ADDIS ABABA UNIVERSITY
FACULTY OF VETERINARY MEDICINE

EFFECT OF FAILURE OF PASSIVE TRANSFER OF IMMUNITY ON CRUDE MORBIDITY AND MORTALITY IN DAIRY CALVES

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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

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TABLE OF CONTENTS

TABLE OF CONTENTS i
LIST OF TABLES iii
LIST OF FIGURES iv
LIST OF ANNEXES v
LIST OF ABBREVIATIONS vi
ABSTRACT vii
1. INTRODUCTION 1
2. LITERATURE REVIEW 3
2.1. Health and immunity of the dairy calf 3
2.1.1. The role of colostrum 4
2.1.2. Failure of passive transfer 6
2.1.3. Testing for passive transfer 7
2.2. Dairy calf diseases 8
2.2.1. Classification 8
2.2.2. Calf diarrhea/Calf scours 9
2.2.3. Calf pneumonia 10
2.2.4. Other diseases conditions 10
2.2.5. Source and routes of infection 10
2.2.6. Morbidity and mortality 11
2.3. Risk factors associated with dairy calf diseases 12
2.3.1. Animal factors 13
2.3.2. Management and environmental factors 15
2.3.3. Agent factors 18
2.4. Dairy calf diseases in Ethiopia 19
2.4.1. Morbidity and mortality 19
2.4.2. Causes of morbidity and mortality 19
2.4.3. Factors associated with dairy calf diseases in Ethiopia 20
3. MATERIAL AND METHODS 22
3.1. Study area 22
3.2. Study population 22
3.3. Study design 22

3.3.1. Prospective study 22
3.3.2. Sampling method and sample size 23
3.4. Data collection 24
3.4.1. Questionnaire based study 24
3.4.2. Prevalence study of failure of passive transfer 24
3.4.3. Calf health monitoring 25
3.5. Data management 26
3.5.1. Serum total protein 26
3.5.2. Describing morbidity and mortality 26
3.5.3. Determination of risk factors 27
3.5.4. Statistical analysis 27
4. RESULTS 29
4.1. Serum total protein 29
4.2. Associations between risk factors and FPT 29
4.3. Morbidity 30
4.4. Associations of risk factors and crude morbidity 34
4.5. Mortality 38
4.6. Associations of risk factors and mortality 40
5. DISCUSSION 43
5.1. Serum total protein 43
5.2. Associations between risk factors and failure of passive transfer of immunity 44
5.3. Morbidity 46
5.4. Associations between risk factors and crude morbidity 47
5.5. Mortality 50
5.6. Associations between risk factors and mortality 51
6. CONCLUSION AND RECOMMENDATION 54
7. REFERENCES 55
8. ANNEXES 62

LIST OF TABLES

Table 1 Morbidity rates of dairy calf diseases compiled from different sources 12
Table 2 Crude mortality rates of dairy calves compiled from different sources 12
Table 3 Calf mortality rates compiled from different studies in Ethiopia 21
Table 4 Descriptive statistics of STP concentrations..... 29
Table 5 Adjusted Odds Ratio for factors associated with FPT..... 30
Table 6 The incidence of different diseases and crude morbidity 30
Table 7 Univariate analysis of risk factors of crude morbidity using Logistic Regression..... 34
Table 8 Multivariate analysis of risk factors for crude morbidity using Logistic Regression..... 34
Table 9 Proportional Hazard (Cox) Regression Model for age at the onset of morbidity..... 36
Table 10 Risk rates of crude morbidity by STP concentrations 36
Table 11 Proportions of crude morbidity by STP concentrations levels 37
Table 12 Relative risk of crude morbidity by STP concentration levels 37
Table 13 Incidence of mortality rates from different diseases and crude mortality 38
Table 14 Multivariate analysis of risk factors for mortality using logistic regression 40
Table 15 Proportional Hazard (Cox) Regression Model for age at the onset of mortality..... 40
Table 16 Risk rates of crude mortality by STP concentration levels..... 41
Table 17 Proportions of deaths by protein concentration levels..... 41
Table 18 Relative risks of crude mortality by protein concentration levels 42

LIST OF FIGURES

Figure 1 Colostrum absorption by the newborn calf 5
Figure 2 Average age at the onset of diarrhea (D), pneumonia (P), other disease conditions (O) and crude morbidity (T) 31
Figure 3 Age specific risk of crude morbidity for the first 6 months of life 32
Figure 4 Age specific risk of diarrhea during the first 6 months of life 32
Figure 5 Age specific risk of other disease conditions during the first 6months of life 33
Figure 6 Age specific risk of pneumonia for the first 6 months of life 33
Figure 7 Proportion of healthy in calves with FPT (___) and with APT (_ _ _) against age 35
Figure 8 Proportions of healthy in calves born at absence (__) and presence (----) of an attendant against age 35
Figure 9 Average at onset of mortality from diarrhea (D), other disease (O), pneumonia (P) ... 39
Figure 10 Age specific hazard of crude mortality 39

LIST OF ANNEXES

Annex 1: Example of questionnaire formats.....62
Annex 2. Calf card format.....68
Annex 3. Criteria for clinical diagnosis of calf sickness.....70
Annex 4. Potential risk factors considered in the analysis with their categories.....71
Annex 5. Descriptive statistics of STP.....73
Annex 6. Simple association between risk factors and status of passive transfer.....74
Annex 7 Adjusted Odds Ratio for factors associated with FPT.....75
Annex 8 Univariate analyses of risk factors of morbidity.....76
Annex 9. Univariate analysis of risk factors of crude mortality.....77
Annex 10. Multivariate analysis of risk factors of crude mortality.....78
Annex 11. Curriculum Vitae.....79
Annex 12. Signed Declaration Sheet.....82

LIST OF ABBREVIATIONS

AEA	Apparent Efficiency of Absorption
AFCI	Age at First Colostrum Ingestion
AHA	Animal Health Assistance
APHIS	Animal and Plant Health Inspection Service
APT	Adequate Passive Transfer
BC	Birth Condition
BS	Birth Site
BT	Birth Time
CDR	Calf Days at Risk
CI	Confidence Interval
CSA	Central Statistical Authority
FPT	Failure of Passive Transfer
GOV	Government
Ig	Immunoglobulin
IgE	Immunoglobulin E
IgG	Immunoglobulin G
ILRI	International Livestock Research Institute
MCF	Methods of Colostrum Feeding
MOSH	Market-Oriented Smallholder
NAHMS	National Animal Health Monitoring Services
NDHEP	National Dairy Heifers Evaluating Project
OR	Odds Ratio
PCV	Packed Cell Volume
ppm	Parts Per Million
PR	Prevalence Ratio
RID	Radial Immuno Diffusion
RR	Relative Risk
SC	Source of Colostrum
SD	Standard Deviation
SE	Standard Error
SP	Serum Protein
STP	Serum Total Protein
TP	Total Protein
TR	True Rate
USDA	United States Department of Agriculture

ABSTRACT

A longitudinal prospective observational study on the concentrations of serum total protein (STP), as a measure of status of passive immunity, and its associations with crude calf morbidity and mortality in dairy farms in Debre Zeit and its surroundings was conducted from October 6, 2006 to May 15, 2007, with the objectives of determining the proportions of calves with failure of passive transfer (FPT) of immunity, describing the incidence rates of crude morbidity and mortality, and investigating the associations of the status of passive transfer of immunity with crude morbidity and mortality in the newborn dairy calves. A total of 354 crossbred dairy calves were included in the study. Serum samples were collected when the calves were from 24hrs to one week of age, and regularly monitored for clinical outcomes (morbidity and mortality) up to the age of six months. The mean STP concentration as measured during the first week of life was 66.4±16.6g/L and the values ranged from 28.8 to 99.8g/L. The proportion of calves with FPT, (where the STP concentrations were less than or equal to 55g/L) was found to be 30.23%. The overall incidence rate of crude morbidity and crude mortality found in this study were 52.3% and 18.9% respectively.

A total of 21 potential risk factors were investigated for their associations with FPT, crude morbidity and crude mortality. Among these 9 variables that were considered for their effect on the status of passive transfer, 7 were found to be statistically significantly associated with FPT. Further analysis of these factors using logistic regression indicated that only 4 factors, age of the dam as represented by parity number (OR = 14.6, 95% CI = 6.27-33.84), age at first colostrum ingestion (OR = 7.2, 95% CI = 2.56-20.13), attendant at parturation (OR = 4.4, 95% CI = 1.48-13.10) and sex of the calf (OR = 3.8; 95% CI= 1.61-8.83) were significantly associated with FPT.

Univariate analysis of 10 risk factors of crude morbidity showed that 6 factors were significantly associated with crude morbidity, but on multivariate analysis, only STP (OR = 11, 95% CI = 4.4-27.4) and attendant at birth (OR = 2.7, 95% CI = 1.3-7.2) had significant interaction in causing morbidity. Similarly, Cox regression model indicated that STP ($p< 0.001$), attendant at birth ($p< 0.05$), age at first colostrum ingestion ($p< 0.05$) and birth condition ($p< 0.05$) were significantly

associated with earlier age at the onset of crude morbidity. The effect of FPT on crude morbidity was further analyzed by partitioning the crude morbidity into 8 STP strata and the highest incidence rates of crude morbidity (>95%) were observed in calves with STP concentrations ≤ 55g/L, but a remarkable drop of crude morbidity was seen in calves with STP concentrations >65g/L. On the other hand, the greatest relative risk (RR = 2.5, 95% CI = 2.07-2.93) of crude morbidity were observed in calves with STP concentrations of ≤ 55g/L.

Out of 11 risk factors of crude mortality, 9 were showed significant association on univariate analysis, but when adjusted for their interaction, only age at the onset of morbidity (OR = 27.2, 95% CI = 7.6-97.1), STP (OR = 3.1, 95% CI = 1.4-9.2) and sex (OR = 2.7, 95% CI = 1.3-5.7) were found to be significantly associated with crude mortality. Similarly, Proportional Hazard (Cox) Regression showed that age at the onset of morbidity ($p< 0.001$), STP concentrations ($p< 0.001$), sex ($p< 0.05$) and time of birth ($p< 0.05$) were significantly associated with mortality at an earlier age of the calf. Furthermore, the highest incidence rate of crude mortality was observed in calves with STP concentrations ≤ 55g/L, while the greatest relative risk (RR = 5.3, 95% CI = 3.73-7.56) of crude mortality was experienced by calves with STP concentrations ≤ 35g/L. Calves with STP concentrations of 35.1-45.0 and 45.1-55.0g/L had lower relative risk (RR = 2.2, 95% CI = 1.32-3.81 and 2.9, 95% CI = 1.86-4.39, respectively) of crude mortality compared to calves with STP concentration ≤ 35g/L. The optimum survival was observed in calves with STP concentrations > 55g/L with insignificant relative risk of crude mortality. Thirty three percent of the total death was attributed to FPT. Calves with lower STP values due to FPT of colostral immunity had increased risk of death and measuring the degree of passive transfer of colostral immunity at the first week of age was very important to proper management of young calves.

Keywords: Serum total protein, failure of passive transfer, dairy calf morbidity and mortality, risk factors.

1. INTRODUCTION

Driven by the rise of human population, rural-urban demographic shift and improved income, the demand for milk and milk products is increasing steadily. In response, dairy farms are growing both in number and size (Gitau, *et al*., 1994) with the use of high grade crossbred dairy cows and increased intensive management practices.

Raising replacement dairy heifers presents a challenge in building for the future. Records show that about 25 to 35% of the milking cows must be replaced annually, and therefore, to maintain herd size and improve genetic material for high milk production, quality heifer replacement must be continuously available (Waltner-Toews, *et al*., 1986b). But calf morbidity and mortality are perennial problems in all countries where cattle are raised. The mortality rates vary from 2% to as high as 20% with mortality on individual farms varying from 0% to above 60%, although in well-managed dairy herds of developed countries, average mortality is usually between 2% to 4%. In developing countries, under poor management and major disease problems, especially in sub-Saharan Africa, the usual average mortality is 7% to 25%. Most of the illness and deaths occur during the first few weeks of life because of the effects of infectious pressure, and mismanagement of both the calf and its environment (Heinrichs and Radostits, 2001).

Although most of the infectious agents implicated as causes of disease and death are commonly found in dairies, the incidences of clinical diseases appear to vary markedly among dairies and individual animal. One explanation for this could be that factors that cause variation in morbidity within a herd are distributed differently, and that factors other than infectious disease agents may contribute to the variation (Pare, *et al*., 1993). In Ethiopia, several factors have been reported in association with dairy calf diseases, some of which have been statistically significant. Hygienic, nutritional and managemental problems were the major problems associated with high mortality (Fantaye, 1993). In an investigation of about 20 potential risk factors for their association with crude calf morbidity and mortality (Jemberu, 2004), age, age at first colostrum feeding and cleanness of the house were found to be significantly associated with high morbidity and mortality rates.

The single most important factor in determining calf health and its survival is the provision of early and adequate high quality colostrums to every calf, because the calves are born without any antibodies to protect themselves from diseases. At birth, the cow passes these antibodies to the calf in the form of immunoglobulins via the colostrum (McGuire and Adams, 1982). This process called passive immunity or passive transfer, which help to protect the calf until it can develop its own functional immune system. The main point to consider about passive transfer in calves is that passive protection often fails to occur in a remarkably high number of cases. The prevalence of failure of passive transfer (FPT) varies with management and type of animal, but is usually greater than 10% and may be as high as 68% in some dairy herds. Furthermore, calves with FPT have a high risk of gastrointestinal and respiratory infections. The risk of death for calves with FPT is from 3 to 10 times greater than calves that absorb adequate amounts of immunoglobulins (McGuire and Adams, 1982). Failure of passive transfer can be assessed by measuring directly serum immunoglobulin (Ig) or indirectly serum total protein (STP) of the newborn calf shortly after birth (Pare, *et al*., 1993), and the knowledge of the extent to which FPT might be associated with morbidity or mortality would be useful in developing preventive measures and in predicting the prognosis of individual cases.

Earlier studies conducted in Ethiopia (Abraham, *et al*., 1992; Amoki, 2001; Jemberu, 2004; Rahmato, 2005) mainly focused on calf morbidity and mortality as well as identification and characterization of viral, bacterial and protozoan pathogens that were associated with calf diarrhea. Status of passive transfer of maternal immunity to the newborn calf and its association with crude morbidity and mortality of calves has not yet studied in Ethiopia, while it was suggested that high risk groups of calves, for morbidity and mortality, could be identified by measuring the status of passive transfer of immunity.

The objectives of this study are, therefore:

1. to determine the rate and factors of failure of passive transfer of immunity in the newborn dairy calves;
2. to describe the incidence of morbidity and mortality rates during the first 6 months of life
3. to establish associations between the FPT and the crude morbidity and mortality.

2. LITERATURE REVIEW

2.1. Health and immunity of the dairy calf

There is no universal agreement in veterinary medicine concerning the time/age at which the newborn animal ceases to be a calf (Thrusfield, 1995). However, the calf refers to the age group of young cattle from birth to six or nine months of age (West, 1995), after which in natural circumstances, it might be expected to be self- sufficient.

Unlike humans, in which antibodies can pass from the maternal side to the fetus in uterus, the cow's antibodies can not move through the placental barriers to the calf. The calves are thus born as naked on the inside as the outside. Their immune system is anatomically complete, but functionally incompetent or immature (Radostits *et al*., 1994) and become functional 3-6 months after birth. Therefore, the newborn calves are dependent on colostrum, containing adequate antibodies, ingested at the right time (Heinrichs and Radostits, 2001; Radostits, *et al*., 1994).

It is because, in calf rearing, the difference between health and disease is very often just a slight tip of a delicate balance that weighs the calf and environmental factors with the bacterial, viral or parasitic agents to which the calves will be exposed (Quigley, *et al*., 1994). Moreover, the infectious agents that are capable of causing scours, pneumonia or septicemia in young calves are ubiquitous (Heinrichs and Radostits, 2001). Though most of the calves would inevitably be exposed to these infectious agents and may become infected, only few of them could develop clinical disease if the risk factors are minimized and the sources of infection are diluted, or by-passed by enhanced natural defense mechanism (Quigley, *et al*., 1994)

The immune system consists of humoral immune response, which is antibody mediated immunity, and cell mediated immunity. In case of humoral immune response, the antibodies are either actively produced in the body as a response to natural infection or vaccination, or passively acquired through administration of pre-formed antibodies, while in the cell mediated immunity lymphocytes and other phagocytic cells cause direct destruction of the pathogens (Donovan, *et al*., 1998). Since the calves are born with incompletely developed disease defense

mechanism, they are dependent on adequate maternal colostrum which provides adequate immunoglobulins or antibodies that are protective against systemic diseases and local lactogenic infection (Francisco and Quigley, 1993), which is termed "Passive immunity" because the immunoglobulins are passively acquired, and are not synthesized by the neonate's own immune system (Earley and Fallon, 1998).

