Cox regression analyses of different class of potential risk factors for crude mortality.

variables	HR	95% CI for HR	P value
Calf factors			
Birth time	1.15	0.56 – 2.40	0.720
Birth condition	2.00	0.76 – 5.26	0.157
sex	0.90	0.42 – 1.95	0.799
Age	**0.03**	**0.01 – 0.24**	**0.001**
Parity of the dam	1.04	0.47 – 2.29	0.919
Management factors			
Age at first colostrum ingestion	**2.58**	**1.23 – 5.39**	**0.012**
Method of colostrum feeding	0.64	0.31 – 1.34	0.237
Time of introduction of additional feed	0.55	0.24 – 1.29	0.167
Amount of milk fed daily	**0.44**	**0.19 – 0.98**	**0.045**
Weaning age	**0.23**	**0.08 – 0.63**	**0.004**
Housing condition	0.67	0.33 – 1.40	0.294
House cleanness	0.91	0.44 – 1.90	0.814
Farm attributes			
Owners education level	1.05	0.49 – 2.23	0.892
Age of the farm	1.26	0.58 – 2.84	0.581
Farm as source of income	1.27	0.59 – 2.72	0549
Ownership of the calf caretaker	1.06	0.51 – 2.22	0.887
Sex of calf caretaker	0.93	0.45 – 1.93	0.840
Experience calf caretaker	1.40	0.65 – 2.94	0.387
Knowledge of caretaker about the importance of colostrum	0.79	0.3 – 1.64	0.530
Knowledge of caretaker on the optimum age to feed colostrum	0.75	0.26 – 2.15	0.590

Annex 5. Result of univairiate Çox regression analyses of different class of potential risk factors for crude morbidity.

variables	HR	95% CI for HR	P value
Calf factors			
Birth time	1.24	0.79 - 1.96	0.34
Birth condition	2.37	1.28 – 4.34	**0.007**
sex	0.64	0.41 – 1.01	**0.057**
Age	0.39	0.24 - 0.62	**0.000**
Parity of the dam	0.74	0.46 – 1.17	0.196
Management factors			
Age at first colostrum ingestion	2.51	1.56 – 4.03	**0.000**
Method of colostrum feeding	0.85	0.54 – 1.33	0.467
Time of introduction of additional feed	0.63	0.38 – 1.04	0.073
Amount of milk fed daily	0.50	0.32 – 0.79	**0.004**
Weaning age	0.54	0.31 – 0.94	**0.029**
Housing condition	1.06	0.67 – 1.63	0.800
House cleanness	1.69	1.05 – 2.73	**0.029**
Farm attributes			
Owners` education level	0.99	0.63 – 1.58	0.970
Age of the farm	0.81	0.5 – 1.25	0.364
Farm as source of income	0.84	0.53 – 1.32	0.446
Ownership of the calf care taker	0.84	0.53 – 1.33	0.457
Sex of calf caretaker	0.97	0.61 – 1.5	0.89
Experience calf caretaker	1.13	0.7 – 1.81	0.613
Knowledge of caretaker about the importance of colostrum	0.91	0.58 – 1.43	0.685
Knowledge on caretaker of the optimum age to feed colostrum	0.66	0.39 – 1.26	0.21

Annex 6. Result of univairiate Cox regression analyses of different class of potential risk for calf diarrhea

variables	HR	95% CI for HR	P value
Calf factors			
Birth time	1.34	0.79 – 2.39	0.298
Birth condition	**3.10**	**1.54 – 6.24**	**0.002**
sex	0.88	0.49 – 1.60	0.69
Age	**0.24**	**0.13 – 0.48**	**0.000**
Parity of the dam	0.66	0.37 – 1.18	0.163
Management factors			
Age at first colostrum ingestion	**2.32**	**1.28 – 4.20**	**0.005**
Method of colostrum feeding	0.95	.0.54 – 1.68	0.870
Time of introduction of additional feed	0.64	0.34 – 1.18	0.150
Amount of milk giving daily	0.62	0.35 – 1.10	0.105
Weaning age	0.66	0.32 – 1.36	0.260
Housing condition	0.79	0.44 – 1.37	0.386
House cleanness	**2.48**	**1.29 – 4.78**	**0.006**
Farm attributes			
Owners education level	0.77	0.44 – 1.37	0.373
Age of the farm	0.95	0.52 – 1.73	0.870
Farm as source of income	0.79	0.45 – 1.39	0.403
Ownership of the calf care taker	1.23	0.69 – 2.16	0.481
Sex of calf caretaker	1.00	0.57 – 1.77	0.997
Experience calf caretaker	0.81	0.43 – 1.53	0.573
Knowledge of caretaker about the importance of colostrum	1.21	0.69 – 2.15	0.505
Knowledge on caretaker of the optimum age to feed colostrum	0.85	0.36 – 2.00	0.714

9. CURRICULUM 'VITAE

1. Personal identification

Name	Wudu Temesgen
Date of birth	30 march, 1975
Place of birth	Debere Yakob kidanemihret, Gojjam
Sex	Male
Marital status	Single
Nationality	Ethiopian
Language	Amharic: Speaking, Reading Writing English: Speaking, Reading, Writing
Occupation	Veterinary practitioner
Address	e- mail wudut@yahoo.com Shind, West Gojjam

2. Education

Education level	years	schools	awards
Primary education	1981 - 1986	Baklaye primary school, baklaye, Gojjam	Primary school certificate
Secondary education	1986 - 1992	Abrhua Wo Atsibha junior and secondary school, Mertule Mariam, Gojjam	ESLCE certificate
Higher education	1993 - 1999	Faculty of veterinary medicine, Addis Ababa university, Debre zeit	DVM degree
Post graduate education	2002 - 2004	Faculty of veterinary medicine, Addis Ababa university, Debre zeit	MSc degree in TVE

3. Work experience

As veterinary practitioner in the public sector (1999 – 2002)

4. Scientific papers

1. Tick vaccine: current status in development (1998). Seminar on current topics on livestock production and development.
2. A study of bovine mastitis in and around Makelle (1999). DVM thesis, FVM, AAU.
3. Calf morbidity and mortality in dairy farms in Debre Zeit and its environs. MSc thesis, FVM, AAU.

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10. SIGNED DECLARATION SHEET

I, the under signed, declare that the thesis is my original work and has not been presented for a degree in any university

Name ___Wudu Temesgen___

Signature ___________

Date of submission ___1st JULY 2004___

This thesis has been submitted for examination with our approval as university advisors.

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