2.1.1. The role of colostrum

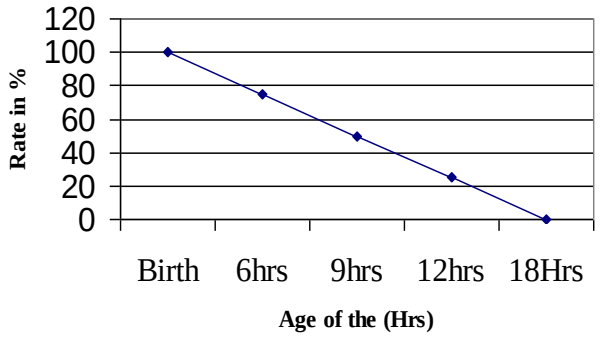
Colostrum is a form of milk produced by the mammary glands in late pregnancy and the first several hours after birth. It contains large numbers of antibodies that are protective against systemic diseases and local intestinal infection (West, 1995). It is well documented that colostrum is an important source of immunoglobulins and provides immunity to disease for the new-born calf (Earley and Fallon, 1998**)**

Cow colostrum contains about 22 percent solids compared with the 12 percent solids of normal whole milk, and much of this extra solid is immunoglobulin (Heinrichs and Radostits, 2001), which may reach 15 to 20 times the concentration of protective antibodies contained in the serum of the dam (Quigley, *et al*., 1994; Rajala and Castrén, 1995).

The major immunoglobulin in colostrum is IgG, but there is also significant amount of IgM and IgA (Guidry, *et al*., 1980; Heinrichs and Radostits, 2001; Radostits, *et al*., 1994; Rajala and Castrén 1995). The presence of IgE has also been reported (Thatcher and Gershwin, 1989). Colostrum is also a rich source of casein, fat and vitamins-especially A and E; there is also a trypsin inhibitor, which helps to protect immunoglobulin from being digested in the calf's gut. Leukocytes are also present in large numbers. In addition, colostrum also contains "transferrin" and "lactoferrin", which bind iron and restrict bacterial growth. These factors, together with immunoglobulin, help to limit the growth of bacteria in the gut (Heinrichs and Radostits, 2001; Riedel-Caspari, 1993).

The absorption of colostrum is maximum during the first 6-8 hours of life, when the upper portion of the calf's small intestine is highly absorptive, after this it is ever-decreasing (Quigley,

et al., 1994) (Fig. 1). The upper portion of the small intestine is also highly permeable to microorganism and any larger proteins, and hence delay in colostrum feeding may result in a massive absorption of the pathogenic organisms like *Escherichia coli* that might result in septicemia (Quigley, *et al*., 1994). Therefore, the first colostrum feeding-time after birth is critical for survival and future performance of the newborn calf.



Source: Quigley, *et al*., 1994

Figure 1 Colostrum absorption by the newborn calf

Factors affecting passive transfer and thereby calf serum Ig concentrations are, Ig concentration in colostrum, amount of colostrum intake, age at first feeding, nutrition of the dam, method of ingestion, and age of the dam (Earley and Fallon 1998; Kossaibati and Esslemont, 1997). Protection against neonatal infection is dependent on the passive immunity that the calf receives in the immediate post-partum period.

Although the importance of colostral antibody transfer in protection against neonatal diseases is universally recognized, ensuring that a calf receives adequate colostrum is not however, a guarantee in itself for protection against infection (McGuire and Adams, 1982). There is the possibility that the colostrum may not contain sufficient immunoglobulins, or that the calf for some reason is not absorbing them, thus resulting in failure of passive transfer (FPT). For this reason, it is always advisable to test the calf's blood for immunoglobulin levels from 24 hours up to 8 days after birth in order to make sure that the desirable levels of serum immunoglobulin concentration have been reached (McGuire and Adams 1982).

The main point to consider about passive transfer in calves is that it fails to occur normally in a remarkably high number of cases depending on the management system and type of animal (McGuire and Adams 1982).

2.1.2. Failure of passive transfer

Colostrum management has a larger impact on calf health than any other management factor**; c**alves are born hypogammaglobulinemic and rely on Immunoglobulins (Ig) from colostrum to obtain passive immunity. In the bovine species, immunoglobulins do not cross the placenta *in utero,* and the new-born calf is, therefore, dependent on antibodies obtained through ingestion of colostrum. The newborn calves have a system in their gut that allows absorption of Ig during the first 24 hours of life. Immediately after birth, the calf's intestine is able to absorb antibodies well, but as soon as the ingestion of any substance (mucous, manure, dirt, straw, colostrum, etc), the cells lining the intestine start to change from rectangular to square cells which are unable to absorb the antibodies (Quigley, *et al*., 1994). The decrease in absorptive capacity occurs rapidly and by 9 hours after stimulation, only about 50% of the available antibodies are absorbed, by 12 hours only 30% is absorbed and by 24 hours the absorptive capacity is completely gone (Quigley, *et al*., 1994).

Thus, immediate ingestion of sufficient colostrum is important for passive transfer of maternal antibodies. It is critical for the health and survival of the newborn calf, because the inadequate passive transfer of maternal antibodies (FPT) dramatically increases the risk of mortality (Turgut, *et al*., 1998). Failure of passive transfer has no primary symptoms in itself, other than a predisposition for developing infection to the calf.

It is unfortunate that FPT is common in dairy calves and is a common cause of sickness and death. It has been reported (Turgut, *et al*., 1998) that FPT occurred approximately in 35% dairy replacement heifers. Logan, (1974), also indicated that FPT occur in 25-65% of the naturally suckled calves, and 90% of calves dying in the first week of life had not absorb adequate amounts of Ig, while of those dying in the second and third week of life, 80% had inadequate Ig

concentration. Results of the National Animal Health Monitoring System (NAHMS) 1992 National Dairy Heifers Evaluation Project (NDHEP) (USDA/APHIS, 1993) showed that the Ig concentration was less than 1000mg/dl in more than 40% dairy calves. They indicated that 22% of all deaths of calves may be prevented by ensuring adequate colostrum consumption. McGuire and Adams, (1982), indicated that the prevalence of FPT was usually greater than 10% and may be as high as 68%, and the calves with FPT have a high risk of gastrointestinal and respiratory infection and death rate in calves with FPT was 3 to 10 times greater than in the calves that absorbed adequate amounts of Ig.

2.1.3. Testing for passive transfer

Different methods of Ig assessment are available to detect FPT (Turgut, *et al*, 1998; Tyler, *et al*., 1999a); thus FPT can be diagnosed in calves aged 1 to 8 days old by measuring serum Ig concentration directly or indirectly.

2.1.3.1. Radial immunodiffusion (RID)

This is the most specific test available for direct calf Ig determination. A specific volume of serum is placed in small wells cut into the plate impregnated with an antibody against bovine IgG proteins. As the serum diffuses out into the surrounding agar, the IgG molecules bind to the anti-IgG antibodies in the agar. This binding creates a precipitate in the agar around the well which can be seen and measured. The concentration of IgG in the sample determines the size of the precipitating ring; the bigger the ring, the higher the IgG level. A numerical value for the IgG concentration is determined based on the size of the ring using a graph of standards. This gives the most specific information of all the tests available and it directly measures the specific proteins of IgG (Turgut, et al., 1998).

2.1.3.2. Total protein (TP)

The serum chemistry panel can be performed to directly measure the amount of protein in the blood. As immunoglobulins are just one of many different proteins in the blood, this test tells if there is moderate to severe problem, but is not very specific. However, using an automated method such as biuret gives more accurate estimates (Quigley, *et al.,* 2000). A borderline FPT may not be detected with this method.

2.1.3.3. Zinc sulfate turbidity

This is another test used to gain a rough estimation of the amount of immunoglobulins present in the serum. A small amount of serum is added to zinc sulfate solution and incubated at room temperature for one hour. Zinc sulfate will cause precipitation of the Ig which makes the solution cloudy instead of being clear; thus lack of cloudiness signifies a lack of Ig. This test is fairly specific for Ig, but is not very good in quantifying the Ig and if they are present and the solution is cloudy, it is difficult to distinguish a borderline problem (Pare, et al., 1993).

2.2. Dairy calf diseases

2.2.1. Classification

The most difficulties in the study of the newborn diseases is the almost unlimited number of classifications by which the diseases are categorized because no standard time of illness and/ or time-of-death definition has been used, it is thus very difficult to compare results and assessments. There is a need therefore, to classify or categorize the diseases of the newborns in order to compare the results and assessments of associated risk factors from different research outputs.

The diseases of the animals, born alive at term, during their early months of life need to be viewed in the context of perinatal diseases-just before, during and immediately after parturition, and postnatal diseases. The following classification of the diseases of the fetus and the newborn is presented to assure that the meanings are definite and consistent (Bradley and Niilo, 1984; Dennis, 1980; Heinrichs and Radostits, 2001)

1. *Perinatal diseases*, stillbirths at more than 270 days gestation and diseases and mortality during the first 24 hours of life.
2. *Neonatal disease and mortality*, calves born alive those become diseased or die between 24 hours and 28 days after birth.
3. *Older calf diseases and mortality*, calves born alive those become diseased or die between 29 and 182 days after birth.

2.2.2. Calf diarrhea/Calf scours

Acute calf diarrhea or calf scours accounts for approximately 75% of the mortality of dairy calves under 3 weeks of age. The cause of calf diarrhea is often multi-factorial and includes exposure to one or more infectious agents as well as management and environmental factors including colostral management, sanitation, housing, grouping strategies, ventilation, stress, and nutrition.
The most important pathogens associated with calf diarrhea are enterotoxigenic *Escherichia coli*, rotavirus, corona virus, *Cryptosporidia* sp. *Salmonella* sp. and Coccidiosis (*Eimeria* sp.) (Heinrichs and Radostits, 2001). Each of the pathogen causes the disease at specific age of the calf. Calf diarrhea is one of the most devastating diseases of the dairy industry, with an estimated incidence as high as 10 to 15% and morbidity approaching 100% in severely affected herds (Turgut, *et al***.,** 1998). It is the most prevalent and together with calf pneumonia, they are the first and the second killers of the calf.

2.2.3. Calf pneumonia

Respiratory disease is second only to diarrhea in health disorders contributing to death in dairy calves between one and six months of age. It occurs primarily in housed calves over 2 months of age. It is caused by infection with respiratory viruses and inadequate ventilation and accounts for about 15% of calf mortality from birth to 6 months of age. Pneumonia is an infection that causes inflammation and damage to the calf's lungs. Bacterial respiratory pathogens include *Pasteurella multocida, Pasteurella hemolytica, Corynebacterium pyogenes, Mycoplasma dispar,* and *Hemophilus somnus.* Viral respiratory pathogens include *Infectious Bovine Rhinotracheitis (IBR), Parainfluenza-3 virus (PI-3), Bovine Respiratory Syncitial Virus (BRSV),* and *Bovine Virus Diarrhea* (BVD). Clinical disease can usually be avoided if proper attention is paid for overcrowding, inadequate ventilation and air movement and inter-mixing of age groups. Calf hood pneumonia can have a negative impact on heifer growth rates, increase the risk of dying or being culled prior to calving, and result in increased age at first calving (Radostits, *et al* 1994).

2.2.4. Other diseases conditions

Other important diseases of the newborn calves include infection of the umbilicus which occurs soon after birth and may result in omphalitis, omphalophlebitis, omphaloarteritis or infection of the urachus with possible extension to the bladder, causing cystitis. Bacteremia and localization with infection may occur in joints, bone, meninges, eye, endocardium and end arteries of the feet, ears, and tail. The navel can also be the source of infection leading to septicemia in neonates with failure of passive transfer (Radostits, *et al*., 1994).

2.2.5. Source and routes of infection

The vast majority of infections are acquired by the neonate after birth from the environment or from the enteric or respiratory tract flora of the dam.

The portal of infection is commonly by ingestion but may occur via aerosol infection of the respiratory tract as an alternate route of infection and invasion via the umbilicus. However, where neonates were in groups or in close contact, direct transmission by fecal, respiratory secretion and urine aerosol can occur (Radostits, *et al*., 1994).

2.2.6. Morbidity and mortality

Dairy calf morbidity statistics are not as reliable as those on mortality, mainly because they depend on the producer's clinical diagnosis, whether the animal was treated for the illness, and the tendency of the owners not to record every illness problems. Some researchers (Waltner-Toews, *et al.,* 1986b), however, indicated that the best available data on morbidity are based on treatment rates. Morbidity and mortality rates of some diseases in dairy calves in different countries were indicated in Table 1 and 2.

Nevertheless, a review of surveys on calf mortality (Radostits, *et al*., 1994) reported mortality rates in dairy calves that vary from a low of approximately 2% to a high of 20%. Mortality on individual farms varies from 0% to 60%, though the estimate for the average on-farm calf mortality rate is 6%. On the other hand, it was indicated (Heinrichs and Radostits, 2001) that calf mortality rates from birth to weaning vary from about 1% to 30% and even higher.

Table 1 Morbidity rates of dairy calf diseases compiled from different sources

Country	Morbidity rates (%)		Source
Florida-USA	Diarrhea	35	Donovan, *et al*., 1998
	Pneumonia	21	
Overall-USA	Morbidity	20	Sivula, *et al*., 1996a
Sweden	Diarrhea	63.1	Svensson, *et al*., 2003
	Pneumonia	48.4	
Bangladesh	Diarrhea	30.7	Debnath, *et al*., 1995
	Pneumonia	16.7	
Kenya	Crude morbidity	27	Gitau, *et al*., 1994
Tanzania	Diarrhea	27	Shoo, *et al*., 1992
	Pneumonia	17	
Ethiopia	Diarrhea	42.9	Jemberu, 2004
	Pneumonia	4.9	

Table 2 Crude mortality rates of dairy calves compiled from different sources

Country	Mortality rates	Source
Florida-USA	12%	Donovan, *et al.*, 1998
Ontario-USA	4%	Waltner-Toews, *et al.*, 1986b
Minnesota-USA	8%	Sivula, *et al.*, 1996a
Overall-USA	8.4%	Heinrichs and Radostits, 2001
Norwegian	18.8%	Heinrichs and Radostits, 2001
Overall-Europe	9-13%	Heinrichs and Radostits, 2001
Global	1-30%	Heinrichs and Radostits, 2001
Bangladesh	35%	Debnath, *et al*., 1995
Kenya	22%	Gitau, *et al*., 1994
Tanzania	23%	Shoo, *et al.*, 1992
Zimbabwe	35%	French, *et al.*, 2001
Ethiopia	18%	Jemberu, 2004

2.3. Risk factors associated with dairy calf diseases

The term "risk" refers to the probability that an event (usually unfavorable) will occur. Situations associated with the probability that an event will occur are known as "risk factors". Usually, risk factors increase the probability that the event will happen. Concerning dairy calf diseases, risk factors can be broken up into those involving the environment, the animal, and the pathogens or infectious agents (Thurmond, 1986).

Understanding the causes of common calf hood diseases and their methods of transmission is the first step in developing effective programs to minimize their impact on calf health. Similarly, there are reports (Pare`, *et al*. 1993; Thurmond, 1986) which indicated management decisions that were made on the basis of the results of epidemiological risk assessment significantly reduced a possibly devastating neonatal diarrhea.

2.3.1. Animal factors

Epidemiological risk assessments were used in several investigations (French, *et al*., 2001; Pare`, *et al*., 1993; Sivula, *et al*., 1996b; Thurmond, 1986) to ascertain if there were high risk groups of calves that could be identified by their health status, breed, sex, age, immune status, and other related factors.

2.3.1.1. Dam factors

In the face of calf morbidity and mortality problems, most of the focus is on the calf and infectious agent, while factors associated with the dam play significant role in the calf survival (Heinrichs and Radostits, 2001). Age of the dam is a risk factor for the morbidity of the calves, i. e. offspring of heifers are more susceptible than those from adult cows, and heifers are more prone to dystocia and difficult births. Calves born to cows with dystocia were five times more likely to die neonatally than calves born without assistance. Also, first and second calf heifers have lower quality colostrum than older cows (Radostits, *et al*., 1994).It was observed that the morbidity and mortality from diarrhea during the first 30 days of life in calves born to heifers was 51% and 14.8% respectively, compared to 28% and 4.3% in the calves born to cows (Schumann, *et al*., 1990). Several possible explanations for higher mortality rates in calves born to heifers were forwarded: large calves were at risk of mortality only when born to 2-year-old dams. Calves born to 2-year-old cows were more susceptible to severe weather conditions than calves born to older cows. Temperature and precipitation affected survival rates nonlinearly and the rates depended on age of dam and dystocia incidence (Schumann, *et al*., 1990).

Similarly, the amount of colostrum available and the colostrum quality were found to be influenced by age and parity of the dam, which in turn determine serum immunoglobulin concentration of the calf (Schumann *et al*., 1990). Physical characteristics of udder and teats are other important factors that affect adequate colostrum intake of the calf. Cleanliness of dams, amount of mud and feces on underbellies and udders are all-important factors for calf health.

2.3.1.2. Calf level factors

2.3.1.2.1. Health and vigor of the calf

Morbidity and mortality are influenced by previous health status and vigor of the calf, indicating that increased calf mortality was associated with prior clinical illness (Heinrichs and Radostits, 2001). Similarly, association of mortality and weak-calf syndrome was reported (Gitau, *et al*., 1994; Shoo, *et al*., 1992).

2.3.1.2.2. Sex

Sex of the animal was found to be related with morbidity and mortality. A study that was conducted in smallholder dairy farms in Zimbabwe (French, *et al*., 2001) reported higher mortality rates in male calves than in females. Significantly higher mortality rates was observed (Debnath, *et al*., 1995; Jemberu, 2004; Roy, 1990) in male calves having exotic blood in Ethiopia

2.3.1.2.3. Age

Age of the newborn calf is also a significant risk factor for morbidity and mortality. Calves are at greater risk of dying during the first week of life than any time thereafter (Thurmond, 1986). A study of morbidity, mortality and productivity of cattle on smallholder dairy farms that was carried out in Zimbabwe (French, *et al*., 2001) reported a calf mortality rate of 35%, which was five times higher than adult mortality. Gitau, *et al*., (1994) demonstrated that mortality peaked during the neonatal period. A study carried out to determine calf mortality in crossbred dairy cattle (Waltner-Toews, *et al*., and 1986b) showed a definite decline of mortality with advancing age.

2.3.2. Management and environmental factors

2.3.2.1. Management

The relationship between management and incidence of morbidity and mortality at both herd and individual calf level, have a significant influence (either increasing or decreasing the risk of occurrence of diseases) on an outcome of infection (death or recovery). Management variables that were described in relation to calf morbidity and mortality include care for the dam (Place of birth), attendance at calving, caretaker for the calf, colostrum administration, feeding, housing and other practices (Heinrichs and Radostits, 2001).

2.3.2.1.1. Feeding

a. Colostrum feeding

Colostrum management has a larger impact on calf health than any other managemental factor. Therefore, early feeding of colostrum is essential. The role of consumption of adequate amount of colostrum on morbidity and mortality is widely recognized, since there is a significant relationship between the morbidity and mortality from neonatal calf diseases and an adequate early intake of colostrum (Schumann, *et al*., 1990). Acquisition of passive immunity by the neonatal calf depends on consumption of a sufficient mass of colostral immunoglobulin prior to cessation of macromolecular transport (closure) by the intestine. Mass of immunoglobulin consumed by the calf is determined by the amount of colostrum and concentration of immunoglobulin in colostrum (Heinrichs and Radostits, 2001). Therefore, determination of colostral immunoglobulin concentration prior to feeding the calf would allow the producer to manage colostrum feeding.

Serum immunoglobulin concentration is well documented as an important factor in calf health. The association of total protein and mortality was quadratic and there is a dramatic decrease in mortality as serum total protein increased from 4.0 to 5.0 g/dl (Donovan, *et al*., 1998). Serum

total protein, which is a measure of passive transfer of immunoglobulin, was found to be a significant risk factor for mortality. High and low total protein and PCV values were found to be associated with age at onset and length of the first episode of diarrhea (Heinrichs and Radostits, 2001; Pare, *et al*., 1993; Schumann, *et al*., 1990).

b. Feeding after colostrum

Management policies related to anti-scour vaccination, offering free choice water and mineral to calves, methods of feeding, and use of medicated feeds significantly altered the odds of experiencing above-median pneumonia rates. Similarly, farm policies with regard to anti-scour vaccination, offering free choice salt to calves, and age at teat removal significantly altered the odds of a farm experiencing above-median scours rates (Waltner-Toews, *et al*., 1986c).

2.3.2.1.2. Herd size

Herd size has a significant effect in the health of the newborn calves; larger farms have significantly greater odds of experiencing mortality than smaller farms. This may result from the impact of increased herd sizes on the microclimate, hygienic condition, as the animals may compete for the available shelter area, thus increasing both the concentration of the pathogen per unit area and the chance of exposure (Heinrichs and Radostits, 2001). An increased percentage of heifers calving in the herd, providing limited shelter in the nursing area, an increased percentage of poorly drained ground in the nursing area and wintering cows and heifers on the same ground were associated with an increase in the odds of high mortality from neonatal diarrhea (Schumann, *et al*., 1990). Composition of the herd also affects mortality. Farms wintering adult cows and heifers together were 6.4 times more likely to have a high-risk mortality from diarrhea (Waltner-Toews, *et al*., 1986c).

2.3.2.1.3. Attendant

Farms which had policies of attending calving and ensuring that the calves received their first colostrum had significantly lower odds of experiencing mortality than farms which did not have

these policies. Place of calving, naval treatment and assistance at first colostrum feeding were all associated with significantly altered odds of dying (Waltner-Toews, *et al*., 1986c).

2.3.2.2. Environmental factors

Population density (degree of crowding), heavily contaminated calving grounds or pens, wet and muddy and poorly drained areas, lack of bedding, lack of windbreak, and any recent marked change in the weather are some of the environmental factors that influence calf morbidity and mortality. Calves should have a well-bedded area in which to rest and sleep that is protected from excessive cold especially during the first 24 to 48 hours after birth. Calf mortality increases progressively as ambient temperature decrease or as precipitation increases on the day of birth (Heinrichs and Radostits, 2001).

2.3.2.2.1. Season

Disease incidence and treatment rates for scour and pneumonia were generally lower in spring and summer than during the autumn and winter and larger farms had significantly greater odds of experiencing mortality than smaller farms in both winter and summer (Waltner-Toews, *et el* 1986b).

2.3.2.2.2. Housing

The main components of the environmental factors that are significantly associated with calf morbidity and mortality are the adequacy of the housing and the hygiene of the calf' microenvironment (Quigley, *et al*., 1994). Housing affects exposure of the calves to infectious organisms and subsequent morbidity and mortality. Waltner-Toews, *et el*., (1986b) indicated that farms that housed calves in hutches had significantly lower odds, and those which housed calves in group pens had significantly higher odds of experiencing mortality than farms which used individual indoor calf pens.

The ammonia concentration and relative humidity in the housing were found to be the risk factors for the respiratory diseases with statistically significant associations at ammonia concentration

below or above 6 ppm (Lundborg, *et al*., 2005). Housing also affects incidence and severity of scours, and it was found that calves raised in hutches were less likely to be treated for scours than were the calves raised in individual pen in a calf barn. It was also reported that housing the calves in the barn increased with fecal scores/diarrhea, probably resulted in increased exposure to pathogens, and isolation of calves by housing in hutches improved the health of the calves (Lundborg, *et al*., 2005; Quigley, *et al*., 1995).

A poorly drained area is likely to support the survival of pathogens and to increase the amount of contamination of the nursing area. As the proportion of the nursing area, which was poorly drained, wet and mud increased, so did the odds of that farm to become a case (in a case-control study). Estimates indicated that for every 1% increase in the area that was poorly drained, there was a 1.4 fold increase in the odds of experiencing high mortality from diarrhea (Lundborg, *et al*., 2005). Summing-up calves need clean; well-ventilated quarters and damp stalls, draft and wet bedding may lower the calf's resistance to certain diseases, especially pneumonia (Heinrichs and Radostits, 2001; Quigley, *et al*., 1995).

2.3.3. Agent factors

The infectious agents that are capable of causing scours, pneumonia, or septicemia in young calves are ubiquitous. Most of all, they are normal inhabitant of the environment, found in cows and isolated from the healthy calves (Snodgrass, *et al*., 1982). Most of the disease causing agents in the newborn calves are opportunists, but with serious consequences when sufficient cause for the disease is present. Co-occurrence of infectious diseases is common in newborn calves indicating that one disease will predispose the calf to another disease. The result of the experimental studies (Snodgrass, *et al*., 1982) reported that prior or simultaneous *rotavirus* infection is necessary to enable enterotoxigenic *Escherichia coli* colonization of the intestine of calves. It was similarly reported that scours and pneumonia were significantly associated with each other at both the farm and the calf level (Waltner-Toews, *et al* 1986d).

2.4. Dairy calf diseases in Ethiopia

Sporadic work has been done on the subject of dairy calf disease in Ethiopia; thus, there is scarcity of information concerning causes of diseases, morbidity and mortality rates and associated risk factors. In addition, much of the work so far done concerns only state farms, and other related institutions (ranches, research institutions etc), and there is paucity of information regarding dairy calf diseases in progressively increasing private dairy farms in the country, however scattered reports indicated.

2.4.1. Morbidity and mortality

Calf mortality rates in preweaned dairy calves in Ethiopia range from 7 to 25% (Jemberu, 2004; Shiferaw, *et al*., 2002; Sisay and Ebro, 1998), but it could go as high as 53% (Hassen and Brannad, 1996). A mortality rate reaching 67% that included abortion rates and stillbirths, have also been reported (Gryseels and de Boodet, 1986) (Table 3). However, most of these reports did not included morbidity rates, may be due to the unreliability of farm records on diseases and their diagnosis.

2.4.2. Causes of morbidity and mortality

In general, there is a tradition of giving treatments before establishing diagnosis in animal health services in the country and dairy farms may not be exceptional in this regard. This could be the reason for most of the studies not to usually include morbidity rates of prevalent diseases and associated risk factors in their reports. Nevertheless, calf diarrhea/scours, calf pneumonia and gastro-intestinal parasites are the most frequently reported causes of calf morbidity and mortality in Ethiopia (Jemberu 2004; Shiferaw, *et al*., 2002; Sisay and Ebro 1998).

These studies have shown that, calf diarrhea and pneumonia are the leading health problems in the newborn calves during the early period of their life, followed by gastro-intestinal parasites later in older calves soon as they started feeding on pasture.

2.4.3. Factors associated with dairy calf diseases in Ethiopia

Several factors have been reported in association with dairy calf diseases, some of which have been statistically significant. Hygienic, nutritional and managemental problems were reported to be the major problems associated with high mortality rates (Fantaye, 1993). In investigating about 20 potential risk factors for their association with crude calf morbidity and mortality (Jemberu, 2004), age, age at first colostrum feeding and cleanness of the house were found to be significantly associated with high morbidity and mortality rates.

Younger age and higher level of exotic blood level were also found to be associated with higher calf mortality (Abraham, *et al*., 1992; Gryseels and de Boodet, 1986; Shiferaw, *et al*., 2002). Other factors that were found to be significantly associated and affected calf morbidity and mortality, and which were reported by different workers include, colostral feeding, housing, calving assistance, production system, herd size, hygiene of micro-environment, season, etc (Abraham, *et al*., 1992; Amoki, 2001; Sisay and Ebro, 1998) .

Table 3 Calf mortality rates compiled from different studies in Ethiopia

Production System	Breed of Calves	Age of calves Considered	Mortality rates (%)	References
Semi-intensive	Friesian x Boran Jersey X Boran	Preweaning (3 months)	7	Shiferaw, *et al*., (2002)
Intensive and extensive	Friesian x Boran Jersey X Boran	Preweaning	14.2	Amoki, (2001)
Semi-intensive	Borans	Preweaning	25	Sisay and Ebro, (1998)
Semi-intensive	Friesian x Local	Preweaning	15	ILRI, (1996)
Semi-intensive	Jersey	-	53	Hassen and Brannang, (1996)
-	Friesian, Jersey, Simmental x Local	Up to 6 months	17.5	Hussien, (1998)
Intensive and extensive	87% Friesian x Local	Up to 2 Years	67	Gryseels and de Boodet, (1986)
Intensive	Friesian x Local	Up to 6 Months	18	Jemberu, (2004)

3. MATERIAL AND METHODS

3.1. Study area

The study was carried out on selected urban dairy farms located in Debre Zeit town and surrounding area. Debre Zeit is a town located at about 45 km South-east of Addis Ababa at an altitude of 1850 meters above sea level. The area has an average annual rainfall of 800 mm and average maximum and minimum temperature of 27.7 ^{o} C and 12.3 ^{o} C, respectively. It has a total human population of 95,000 (CSA, 2001). Debra Zeit is a capital town of Ada`a Liben woreda administration in East Showa zone of Oromia region.

3.2. Study population

The target population of this study constitutes all dairy calves found in all dairy farms that are found in Debra Zeit town and the surroundings. According to the data obtained from the Agricultural Office of the area, there were few relatively large dairy farms with milking herd size of greater than 30 cows and a lot of market-oriented smallholder (MOSH) dairy farms with average herd size of about 3 cows. The majority of the MOSH farms are organized under one dairy cooperative called Ada`a Liben Milk and Milk Products Marketing Cooperative, plc with about 614 member farms. All the commercial scale farms, the two farms that belong to the research centers and MOSH dairy farms keep Holstein and cross breed animals. The sampling units for the study were all dairy calves 24hrs to 8 days old.

3.3. Study design

3.3.1. Prospective study

- Questionnaire survey
- Prevalence study of FPT through measurement of STP concentration
- Follow up of the calves for clinical illness and death

3.3.2. Sampling method and sample size

One stage cluster sampling method was used with market oriented smallholder dairy farms as clusters and list of the farms 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 interacluster correlation and mathematically expressed as:

$$n` = n[(1+(m-1)*p)]$$ (Thrusfield, 1995)

where:

n` = sample size for cluster sampling

n = sample size calculated for simple random sampling

m = average cluster size

p = intracluster correlation

But in Debre Zeit and its surrounding area, the average herd (cluster) size that is number of calves per farm is estimated (Jemberu, 2004) to be 1.6. With this small clustering, the effect of intracluster correlation is minimum and n` will approximate n. Therefore, the sample size for the study was directly calculated by using the method used in simple random sampling. The sample size for estimating prevalence of disease problem, in this case prevalence of FPT, using simple random sampling was calculated according to Thrusfield (1995).

$$n = \frac{1.96^2 P_{exp}(1- P_{exp})}{d^2}$$

where,

n = required sample size,

P_{exp} = expected prevalence and

d = desired absolute precision

Using the expected prevalence of FPT of 67% (Amoki, 2001), at confidence level of 95% and required absolute precision of 5% a sample size of 334 calves was determined. Selection of the farm was done by lottery system from the sampling frame until 334 calve were included by sampling all calves that are eligible for the study in selected farms.

3.4. Data collection

3.4.1. Questionnaire based study

Selected farms were initially visited during which time, information on type of the farm, herd size and herd composition, how long the farm was running and herd management practices were collected using pre-prepared formats (Annex 1). During this initial visit, numbers of pregnant cows were recorded with expected date of delivery for not to miss sampling the newborn calf.

3.4.2. Prevalence study of failure of passive transfer

3.4.2.1. Sampling

After the initial visit, every selected farm was visited once per week for not to miss sampling the newborn calves within 8 days after birth. For MOSH and private dairy farms that are found in Debre Zeit town and its surrounding, sampling was done by the investigator and 3 more free lance Animal Health Assistants (AHA) who were providing veterinary services to these farms. The AHA`s also served as mediators (contact persons) between the investigator and the farms, otherwise the owners were reluctant to cooperate. Similarly, for dairy farms under agricultural research centers at Debre Zeit, Holeta and Asella towns, AHA `s that were staff of the respective farms, were hired to collect the samples.

Seven to ten ml of blood was collected using plain vaccutainer tubes from all calves that were 24hrs to 8 days old in the selected farms. The blood was allowed to clot at room temperature and serum was extracted by centrifugation and stored at -20^{o}C for Debre Zeit and the surrounding area at the physiology and biomedical laboratory of Faculty of Veterinary Medicine. Samples collected from the dairy farms of the research centers were stored at the same temperature in the respective center before collected by the investigator through regular visits to the centers once per 2 weeks.

3.4.2.2. Serum total protein determination

The prevalence of FPT was indirectly determined by measuring STP concentration of each calf according to Quigley, *et al.,* (2000) and Weaver, *et al.,* (2000), using the colorimetric method (Coromatest, LiNEAR Chemicals. S.L) that uses the biuret reaction, in which a chelate is formed between the Cu^{2+} ion and the peptide bonds of the proteins in alkaline solutions to form a violet colored complex whose absorbance is measured photometrically. The intensity of the color produced is proportional to the concentration of protein in the sample. The cut-off value was set at 55g/L (Quigley, *et al.,* 2000**;** Tyler, *et al.,* 1998) and the status of calves having STP concentration of less than and equal to 55g/L were identified as failure of passive transfer (FPT), while the status of calves having above 55g/L was identified as adequate passive transfer (APT).

3.4.3. Calf health monitoring

Monitoring of dairy farms for calf morbidity and mortality was carried out for 6 months from October 6, 2006 to April 15, 2007. For the purpose of health monitoring, calf was defined as young cattle of age between 24hrs and 6 months, crude morbidity as any sickness that has recognizable clinical manifestation and crude mortality as death of calves above the age of 24 hrs. Check-off format was used to capture the individual calf risk factors. Data collected included events surrounding each calf's birth: time, place, date of birth, and ease of birth. Similarly, farm level management data such as presence or absence of an attendant at birth and colostrum administration were also recorded for individual calf on calf card format when the calves joined

the study. The sample of the format is shown in Annex 2. For the purpose of the study, calves were identified during the initial sampling and individual record was kept afterwards. The calves were withdrawn from the follow up when they completed their 6 months of age, or censored due to death. Between these 2 times, outcomes of interest were any occurrence of diarrhea, pneumonia and other disease conditions including dullness, navel disorders and lameness. Calf health was assessed visually using objective criteria of appetite, fecal consistency, respiratory effort and attitude (Annex 3), subsequent to these evaluations, calves were designated as "normal" or "sick" (Berge, *et al.*, 2005).

Calf morbidities and mortalities that were encountered during the monitoring period were categorized into 3: diarrhea, pneumonia and other disease conditions (septicemic conditions, navel ill and joint disorders were included in the other disease conditions).

3.5. Data management

3.5.1. Serum total protein

The mean and standard deviation of STP were calculated and compared for different categories of calves. According to Quigley, *et al.,* (2000), the proportion of calves with FPT was calculated from the distribution of STP by using STP concentration of 55g/L as a cutoff value to differentiate between FPT and APT, then by dividing the number of calves with FPT with the total number of samples.

3.5.2. Describing morbidity and mortality

The incidence density (True rate, TR) was used to measure incidence of crude morbidity and crude mortality during the 6 months of the follow up, then the risk rates of all morbidity and all mortality was estimated from the incidence density using the formula Risk Rates = $1-e^{-TR}$

(Thrusfield, 1995) . Incidence density was calculated by dividing the number of cases of each disease with the number of calf days that the calf remained at risk for respective disease and was expressed by number of cases per 6 calf-months by dividing the denominator (Calf-days at risk) with 180 days. Moreover, the incidences of diarrhea, pneumonia and other disease conditions were measured in the same way; by considering a calf recovered from an illness was remained at risk for another illness including the previous one so long as it completely recovered (disappearance of the clinical signs at least for 2 consecutive days).

3.5.3. Determination of risk factors

Initially, a total of 21 risk factors (explanatory variables) were considered for the investigation of their association with values of STP, crude morbidity, and crude mortality but only 12 risk factors were carried on for analysis (Annex 4). The rest risk factors were dropped because of different reasons (too small and/or too large observations per category, similar responses for the same calf). In the analysis of the associations between risk factors and morbidity and mortality, only the first occurred cases of the diseases were considered as the subsequent cases might not be independent of the first ones.

3.5.4. Statistical analysis

All computations were carried out using computer soft wares. Microsoft Office Excel (2003) software was used to summarize the data and to calculate incidence rates of crude morbidity and crude mortality, as well as incidence rates of diarrhea, pneumonia and other disease conditions.
The same software was also used to calculate average age at the onset of diarrhea, pneumonia, other disease conditions, crude morbidity and crude mortality. Furthermore, it was used to calculate the risk rates and proportions of crude morbidity and crude mortality in each STP concentration stratum.

Win Episcope epidemiological software was used to calculate relative risks (prevalence ratios) of crude morbidity and crude mortality in each STP concentration stratum. Descriptive statistics of the STP concentration, and measuring of the associations between risk factors and FPT, crude morbidity and crude mortality were done by statistical soft ware called STATISTICA 6.1 (StatSoft, Inc. 1984-2003).

Relationships among different variables were described using Logistic regression of the same software, while the Actuarial life Table methods were used to estimate and construct figures of age specific risk rates (hazards) of crude morbidity, crude mortality, diarrhea, pneumonia and other disease conditions. Similarly, Proportional Hazard (Cox) Regression Models for age at the onset of crude morbidity and crude mortality were constructed to assess the interaction of the risk factors. Significance levels of *p-values* below 0.05 were considered as significant while *p-values* below 0.001 considered as highly significant.

4. RESULTS

4.1. Serum total protein

Data was collected from a total of 354 calves and the overall mean of STP concentration and the proportion of calves with FPT were 66.4±16.6g/L and 30.23%, respectively. Descriptive statistics of the STP concentration measured in different categories of calves are presented in Table 4 and Annex 5.

Table 4 Descriptive statistics of STP concentrations

No	Variables	Category	No	STP(g/L)		*t-value*	*p-value*
				Mean	SD		
1	Sex	Male	165	64.5	17.40	-2.07	< 0.05
		Female	189	68.1	15.79		
2	Parity number	Heifer calf	122	52.0	10.81	-15.18	< 0.001
		Cow calf	232	74.0	13.94		
3	Birth time	Night	131	56.1	16.21	-10.18	< 0.001
		Day	223	72.5	13.63		
4	Attendant	Absent	60	48.0	8.81	-10.86	< 0.001
		Present	294	70.2	15.30		
5	AFCI[1]	> 6hrs	171	59.6	18.05	-8.16	< 0.001
		< 6hrs	183	72.8	12.12		
6	Birth condition	Dystocia	45	50.4	13.02	-7.42	< 0.001
		Normal	309	68.8	15.81		
8	Birth site	Same barn	267	68.0	15.83	-3.17	< 0.001
		Calving pen	87	61.6	18.13		
10	Health status	Sick	165	57.6	16.27	-10.78	< 0.001
		Healthy	189	74.2	12.63		

[1]Age at first colostrum ingestion

4.2. Associations between risk factors and FPT

Out of 9 risk factors that were considered for their effect on STP concentration as measured with in a week after birth, only 7 were found to be associated with FPT. The associations between each of the risk factor and the status of the passive transfer of colostral immunoglobulins as measured by STP concentration are presented in Annex 6.

But, when the same risk factors were adjusted for their joint effect, only 4 factors were found to be significantly associated with FPT (Annex 7 and Table 5).

Table 5 Adjusted Odds Ratio for factors associated with FPT

Variable	Component	FPT	APT	OR	95% CI	X^2	p-value
Sex	Male	64	101	3.8	1.61-8.83	9.401	<0.05
	Female	42	147				
Parity number	Heifer-calf	86	36	14.6	6.27-33.84	39.059	<0.001
	Cow-calf	20	212				
Attendant	Absent	50	10	4.4	1.48-13.10	7.114	<0.05
	Present	56	238				
AFCI	>6hrs	94	77	7.2	2.56-20.13	14.139	<0.001
	<6hrs	12	171				

4.3. Morbidity

The incidence of crude morbidity during the first 6 months of calf hood was 52.3%. Summary of crude morbidity for different disease conditions is presented in Table 6.

Table 6 The incidence of different diseases and crude morbidity

Disease/ Syndrome	No of cases	Calf-days at Risk (CDR)	Incidence Rates	
			True Rate/6 cm	Risk Rates%[1]
Diarrhea	85	50725	0.30	25.90
Pneumonia	36	60234	0.11	10.40
Others	44	56612	0.14	13.10
Crude morbidity	165	40131	0.74	52.30

[1] Estimated from True Rate using the formula $1-e^{-\text{True Rate}}$ (Thrusfield, 1995)

Calves became sick as early as 3 days of age and observed to become sick at any time throughout the first six months of age with the overall average age at onset of crude morbidity of about 37.04±30.63 days. The average ages at the onset of diarrhea, pneumonia and other disease conditions are illustrated by Figure 2.

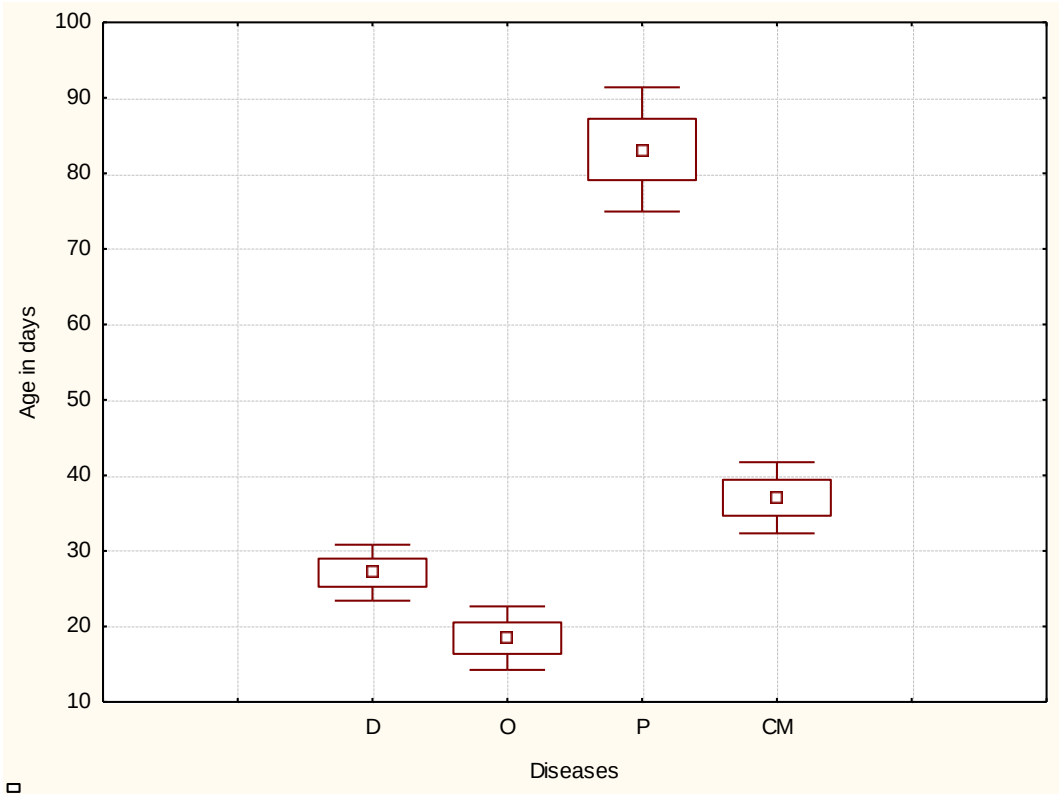


Figure 2 Average age at the onset of diarrhea (D), pneumonia (P), other disease conditions (O) and crude morbidity (T)

Figures 3-6 illustrate the daily risk of crude morbidity, diarrhea, other disease conditions and pneumonia throughout the first 6 months of life, as estimated by the actuarial life Table method.

Figure 3 Age specific risk of crude morbidity for the first 6 months of life

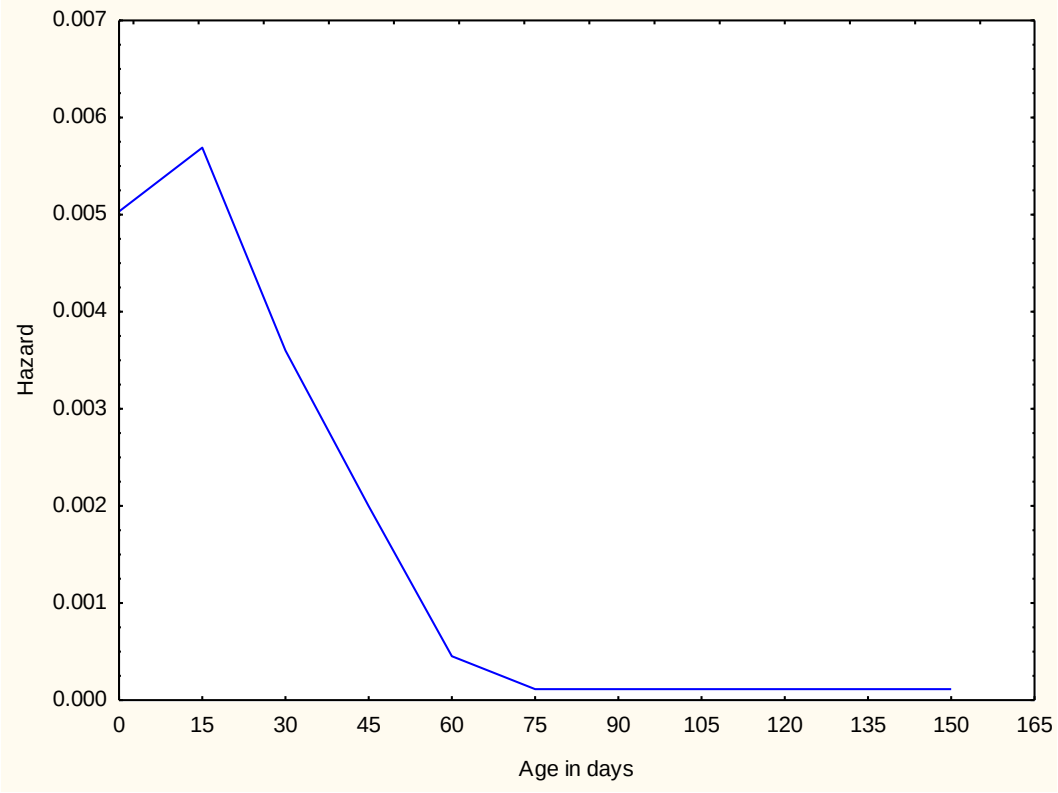


Figure 4 Age specific risk of diarrhea during the first 6 months of life

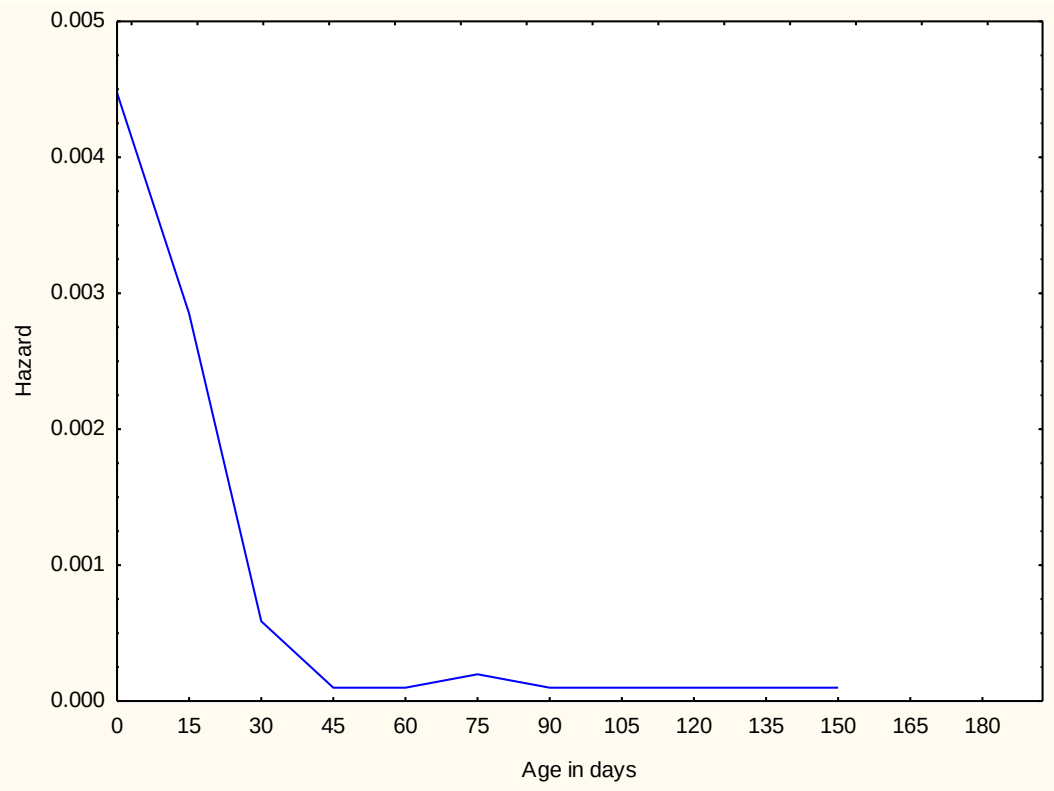


Figure 5. Age specific risk of other disease conditions during the first 6months of life

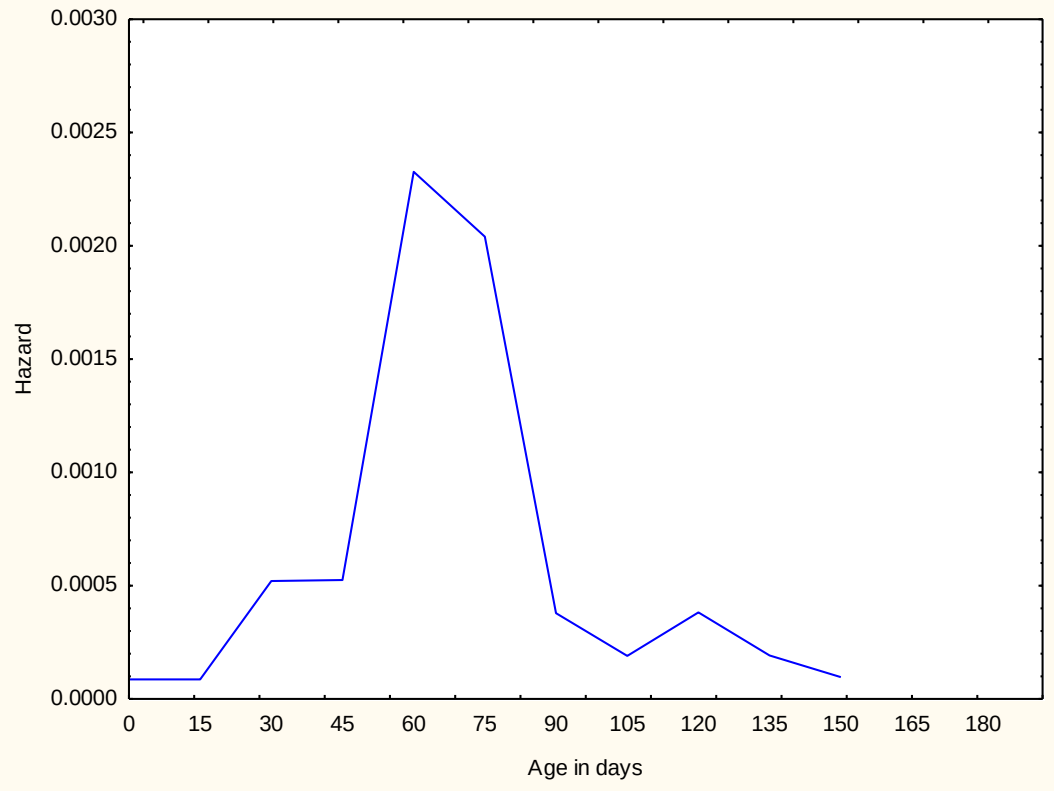


Figure 6 Age specific risk of pneumonia for the first 6 months of life

4.4. Associations of risk factors and crude morbidity

Risk factors for crude morbidity of the newborns that were considered in the study are listed under Annex 8. Out of 10 risk factors considered only 6 were showed to have significant association with crude morbidity on univariate analysis using logistic regression (Table 7).

Table 7 Univariate analysis of risk factors of crude morbidity using Logistic Regression

Variable	Category	Sick	Healthy	OR	95% CI	X^2	p-value
STP	FPT	94	13	17.92	9.4-34.1	77.59	<0.001
	APT	71	176				
Parity	Heifer-calf	87	35	4.91	3.0-7.9	42.53	<0.001
	Cow-calf	78	154				
BT[1]	Night	87	44	3.68	2.3-5.8	31.37	<0.001
	Day	78	145				
Attendant	Absent	52	8	10.41	4.8-22.8	34.44	<0.001
	Present	113	181				
AFCI	>6hrs	108	63	3.79	2.4-5.9	35.02	<0.001
	<6hrs	57	126				
BC[2]	Dystocia	32	13	3.26	1.6-6.5	11.47	<0.001
	Normal	133	176				

[1]Birth time [2]Birth condition

But, when the multivariate analysis of the risk factors for their combined effects was done, only STP and absence or presence of an attendant were significantly associated with crude morbidity (Table 8) (Figure 9 & 10)

Table 8 Multivariate analysis of risk factors for crude morbidity using Logistic Regression

Variable	Component	Sick	Healthy	OR	95% CI	X^2	p-value
STP	FPT	94	13	11.0	4.4-27.4	26.67	<0.001
	APT	71	176				
Attendant	Absent	52	8	2.7	1.3-7.2	4.12	<0.05
	Present	113	181				

Occurrences of disease against age in calves with FPT and APT, and in calves born in the absence or presence of an attendant were compared using survival function and the results are displayed in Figure 7 and 8.

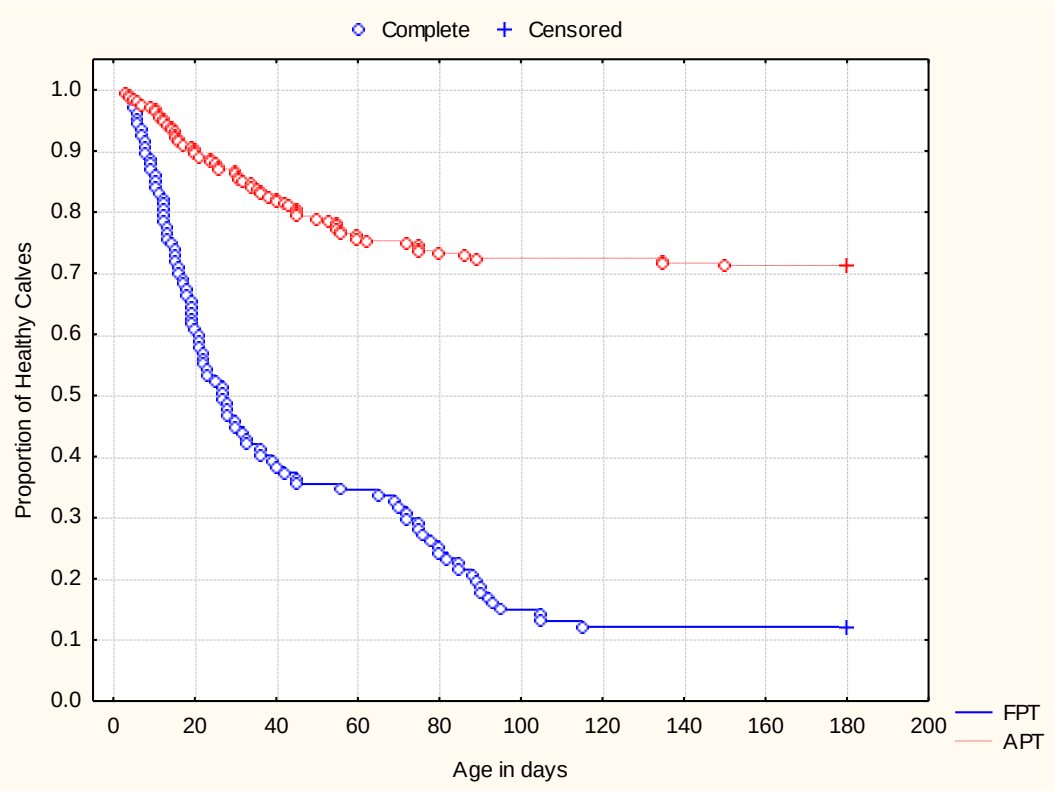


Figure 7 *Proportion of healthy in calves with FPT (___) and with APT (_ _ _) against age*

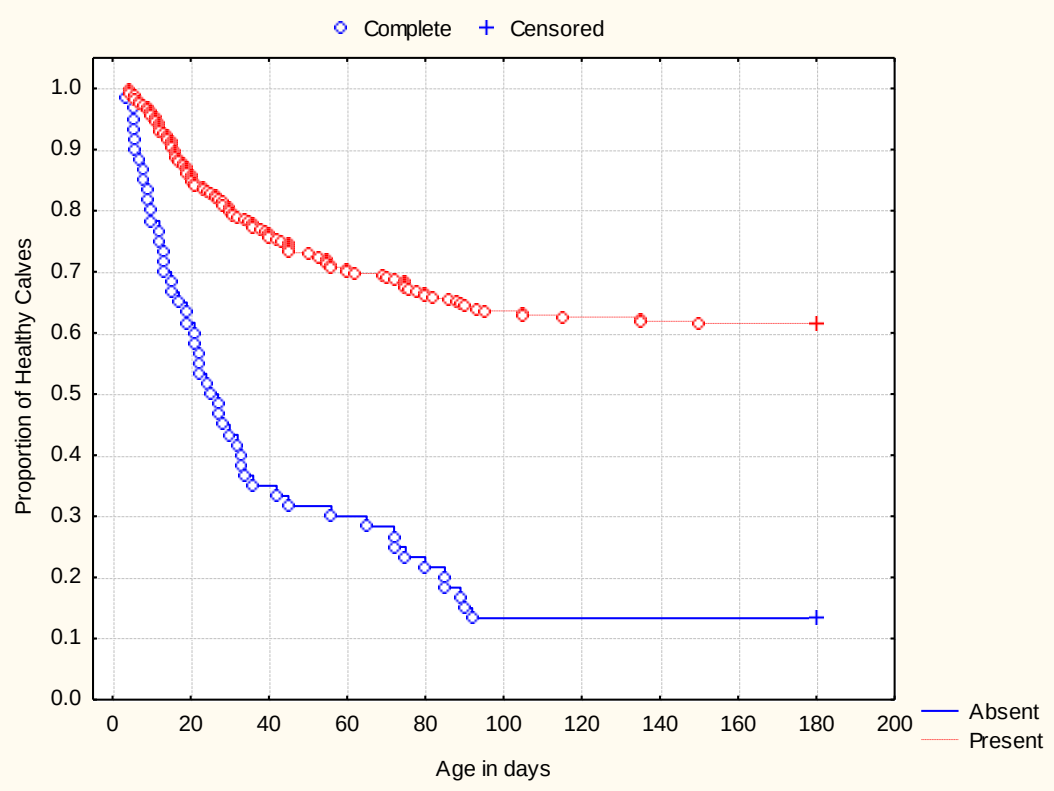


Figure 8 *Proportions of healthy in calves born at absence (__) and presence (----) of an attendant against age*

Cox proportional hazard model was examined age at onset of morbidity. The coefficients (Beta), t-values, and corresponding p-values for the variables that showed significant association at *p-values* of 0.05 are presented in Table 9.

Table 9 Proportional Hazard (Cox) Regression Model for age at the onset of morbidity

N-354	Beta	SE	t-value	p-value
STP	-0.43	0.08	-5.08	<0.001
Attendant	-0.46	0.20	-2.27	<0.05
AFCI	-0.49	0.23	-2.11	<0.05
Birth condition	0.55	0.23	2.36	<0.05

Serum total protein concentration was categorized in to 8 intervals and the risk rates of crude morbidity were calculated for each interval (Table 10).

Table 10 Risk rates of crude morbidity by STP concentrations

Category	SP concentration (g/L)	No. of cases	CDR	Morbidity	
				True rate	Risk rate (%)
1	26.1-35.0	8	158	9.11	99.99%
2	35.1-45.0	25	1835	2.45	91.37%
3	45.1-55.0	61	3568	3.08	95.40%
4	55.1-65.0	29	6172	0.85	57.25%
5	65.1-75.0	13	11486	0.20	18.13%
6	75.1-85.0	15	9890	0.27	23.66%
7	85.1-95.0	9	4385	0.37	30.92%
8	95.1-105.0	5	2637	0.34	28.82%

Similarly, the proportions of crude morbidity in each STP concentrations were compared with the total crude morbidity (Table 11).

Table 11 Proportions of crude morbidity by STP concentrations levels

Category	Serum protein concentration (g/L)	Morbidity		
		% within category	% of total sick	% of Total calves
1	26.0-35.0	100.0	4.8	2.3
2	35.1-45.0	83.3	15.2	7.1
3	45.1-55.0	89.7	37.0	17.2
4	55.1-65.0	51.2	17.6	8.2
5	65.1-75.0	17.6	7.9	3.7
6	75.1-85.0	22.4	9.1	4.2
7	85.1-95.0	28.1	5.5	2.5
8	95.1-105.0	26.3	3.0	1.4

Furthermore, the relative risks of crude morbidity for each protein concentration stratum were estimated and the results are summarized by Table 12.

Table 12 Relative risk of crude morbidity by STP concentration levels

Category	Protein Concentration	PR[2]	95%CI	Attributable Risk
1	26.0-45.0[1]	2.1	1.74-2.48	0.45
2	45.1-55.0	2.5	2.07-2.93	0.53
3	55.1-65.0	1.1	0.86-1.5	0.06
4	65.1-75.0	0.3	0.2-0.53	-0.38
5	75.1-85.0	0.4	0.27-0.68	-0.30
6	85.1-95.0	0.6	0.33-1.02	-0.20
7	95.1-105.0	0.6	0.23-1.18	-0.21

[1]Category 1 and 2 merged

[2] Prevalence Ratio which has the same meaning as the relative risk (RR) (Thrustfield, 1995)

4.5. Mortality

The crude mortality observed in this study was 18.9%. Summary of mortality from different causes is presented by Table 13.

Table 13 Incidence of mortality rates from different diseases and crude mortality

Disease/ Syndrome	No of cases	CDR	Incidence Rates	
			TR/6 cm	RR%[1]
Diarrhea	34	59199	0.10	9.5
Pneumonia	14	62565	0.04	3.9
Others	16	61474	0.04	3.9
Crude mortality	64	55798	0.21	18.9

[1] Calculated from True Rate using the formula $1-e^{-\text{True Rate}}$ (Thrusfield, 1995)

The average age of occurrence of crude mortality of all causes, mortality due to diarrhea, pneumonia and other disease conditions is presented by Figure 9.

Estimates of hazard function indicated that calves are at higher risk of mortality during the neonatal period than any other time of the first 6 months of life (Fig 10).

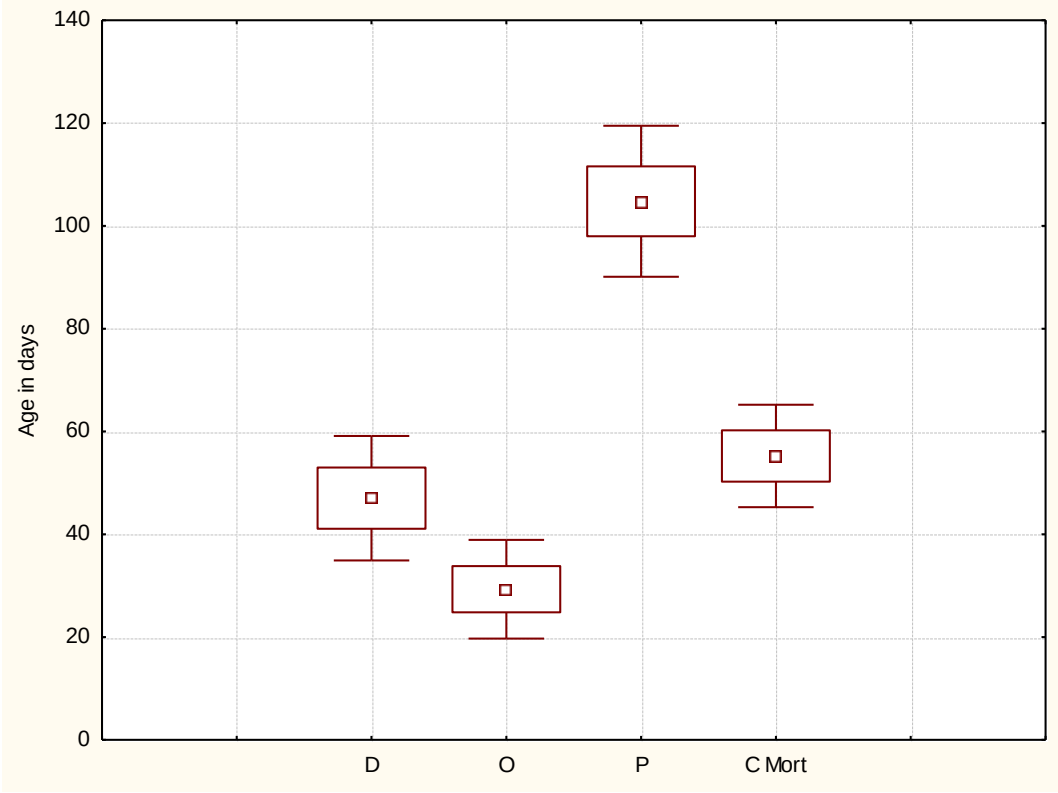


Figure 9 Average at onset of mortality from diarrhea (D), other disease (O), pneumonia (P) and crude mortality (T)

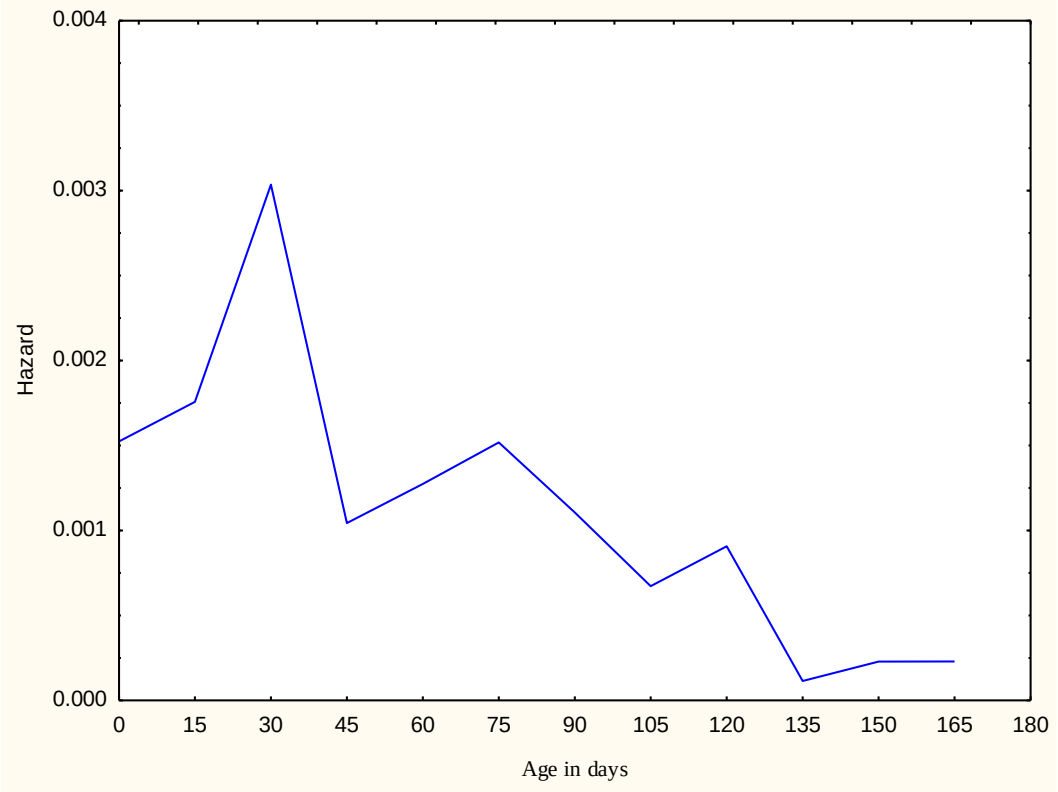


Figure 10 Age specific hazard of crude mortality

4.6. Associations of risk factors and mortality

Risk factors of mortality for dairy calves during the first 6 months were examined using the logistic regression for their individual effect and the result is presented in Annex 9. The same risk factors were subjected to multivariate analysis using logistic regression to assess their joint effect on calf mortality during the first six months of life. The result of this analysis is presented in Annex 10 and Table 14.

Table 14 Multivariate analysis of risk factors for mortality using logistic regression

Variable	Component	Died	Survive	OR	95% CI	X^2	p-value
STP	FPT	44	63	3.1	1.4-9.2	12.32	<0.001
	APT	20	227				
Sex	Male	44	121	2.7	1.25-5.65	6.48	<0.05
	Female	20	169				
Age at onset of Morbidity	<=3 months	61	95	27.2	7.6-97.1	26.14	<0.001
	>3 months	3	195				

Cox proportional hazard model was used to examine the association of the potential risk factors in determining the age of the onset of mortality. The coefficients (Beta), the standard error of beta (SE), the t-value and the corresponding p-value are presented in Table 15.

Table 15 Proportional Hazard (Cox) Regression Model for age at the onset of mortality

N = 354	Beta	SE	t-value	*p-value*
Age at onset of morbidity	-2.95	0.61	-4.84	<0.001
STP	-0.59	0.15	-3.96	<0.001
Sex	-0.75	0.29	-2.56	<0.05
BT	0.94	0.36	2.61	<0.05

Serum total protein concentration was categorized into 8 intervals and the risk rates of crude mortality were calculated for each interval (Table 16).

Table 16 Risk rates of crude mortality by STP concentration levels

SP concentration (g/L)	No. of cases	CDR	Mortality	
			True rate	Risk rate (%)
26.0-35.0	7	367	3.43	96.76%
35.1-45.0	11	4117	0.48	38.12%
45.1-55.0	26	8732	0.54	41.72%
55.1-65.0	9	9074	0.18	16.47%
65.1-75.0	4	12822	0.06	5.82%
75.1-85.0	4	11687	0.06	5.82%
85.1-95.0	1	5731	0.03	2.96%
95.1-105.0	2	3370	0.11	10.42%

Similarly, when the proportions of crude mortality within each protein level was compared to total crude mortality, the highest proportion of mortality was observed among the calves with total serum protein concentrations 45.1-55.0g/L (Table 17).

Table 17 Proportions of deaths by protein concentration levels

Protein concentration (g/L)	Mortality		
	% Within category	% of total death	% of total calves
26.0-35.0	87.5	10.9	2.0
35.1-45.0	36.7	17.2	3.1
45.1-55.0	38.2	40.6	7.3
55.1-65.0	16.1	14.1	2.5
65.1-75.0	5.4	6.3	1.1
75.1-85.0	6.0	6.3	1.1
85.1-95.0	3.1	1.6	0.3
95.1-105.0	10.5	3.1	0.6

In a similar fashion, the relative risks of crude mortality for each protein concentration interval were estimated and the greatest relative risk (RR=5.3) of mortality was observed in calves with total serum protein concentrations 26.0-35.1g/L (Table 18).

Table 18 Relative risks of crude mortality by protein concentration levels

Protein concentration (g/L)	PR[1]	95% CI	Attributable Risk
26.0-35.0	5.3	3.73-7.56	0.71
35.1-45.0	2.2	1.32-3.81	0.20
45.1-55.0	2.9	1.86-4.39	0.25
55.1-65.0	0.9	0.46-1.66	-0.02
65.1-75.0	0.3	0.09-0.67	-0.16
75.1-85.0	0.3	0.11-0.76	-0.15
85.1-95.0	0.2	0.02-1.11	-0.16
95.1-105.0	0.6	0.15-2.15	-0.08

[1]Prevalence ratio with the same meaning as relative risk (Thrusfield, 1995)

5. DISCUSSION

5.1. Serum total protein

The average STP concentration, measured during the first week of life, was 66.4 ± 16.6g/L, and it ranged from 28.8 to 99.8g/L (Table 4), which corresponds with the finding of Pare, *et al.,* (1993) who reported a mean of 68.2g/L and 65.0g/L, with the range of 50.0 to 109.0 and 49.0 to 92.0g/L in two separate dairy farms. The proportion of calves that had FPT, where STP was equal or less than 55g/L, was 30.23%. This result is lower than as was reported by Amoki, (2001) (67%) in Ethiopia. The reason for the higher proportion of FPT that was reported by Amoki might be because of the small number of samples (19 out of the 25 calves) which were all sick and eventually died. But, the results of this study were in agreement with that of Tyler, *et al.,* (1998) who reported a FPT, where STP was less than 50g/L, in 34% of calves, and inadequate transfer, where STP was less than 55g/L, in 60.5% of calves. However, Pare, *et al.,* (1993) reported FPT in 9.2% and 13% of dairy calves from two separate dairy farms, which was lower than the present study.

Several factors have been reported which significantly affect the acquisition of passive immunity by the newborn calves. During the study, female calves had significantly ($p < 0.05$) higher mean of STP than male calves (Table 4). Roy, (1990) similarly indicated that female calves generally have higher serum immunoglobulin concentrations than do male calves. He also stated that it was not clear whether gender of the calf might be related more to blood volume than to apparent efficiency of absorption (AEA). The other possibility may be that the larger size of bull calves may influence the metabolic state of the calves, thereby affecting immunoglobulin absorption (Roy 1990). The commercial value of male calves in market-oriented smallholder dairying might be yet another reason for the lower mean of STP in male calves than that of female calves that was observed in this study, as male calves receive less attention from the very beginning, because low STP concentrations are also attributable to failures to obtain adequate colostral

immunoglobulins in the period immediately following birth (Earley and Fallon, 1998).. However, further investigation is needed in this area.

Calves born from first calf-heifers had significantly ($p < 0.001$) lower mean of STP than calves born from cows of more than two parturations (Table 4). Several publications frequently report this fact (Fleenor and Stott, 1980; Mechor, *et al.*, 1991; Morin, *et al.*, 1997), and it is generally true that cows tend to produce immunoglobulins in response to pathogens to which they have been exposed. Therefore, cows exposed to a large number of pathogens tend to produce colostrum with greater immunoglobulin concentration than cows exposed to fewer pathogens.

Similarly, the presence or absence of an attendant at birth, time of the first colostrum ingestion, birth condition, birth site and source of colostrum were significantly affected the mean of STP measured shortly after birth (Table 4). Furthermore, healthy calves had highly significantly ($p <0.001$) higher mean of STP concentration than calves that were developed disease later, because of the well established fact that calves with a lower immune status are generally more susceptible to morbidity and mortality (Donovan, *et al.*, 1998; Rea, *et al.*, 1996; Tyler, *et al.*, 1998).

5.2. Associations between risk factors and failure of passive transfer of immunity

The most important findings of this study was the lack of associations of birth time, method of colostrum feeding (MCF) and birth site with the concentration of STP ($p > 0.05$) (Annex 7) (Table 5), while it was known (Sivula, *et al*., 1996b; Weaver, *et al.*, 2000) that these factors could influence the passive transfer of immunoglobulins in the newborn calves. Calves that were allowed to suck the dam generally achieve lower immunoglobulin concentration than are calves fed colostrum by nipple bottles (Logan, 1981), because calves allowed nursing the dam often consume less colostrum than do calves fed by nipple bottle (Brignole and Stott, 1980) thereby, lower immunoglobulin intake. On the other hand, a research that has measured the intake of immunoglobulin by calves allowed to suck the dam early, have reported apparent efficiency of absorption (AEA) better than for calves fed by nipple bottle (Selman, *et al.*, 1970; Stott, *et al.*, 1979) and therefore, higher serum immunoglobulin concentration.

The results of the study indicated that absence or presence of an attendant at parturation (OR = 4.4, 95% CI = 1.5-13.1) and age at first colostrum feeding (OR = 7.2, 95% CI = 2.6-20.1) (Table 5) were significant risk factors for FPT. The decline in AEA of immunoglobulin with increasing age is a long established concept (Quigley, *et al.*, 1995). The age at first feeding is more properly classified as a loss of efficiency of absorption through maturation of intestinal epithelial cells, establishment of intestinal bacteria and increasing production of intestinal enzymes that will reduce AEA of immunoglobulins (Quigley, *et al*, 1995). The presence of a caretaker at parturation who supervise ingestion of the first two colostrum feedings is essential for establishing the maximum number of calves with the required level of maternal antibody and therefore, the presence of caretaker is more important factor than birth time, method of feeding and birth site. Similar observations were reported by Weaver, *et al.,* (2000) and Waltner-Toews, *et al.,* (1986d). Therefore, the results of this study that suggested birth time, birth condition, method of colostrum feeding and birth site may not necessarily be risk factors for FPT are acceptable.

On the other hand, age of the dam, as estimated by parity number, (OR = 14.6, 95% CI = 6.3-33.8) and sex of the calves (OR = 3.8, 95% CI = 1.6-8.8) (Table 5), was important risk factors for FPT in the newborn calves. There are several reports (Pare`, *et al.,* 1993; Quigley, *et al.,* 1995; Roy, 1990; Weaver, *et al.,* 2000) in which age of the dam and sex of the calf has been implicated to affect status of passive transfer. It was known that as cows get older they will be exposed to a large number of pathogens and will produce more protective immunoglobulins that will transfer through colostrum to the newborn. The significant association of sex with status of passive transfer was not clear. It was suggested (Roy 1990) that the gender of calf might be related more to blood volume than to apparent efficiency of absorption (AEA) and the larger size of bull calves may influence the metabolic state of the calves, thereby affecting immunoglobulin absorption. The other possibility that was observed in this study, was a husbandry problem, that is in MOSH dairy production, male calves have less commercial value and have got less attention from the very beginning when compared to the female calves, thereby less colostrum consumption and lower serum immunoglobulin concentration than female calves. However, this observation needs further investigations.

5.3. Morbidity

The results of this study revealed that the incidence (Risk Rate) of crude morbidity during the first 6 months of calf hood were 52.3% (Table 6), which was some what less than that was reported by Jemberu, (2004) which was 61.5%. Nevertheless, the morbidity rates determined in the present study were higher than similar reports. Crude calf morbidity rates less than 30% were reported by many authors in different parts of the world (Gitau, *et al*., 1994; Sivula, *et al*., 1996a; Waltner-Toews, *et al*., 1986b). Comparable morbidity rates to the present study were reported by Virtala, *et al.,* (1996) and Debnath, *et al.,* (1995) who reported 52% crude morbidity in calves. Generally, reports of morbidity rates showed wide variability due to the different methods used in diagnosis (Radostits, *et al.,* 1994). Some authors reported calf morbidity based on producer diagnosis and treatments, while others depend on Veterinarian's diagnosis.

Among the individual diseases, diarrhea was the first and the most common cause of morbidity with the true incidence rate of 0.30 per 6 calf-months (Table 6). This finding is in agreement with most of the reports on the subject of dairy calf morbidity. Jemberu, (2004) reported that diarrhea was the predominant calf health problem in Debre Zeit and its surroundings with true incidence of 0.56 per 6 calf-months. Lemma, *et al*., (2001) and Hussein, (1998) in Ethiopia and many other studies elsewhere, were reported diarrhea and pneumonia as the first and second important disease complexes that affect calf health (Debnath., *et al*., 1995; Shoo, *et al*., 1992; Sivula, *et al*., 1996a). But, there are studies, which found pneumonia as the leading cause of calf morbidity and mortality (Agerholm, *et al*., 1993; Rao and Nagarcenkar, 1980; Shiferaw, *et al*., 2002).

In the study, the incidence of diarrhea was followed by the other disease conditions with true incidence rate of 0.14 per 6 calf-months and pneumonia with the true incidence rate of 0.11 per 6 calf-months (Table 6). The relatively lower incidence of pneumonia in this study might be due to the small herd size of the farms. Large herd size has strong correlation with environmental stress and accumulation of ammonia that expose calves to respiratory problems; it was observed that a 50% decrease in stocking density was increasing the ventilation rate by 20 times thereby decreasing the risk of pneumonia (Blowey, 1990; Lundborg, *et al*., 2005).

It was observed that dairy calves could become sick at early age of 3 days and could become sick at any time throughout the first 6 months of life with the overall average age at the onset of crude morbidity of about 37 days (Fig. 2 and 3). The risk of calf diarrhea was peaked during the first month of life (Fig. 2 and 4), after which it was significantly dropped indicating that the neonatal period was a critical time in the life of the dairy calf. There are several research reports that support this result. Waltner-Toews, *et al.,* (1986b) reported that the risk of diarrhea peaked during the first 2 weeks of life and approached 0 by about six weeks, while Sivula, *et al*., (1996b) reported that the risk of diarrhea was highest in the first week of life. Virtala, *et al*., (1996) in their three months study showed the peak occurrence of diarrhea at the second week of life, which was decreased sharply thereafter.

Similarly, the risk of other disease conditions was also peaked during the neonatal life period, with an average age at the onset of about 18 days. In the contrary, the risk of pneumonia was peaked during about 10 weeks of age, with an average age at the onset of about 83 days (Figs. 2, 5 and 6), which are again in agreement with Waltner-Toews, *et al*., (1986c) who also reported that pneumonia was peaked at about 6 weeks of age, while Sivula, *et al*., (1996a) reported that the risk of pneumonia was peaked during the 10^{th} week of life.

5.4. Associations between risk factors and crude morbidity

All the risk factors of morbidity, that were considered in the study were found to be significantly associated with calf sickness on univariate analysis except the birth site (BS) (OR = 0.60; 95% CI = 0.4-1.0) and MCF (OR = 0.94; 95% CI = 0.6-1.5) (Annex 8).

Failure of passive transfer, as estimated from STP concentration was found to be the most important risk factor of crude morbidity, thus calves with FPT, where STP as measured soon after birth was less than or equal to 55g/L, had 17.9 (95% CI 9.4-34.1) (Table 7) times greater odds of becoming sick when compared to calves with APT, where STP concentrations were > 55.0g/L.

Similarly, attending calves at parturation was significantly associated with crude morbidity, such that, calves born at the absence of an attendant had 10.4 (95% CI 4.8-22.8) times greater odds of becoming sick when compared to those born at the presence of an attendant. Furthermore, parity number (OR = 4.91; 95% CI = 3.0-7.9), time of first colostrum ingestion (OR = 3.79; 95% CI = 2.4-5.9), birth time of the calf (OR = 3.68; 95% CI = 2.3-5.8), and birth condition (OR = 3.26; 95% CI = 1.6-6.5) were significantly associated with crude morbidity of the calf (Table 7), while source of colostrum (OR= 0.27; 95% CI = 0.2-0.5) was only marginally associated with crude morbidity of the calf during the first 6 months of life. In this study, birth site (OR = 0.60; 95% CI = 0.4-1.0) and MCF (OR = 0.94; 95% CI = 0.6-1.5) were not associated with crude morbidity of the calf (Annex 8).

But, when the joint effect that the risk factors exert on crude morbidity was analyzed with the multivariate logistic regression, only STP concentration and presence or absence of attendant at parturation were found to be significantly associated with calf morbidity. Level of serum total protein was found to be a good predictor of morbidity with the odds of becoming sick for calves having FPT being 11.0(95% CI = 4.4-27.4) times greater than for calves having APT (Table 8 & Fig. 7). Similarly, calves born without an attendant had 2.7 (95% CI = 1.3-7.2) times more odds of becoming diseased during the first 6 months of life when compared to the calves born at the presence of an attendant (Table 8 and fig 8). Numerous publications in the past have indicated that these factors are associated with calf morbidity. Weaver, *et al*., (2000) reported that many factors, including first time of colostrum ingestion, age of the dam, the practice of colostrum pooling, assistance parturation and supervising at the first 2 colostrum ingestions were all significantly associated with crude morbidity of the calf. Similarly Jemberu (2004) and Amoki (2001) were indicated increased crude morbidity in calves that were ingested their first colostrum meal 6hrs after birth. Donovan, *et al.,* (1998) also reported that STP was a significant risk factor of crude morbidity, while Sivula, *et al.,* (1996b) indicated significant association between birth condition and crude morbidity.

On the other hand, estimation of crude morbidity risk rates at 8 categories of STP concentrations levels revealed that the highest risk rates of crude morbidity, that were above 91%, were observed in calves with STP concentrations $\leq$ 55g/L, but calves with STP concentrations 55.1-

65.0g/L were experienced significantly higher risk rates (57.3%) compared to calves with STP concentrations > 65.0g/L, while calves with STP concentrations > 65.1g/L were generally experienced lower risk rates of crude morbidity (Table 10).

Furthermore, the highest proportions of crude morbidity were observed in calves with STP concentrations ≤ 65g/L, while the lower proportion of crude morbidity were observed in calves with STP concentrations > 65g/L (Table 11). Again, the highest relative risk of crude morbidity (RR = 2.47; 95% CI = 2.07-2.93) was experienced by calves with STP concentrations 35.1-45.0g/L (Table 12) indicating that the level of STP concentrations was a significant risk factor of crude morbidity. Rea, *et al.,* (1996) was observed the greatest relative risk of crude morbidity in calves with STP concentrations < 45g/L and concluded that lower passive transfer values had increased risk of crude morbidity. In this study, 53.3% of the observed morbidity was attributed to FPT (Table 12).

On the other hand, estimation of hazard of age at the onset of crude morbidity indicated that STP concentration ($p<0.001$), attendant at birth ($p<0.05$), time of the first colostrum ingestion ($p<0.05$) and birth condition ($p<0.05$) were found to be significant risk factors for the onset of crude morbidity at an earlier age of the calf (Table 9). Sivula, *et al.,* (1996b) indicated that calves that required assisted delivery were at increased risk of developing diarrhea sooner than those born without assistance. The intestinal tract of the neonate, which is sterile at birth but, within a few hours, environmental bacteria begin to colonize the intestine and result in early septicemic conditions (Radostits, *et al.,* 1994) and delay in the first time of colostrum ingestion will enhance the colonization of the intestine. Logan, *et al.,* (1981) indicated that early colonization of pathogens had resulted in 100% morbidity and about 75% mortality. Furthermore, the presence of bacteria in the intestine may actually increase the rate of intestinal closure, thereby reducing AEA and acquisition of passive immunity (Quigley, *et al.,* 1994). Respiratory acidosis, which is common at birth (Besser, *et al.,* 1990), especially in calves born with difficulty (Radostits, *et al.,* 1994) may affect AEA and the acquisition of passive immunity (Radostits, *et al.,* 1994; Quigley, *et al.,* 1994) thereby increasing the risk of the calf to become sick or die early at perinatal or neonatal periods.

5.5. Mortality

The crude mortality observed in this study was 18.9%, and diarrhea was still the most common cause of death, directly accounting for 34 cases or 53.13% of the total deaths, followed by other disease conditions and pneumonia with 25% and 21.9% of the total deaths respectively (Table 13). The crude mortality rate found for 6 months has considerably agreed with the crude mortality rates reported for similar period by different studies in Ethiopia (Amoki, 2001; Hussein, 1998; Jemberu, 2004). However, it was higher than the 12% of mean calf mortality rate in smallholder dairy production in sub-Saharan Africa (Otte and Chilonda, 2000) and even much higher than those from the western world which was reported in the range of 9 to 13% for Europe and 6.3% for USA (Heinrichs and Radostits, 2001). On the other hand, the result of this study is lower than the 25% and 50% crude calf mortality rates reported by Sisay and Ebro (1998) and Hassen and Brannad, (1996) respectively. Furthermore, French, *et al*., (2001) reported crude calf mortality rate of 35% in smallholder dairy farming in Zimbabwe while Shoo, *et al.*, (1992) was reported 23% cause specific mortality rates of dairy calves on farms in the eastern zone of Tanzania. The differences in the mortality rates may be due to the difference in the herd health management practices and the methods of measurements.

In this study it was found that calves were at greater risk of dying during the neonatal period with a progressive decrease thereafter, the average age of death being at about 56 days and daily hazard of mortality was peaked during the first month of life (Figs. 9 and 10). Similarly, Jemberu, (2004) reported that the risk of death was highest at 2 weeks of age, while Debnath, *et al*., (1995) reported mortality peak during the neonatal period and Waltner-Toews, *et al*., (1986c) mortality peak during the first week of life. Furthermore, the result of the study suggested that mortality was more persistent than morbidity (Fig 10).

5.6. Associations between risk factors and mortality

In this study, age at the onset of morbidity was found to be the most important risk factor of mortality when factors were analyzed using univariate logistic regression (Annex 9). This means that the younger the calf become sick, the sooner it will die. Several publications on the subject of calf mortality support this finding (Amoki, 2001; Debnath, *et al.,* 1998; Jemberu, 2004; Pare *et al.,* 1993).

Like the case of calf morbidity, FPT, as estimated by STP concentrations, was found to be highly significant ($p < 0.001$) risk factor of crude mortality of the calf. Sex of the calf ($p<0.001$), parity number ($p<0.001$), attendant at parturation ($p<0.001$), age at first colostrum ingestion ($p<0.001$), source of colostrum (SC) ($p<0.001$) and birth condition (BC) ($p<0.001$) were also found to be highly significant risk factors of crude mortality, while birth time ($p<0.05$) was only marginally associated with crude mortality. Similarly, like crude morbidity, method of colostrum feeding was not significantly ($p>0.05$) associated with crude mortality. In addition, birth site was also found not to be a risk factor ($p>0.05$) of crude mortality (Annex 9). Donovan, *et al.,* (1998) reported the association of STP and mortality.

But, when the risk factors were adjusted for their interactions, only age at onset of morbidity ($p<0.001$) and the level of STP concentrations ($p<0.001$) were highly significantly associated with crude mortality (Table 14), while sex of the calf ($p<0.05$), attendant at parturation ($p<0.05$) and birth time ($p<0.05$) were also showed significant association with crude mortality (Annex 10). Here, it is important to note that the odds of dying for the calf which became sick at the age below 3 months was 27.2 (95% CI = 7.6-97.1) times greater than the odds of dying for the calf that became sick at the age of above 3 months. Similarly, the odds of dying for the calf with FPT, as estimated from STP during the first week of life, was 3.1 (95% CI = 1.4-9.2) times greater when compared to the calf with APT. It is a well-recognized fact that the most critical time in the life of the dairy calves is during the first few days of life, when crude morbidity and crude mortality are greatest. A USDA study of farms throughout the U.S. with more than 30 cows (NAHMS, 1992) indicated that preweaning mortality of calves born alive was 8.4%, whereas

mortality after weaning was only 2.2%. On the other hand, the resistance of the calf to the infectious agents, that cause early calf morbidity and mortality, depends upon the amount of passive immunity received from colostrum (Earley and Fallon, 1998**)**

The results of proportional hazard (Cox) regression model for age at the onset of mortality showed that age at the onset of morbidity ($p<0.001$), FPT as estimated from STP during the first week of life ($p<0.001$), sex of the calf ($p<0.05$) and birth time ($p<0.05$) were significantly interact in causing death of the calf at an earlier age (Table 15). This result also indicates that age below 3 months and FPT were highly significant risk factors of crude mortality of the calves.
The influence of serum immunoglobulin concentration as measured during the first week of life on subsequent health and survival of the calf was well documented by many researchers. According to Wittum and Perino, (1995) calves with inadequate colostral immunoglobulin concentration within the first week of life were at greater risk of neonatal morbidity and mortality. There are numerous other publications in the three decades that correlated neonatal morbidity and mortality rates with low level of serum immunoglobulin concentration or FPT in calves (Aldridge, *et al*., 1992; Amoki, 2001; Edwards, *et al*., 1982; Hopkins, *et al*., 1984; Selim *et al*., 1995).

Furthermore, the association between FPT and crude mortality were also viewed by partitioning the crude mortality into 8 categories of STP concentrations. Partitioning of the crude mortality according to the STP concentration strata showed that the greatest incidence rate (estimated by risk rate) of crude mortality (96.7%) was experienced by calves with STP concentrations 26.0-35.1g/L, and generally, calves with STP concentrations $\leq$ 55g/L were suffered relatively higher risk rates of crude mortality, while optimal survival was observed in calves with STP concentrations > 65.0g/L (Table 16).

Similarly, the highest proportion of calves (87.5%) were died from the calves with STP concentrations 26.0-35.0g/L, while calves with STP concentrations $\leq$ 55g/L were generally had higher proportion of mortality (Table 17). On the other hand, optimum survival proportions were observed in calves with STP concentrations > 65.0g/L. The proportions of crude mortality in calves with STP concentrations 55.1-65.0g/L was 16.1% and was significantly higher, because a remarkable drop in proportions of crude mortality was observed in calves with STP

concentrations > 65.0g/L (Table 17). Similarly, Tyler, *et al.,* (1998) was reported optimal survival in calves with STP concentrations > 55g/L, while calves with STP concentrations 50-54g/L had only slightly increased proportions of mortality when compared to calves with STP concentrations > 55g/L. According to Donovan, *et al.,* (1998), the association of STP and mortality was quadratic and showed a dramatic decrease in mortality as STP concentration increased from 40.0 to 59.0g/L, but a small improvement in mortality at STP concentrations from 50.0 to 60.0g/L and virtually no improvement in mortality rates as STP increased over 60.0g/L.

Similarly, Tyler, *et al.,* (1999b) used population mortality and the relative risk of mortality in each serum protein concentration stratum to determine the population baseline mortality and the mortality due to inadequate passive transfer and observed that 39% of the observed mortality was attributed to inadequate passive transfer or FPT.

Furthermore, the greatest relative risk of mortality (RR = 5.3, 95% CI = 3.73-7.56) was observed in calves with STP concentrations 26.0-35.0g/L, while calves with STP concentrations 35.1-45.0 and 45.1-55.0g/L, generally had higher relative risks (RR= 2.24, 95% CI = 1.32-3.81 and 2.88, 95% CI = 1.86-4.39 respectively) compared to calves with STP concentration >55.0g/L indicating that calves with FPT, where STP concentrations were lower than 55.1g/L (Table 18) had increased relative risk of death. Similarly, Tyler, *et al.,* (1998) reported that the highest RR was experienced by calves with STP concentrations < 40g/L, while Rea, *et al.,* (1996) was observed the highest RR in calves with STP concentrations < 45g/L and concluded that calves with lower passive transfer values had increased risk of death.

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6. CONCLUSION AND RECOMMENDATION

The status of passive transfer of maternal immunity in the newborn calf can be estimated by measuring STP concentration during the first week of life. The proportion of dairy calves with failure of passive transfer of immunity that was found in this study was significantly higher. Among the risk factors that were considered to affect the acquisition of passive transfer of protective immunoglobulins, sex of the calf, parity number, attendant at parturation, and age of the calf at first colostrum ingestion were found to be significantly associated with FPT. The implications of the present findings are that, dairy calves are not receiving adequate quantity or quality of colostrum, or they may not receive the colostrum soon enough after birth.

The calf morbidity and mortality rates that were found in the present study were higher than economically tolerable limits. It was observed that the highest proportion of morbidity and mortality occurred during the neonatal period and in calves with FPT indicating that the status of passive transfer of protective immunoglobulins was the most important risk factor for the health and survival of the newborn dairy calves. Furthermore, early measurement of STP concentration is important for a good management of the newborn calves.

The associations of some factors like birth condition, methods of colostrum feeding, and birth site with FPT and morbidity and mortality were not clear, indicating the need for further investigations in order to have a more complete understanding of the factors that affect the incidence and severity of FPT of colostral immunity. Nevertheless, based on the findings of the present study, its worth to recommend that the newborn dairy calves deserve due attention at birth than anytime thereafter, with more vigilant farm policies and management practices that ensure the newborn calves have ingested sufficient amount of colostrum as soon after birth as possible.

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8. ANNEXES

Annex 1: Example of questionnaire formats

1. Farm description

1.1. Business name of the farm: _____

1.2. Address: Woreda _____ Kebele _____

House number _____ Telephone _____

1.3. Established (year): _____

1.4. Purpose of the farm (√): Dairy enterprise _____

Primary source of income _____

Secondary source of income ____

1.5. Owner and/or manager:

Name _____ Age ____ Sex ____

Living address (√): In the farm __ __ Separate___

Educational status (√): Non _____

Elementary ____

High school_____

Professional ____ Animal science related Y/N ____

1.6. Herd size, composition and breed

Cow: exotic _____ cross_____ local _____ Pregnant _____

Expected calving times _____

Heifers: exotic _____ cross_____ local _____

Bulls: exotic _____ cross_____ local _____

Calves: Males: 0-1 month: exotic _____ cross_____ local _____

2-3 months: exotic _____ cross_____ local _____

4-6 months: exotic _____ cross_____ local _____

7-9 months: exotic _____ cross_____ local _____

10-12 months: exotic _____ cross_____ local _____

Females: 0-1 month: exotic _____ cross_____ local _____

2-3 months: exotic _____ cross_____ local _____

4-6 months: exotic _____ cross_____ local _____

7-9 months: exotic _____ cross_____ local _____

10-12 months: exotic _____ cross_____ local _____

1.7. Where do replacement stocks come from? Home reared ___ Purchased ____

2. Calf health problems (last 12 months)

2.1. Number of calves born/purchased

Male: exotic _____ cross_____ local _____

Female: exotic _____ cross_____ local _____

2.2 Number of:

Late abortion (after 270 days of gestation): exotic ___ cross__ local ___

Stillbirth: exotic _____ cross_____ local _____

Died: Male: 0- 48 hours: exotic _____ cross_____ local _____

3-28 days: exotic _____ cross_____ local _____

29-90 days exotic _____ cross_____ local _____

91-180 days exotic _____ cross_____ local _____

181-360 days exotic _____ cross_____ local _____

Female: 0- 48 hours: exotic _____ cross_____ local _____

3-28 days: exotic _____ cross_____ local _____

29-90 days exotic _____ cross_____ local _____

91-180 days exotic _____ cross_____ local _____

181-360 days exotic _____ cross_____ local _____

2.3 Type of disease encountered/ treated

Diarrhea: Number of calves treated _____ died _____

Pneumonia: Number of calves treated _____ died _____

Both: Number of calves treated _____ died _____

Joint ill: Number of calves treated _____ died _____

Injury: Number of calves treated _____ died _____

Others: Number of calves treated _____ died _____

2.4. Use of medicated feed: Y/N _____

If yes, coccidiostat (specify) Y/N _____

Antibiotic (specify) Y/N _____

Mineral salt (specify) Y/N _____

Vitamins (specify) Y/N _____

Regular deworming Y/N

2.5. Vaccination program:

For late pregnant dam to enrich colostral antibodies Y/N _____

If yes, type and time of vaccination: _____

_____

_____

For newborn calves Y/N _____

If yes, type and time of vaccination: _____

_____

_____

3. Farm level factors that affect serum levels of circulating immunoglobulin and health

3.1. Management

3.1.1. General: Is there regular record keeping for individual animal: Y/N ____

Do you practice "All-in, all-out" principle: Y/N _____

If yes, calving season: from (month) _____ to _____

Policy of attending at calving: Y/N _____

3.1.2. Feeding

3.1.2.1. Colostrum

3.1.2.1.1. Do you think ingestion of colostrum by the newborn calf is:

Must _____

Important: ____

Not important at all _____

Why? _____

3.1.2.1.2. How soon is colostrum fed to the newborn calf at your farm

< 6 hours after birth _____

6-12 hours after birth _____

13- 24 hours after birth _____

> 24 hours after birth _____

3.1.2.1.3. When are the calves separated from their dam after birth?

Immediately, before nursing and licking (√) _____

Immediately after nursing (√) _____

2-12 hours after birth (√) _____

13-24 hours after birth (√) _____

2-4 days after birth (√) _____

3.1.2.1.4. Method of colostrum feeding of the farm

Natural suckling (√) _____

Hand feeding (√) _____

Feeding with bottle nipple (√) _____

Feeding with bucket (√) _____

Feeding with esophageal tube (√) _____

3.1.2.1.5. If natural suckling, how often the calf is allowed to suckle

Once every 6 hours (√) ___ for ____ days

Twice every 12 hours (√) ____ for _____ days

Twice every 24 hours (√) ____ for ____ days

Not limited (√) _____ for ___ days

3.1.2.1.6. If hand feeding:

Source of colostrum: The dam itself (√) _____

From any other fresh cow (√) _____

Pooled colostrum (√) _____

Frequency of feeding: _____ liters, every ____ hours, for ____ days or

____ liters for 1st feeding within ____ hours

____ liters for 2nd feeding within ____ hours

____ liters for 3rd feeding within ____ hours

____ liters for 4th feeding within ____ hours

3.1.2.1.7. Do you use: Colostrum replacers Y/N ____, Colostrum supplement Y/N ____

3.1.2.2.Feedind and provision of water

3.1.2.2.1. When do you stop feeding colostrum:

1 day after birth (√) _____

2 day after birth (√) _____

3 day after birth (√) _____

4 day after birth (√) _____

> 4 day after birth (√) _____

3.1.2.2.2. What do you feed after colostrum:

Milk for ____ days, _____ liters per day or ___% of body weight

Milk replacers for _ days, __ liters per day or __% of body weight

Feed supplementation other than milk or milk replacers:

Grazing (√): ___, for ____ hours per day

Concentrates (√): _, at __% of body weight or __Kg/day

Hay (√): ___, at ____% of body weight or ____Kg/day

Time of introduction of this supplement: _ days after birth

3.1.2.2.3. Water provision: Free access Y/N _____

If no, then how (specify) _____

Frequency (√): Once _, Twice ___ >Trice___ /day

3.1.2.2.4. Weaning age in the farm: < 5 weeks(√) ___,

5-8 weeks(√) ___,

8-12 weeks(√) ___,

> 12 weeks(√) ___,

3.1.3. Farm personnel caring for calves:

Owner (M/F): ____ for _____ years

Owner's wife(√): ____ for _____ years

Children/relatives (M/F): ____ for _____ years

Hired (M/F): ____ for _____ years

If hired: Permanent employee (M/F): ____ for _____ years

Daily laborer (M/F): ____ for _____ days/months/years

3.2. Environment

3.2.1. Housing: Preweaning: Individual pen in barn(√) ___,

Group pen in barn(√) ___,

Outdoor in individual pen(√) ___,

Outdoor in group pen(√) ___,

Tethered(√) ___,

Postweaning: Individual pen in barn(√) ___,

Group pen in barn(√) ___,

Outdoor in individual pen(√) ___,

Outdoor in group pen(√) ___,

Tethered(√) ___,

Mixing of calves with different ages Y/N _____

Type of floor(√): Earth ____ Metal ___ Concrete ____ Wood ____

Bedding Y/N _____

If yes, how often do you change(√): > Once/week once/week_<Once/week

3.2.2. Hygiene: Method of cleaning

Sweeping only(√): _____

Sweeping and washing(√): _____

Washing and disinfection(√): _____

Frequency of cleaning: Daily(√): _____

Weekly(√): _____

Every two weeks(√): _____

> every two weeks(√): _____

Drainage system Y/N _____

Do you have separate maternity facilities Y/N: _____

If yes, multiple cow(√)____, individual cow(√)_____

Cleaning between parturitions Y/N _____

If yes, Sweeping only(√): _____

Sweeping and washing(√): _____

Washing and disinfection(√): _____

3.2.3. Ventilation Y/N: _____

Annex 2. Calf card format

4. Calf level factors that affect serum levels of circulating immunoglobulins and health

4.1. Genealogy and periparturient care

Name of the farm: _____

Calf identification number: _____ Sex (M/F) _____

Birth day_____

Time of birth: Night(√): _____ Day (√): _____

Site of birth: The same cow barn (√): _____ Calving pen (√): _____

Attendance at birth: Present (√): _____ Not present (√): _____

Condition of birth: Normal (√): ___ Minor assistance (√): ___ Dystocia (√): __

Birth weight: _____

Parity of the dam: 1st birth (√): __ 2nd birth (√): __ 3rd birth (√): __ ≥4th (√): __

Exotic blood level: <50% (√): ___ 50-75% (√): ___ >75% (√): __ Local (√): __

Navel disinfection: Yes (√): _____ No (√): _____

If yes, chemical used: _____

4.2. Colostrum feeding:

Time of 1st ingestion after birth(√): <6hrs _ 6-12hrs ___ 13-24hrs__ >24hrs__

Method of feeding(√): Hand feeding _____ Natural suckling _____

If hand fed, using (√): Bottle nipple ___ Esophageal tube ___ Bucket __

Source (√): Own dam ____ Another fresh cow _____ Pooled _____

If pooled, method of (specify): Preservation ____ Thawing _____

If natural suckling, number of days stayed with the dam _____

Amount ingested:

1st ____ liters within ____ hrs after birth

2nd ____ liters within ____ hrs after birth

3rd ____ liters within ____ hrs after birth

4th ____ liters within ____ hrs after birth

5th ____ liters within ____ hrs after birth

When did the calf separated from its dam (specify)

Immediately, before nursing and licking (√) _____

Immediately after nursing (√) _____

2-12 hours after birth (√) _____

13-24 hours after birth (√) _____

2-4 days after birth (√) _____

4.3. Sampling:

Type(√): Serum __ PCV __ Blood smear __ Faeces __ Nasal swab __ Other __

Day of sampling (Specify): _____

Incidence of disease before and/or at sampling

(specify):_____

4.4. Feeding and provision of water

Type of liquid feed(LF) given (√): Milk ____ Milk replacers ___Whey __

Time of introduction of liquid feed(specify): _____

Time of introduction of non-liquid feed(NLF)__ days after birth Type ____

Amount of LF before introduction of NLF: ____ liters/day in _____ feedings

Amount of NLF: _____Kg/day in _____ feedings

Provision of water(√):Free access __ Limited __ Provided(specify)__ times/day

4.5. Weaning age(specify): _____

4.6. Housing type(√): The same with the adults ____ Separate _____ Group calves ____

Bedding Y/N: _____

4.7. Case incidence record

Vaccination Y/N _____, If yes type_____ Date _____

Date of appearance of clinical symptoms(specify): _____

Major clinical symptoms(specify): _____

_____

_____

Diagnosis: _____

Treatment: _____

Outcome of treatment: _____

Annex 3. Criteria for clinical diagnosis of calf sickness

Health condition	Clinical signs
Diarrhea	Semi formed feces with increased frequency
	Watery feces with increased frequency
	Watery feces with mucous and increased frequency
	Blood in feces
Pneumonia	Frequent coughing with or without respiratory discharge
	Heavy thoracic breathing
	Abdominal breathing
Septicemic condition	Depressed
	Nonresponsive
	Anorexia and fever without any distinct involvement of specific body system
Navel ill	Swelling, heat, and pain of umbilical cord with or without abscess formation
Joint ill	Swelling, heat, pain and lameness with abscess formation in any one or all limbs and could or could not be preceded by other disease condition

Adopted from Berge *et al*., (2005)

Annex 4. Potential risk factors considered in the analysis with their categories

S/N	Variables	Codes and description
1	**Calf factors**	
	Birth time (BT)	0 = Night
		1 = Day
	Birth condition (BC)	0 = Dystocia
		1 = Normal
	Sex	0 = Male
		1 = Female
	Status of passive transfer	0 = FPT
		1 = APT
	Age	0 = <= 3 months
		1 = > 3 months
2	**Dam factors**	
	Parity number	0 = Calves born from 1st & 2nd calving heifers
		1 = Calves 3rd & above calving cows
	Vaccination prior to parturation[1]	0 = No
		1 = Yes
3	**Management factors**	
	Birth site (BS)	0 = Calving within the same barn
		1 = Calving in separate calving pen
	Method of colostrum feeding	0 = Sucking
	(MCF)	1 = Hand feeding
	Age at first colostrum ingestion	0 = > 6hrs after birth
	(AFCI)	1 = Within 6hrs after birth
	Source of colostrum (SC)	0 = Pooled
		1 = From owned dam

Annex – Continued

S/N	Variables	Codes and Descriptions
	Housing	0 = The same barn with cows
		1 = Separate calf pen
	Attendant at parturation	0 = Absent
		1 = Present
	Weaning age	0 = <= 3 months
		1 = > 3 months
	Time of introduction of additional	0 = <= 3 weeks
	feed	1 = > 3 weeks
	Amount of milk fed daily	0 = < 4 liters
		1 = >= 4 liters
4	**Farm level factors**	
	Farm ownership	0 = GOV
		1 = Private
	Purpose of the farm	0 = Foe additional income
		1 = Main income/commercial
	Age of the farm	0 = < 5 years
		1 = >= 5 years
	Calf caretaker	0 = Hired
		1 = owner
	Knowledge of Calf Caretaker about the	0 = No
	Importance of colostrum	1 = Yes
	Herd size	0 = >= 5 calving per year
		1 = < calving per year

Annex 5. Descriptive statistics of STP

S/N	Variables	Component	No	Measures						p-value
				Mean	Median	Min	Max	SD	Skewness	
1	Sex	Male	165	6.45	6.75	2.88	9.96	1.740	-0.04	0.02
		Female	189	6.81	6.78	3.55	9.98	1.579	0.08	
2	Parity	Heifer calf	122	5.20	5.28	2.88	7.76	1.081	0.24	0.00
		Cow calf	232	7.40	7.49	3.05	9.98	1.394	-0.33	
3	Birth time	Night	131	5.61	5.39	2.88	9.96	1.621	0.57	0.00
		Day	223	7.25	7.26	4.20	9.98	1.363	0.12	
4	Attendant	Absent	60	4.80	4.98	2.88	6.18	0.881	-0.68	0.00
		Present	294	7.02	6.98	3.05	9.98	1.530	-0.15	
5	TFCI	>6hrs	171	5.96	5.45	2.88	9.98	1.805	0.51	0.00
		<6hrs	183	7.28	7.10	4.71	9.97	1.212	0.33	
6	Birth condition	Dystocia	45	5.04	4.97	2.88	7.77	1.302	0.26	0.00
		Normal	309	6.88	6.87	2.99	9.98	1.581	-0.04	
7	MCF	Suck	266	6.66	6.79	2.88	9.98	1.669	-0.04	0.72
		Hand	88	6.59	6.53	3.21	9.97	1.654	0.07	
8	Birth site	Same barn	267	6.80	6.82	2.98	9.98	1.583	-0.04	0.00
		Calving pen	87	6.16	5.53	2.88	9.96	1.813	0.25	
9	SC	Pooled	70	5.05	4.74	2.88	7.79	1.492	0.64	0.00
		Own	284	7.04	6.94	4.07	9.98	1.458	0.14	
10	Health status	Sick	165	5.76	5.44	2.88	9.93	1.627	0.72	0.00
		Healthy	189	7.42	7.43	3.55	9.98	1.263	-0.10	
11	Outcome	Died	64	5.29	5.11	2.88	9.96	1.570	0.97	0.00
		Survive	290	6.94	6.94	3.21	9.98	1.533	-0.08	
12	Diarrhea		85	5.76	5.55	2.88	9.93	1.779	0.43	0.00
13	Pneumonia		36	5.22	5.12	3.45	9.29	1.282	1.36	0.00
14	Others		44	6.20	5.48	4.74	9.90	1.461	1.42	0.03
15	Total		354	6.64	6.77	2.88	9.98	1.663	-0.01	

Annex 6. Simple association between risk factors and status of passive transfer

S/N	Variables	Category	FPT	APT	OR	95% CI	AR
1	Sex	Male	64	101	2.27	1.22-4.22	0.20
		Female	42	147			
2	Parity	1st & 2nd calf heifer	86	36	23.59	10.52-52.90	0.64
		3rd & above calf cows	20	212			
3	BT	Night	78	53	10.04	4.95-20.36	0.51
		Day	28	195			
4	Attendant	Absent	50	10	20.81	10.11-42.86	0.64
		Present	56	238			
5	AFCI	> 6hrs after birth	94	77	16.24	6.85-38.50	0.56
		Within 6hrs after birth	12	171			
6	BC	Dystocia	32	13	7.75	4.13-14.56	0.47
		Normal	74	235			
7	MCF	Suckling	82	184	1.22	0.66-2.24	0.05
		Hand feeding	24	64			
8	BS	Within the same barn	63	204	0.33	0.18-0.60	-0.27
		Separate calving pen	43	44			
9	SC	Pooled	49	21	9.33	4.87-17.89	0.51
		From own dam	57	227			

Annex 7 Adjusted Odds Ratio for factors associated with FPT

Variable	Component	FPT	APT	OR	95% CI	X^2	p-value
Sex	Male	64	101	3.770	1.609-8.831	9.401	<0.05
	Female	42	147				
Parity	1&2	86	36	14.566	6.269-33.841	39.059	<0.001
	>2	20	212				
BT	Night	78	53	2.049	0.792-5.300	2.203	>0.05
	Day	28	195				
Attendant	Absent	50	10	4.396	1.475-13.099	7.114	<0.05
	Present	56	238				
AFCI	>6hrs	94	77	7.178	2.560-20.125	14.139	<0.001
	<6hrs	12	171				
BC	Dystocia	32	13	2.912	0.865-9.809	2.998	>0.05
	Normal	74	235				
MCF	Suck	82	184	1.012	0.401-2.558	0.001	>0.05
	Hand	24	64				
BS	Same	63	204	0.433	0.176-1.065	3.348	>0.05
	C pen	43	44				
SC	Pooled	49	21	0.140	0.051-0.384	14.639	<0.001
	Own	57	227				

Annex 8 Univariate analysis of risk factors of morbidity

Variable	Component	Sick	Healthy	OR	95% CI	X^2	p-value
STP	FPT	94	13	**17.92**	9.4-34.1	77.6	<0.001
	APT	71	176				
Sex	Male			**1.82**	1.2-2.8	7.76	**<0.05**
	Female	90	75				
Parity	Heifer calf	75	114	**4.91**	3.0-7.9	42.53	**<0.001**
	Cow calf	87	35				
BT	Night	87	44	**3.68**	2.3-5.8	31.37	**<0.001**
	Day	78	145				
Attendant	Absent	52	8	**10.41**	4.8-22.8	34.44	**<0.001**
	Present	113	181				
AFCI	>6hrs	108	63	**3.79**	2.4-5.9	35.02	**<0.001**
	<6hrs	57	126				
BC	Dystocia	32	13	**3.26**	1.6-6.5	11.47	**<0.001**
	Normal	133	176				
MCF	Suck	123	143	**0.94**	0.6-1.5	**0.81**	**0.94**
	Hand	42	46				
BS	Same	116	151	**0.60**	0.4-1.0	4.33	**<0.05**
	C pen	49	38				
SC	Pooled	115	169	**0.27**	0.2-0.5	19.99	**<0.05**
	Own	50	20				

Annex 9. Univariate analysis of risk factors of crude mortality

Variable	Component	Died	Survive	OR	95% CI	X^2	p-value
STP	FPT	44	63	7.9	4.4-14.4	46.1	<0.001
	APT	20	227				
Sex	Male	44	121	3.1	1.7-5.5	14.5	<0.001
	Female	20	169				
Parity	Heifer calf	38	84	3.6	2.0-6.3	19.9	<0.001
	Cow-calf	26	206				
BT	Night	32	99	2.0	1.1-3.3	5.5	<0.05
	Day	32	191				
Attendant	Absent	20	40	2.8	1.5-5.3	10.7	<0.001
	Present	44	250				
AFCI	>6hrs	45	126	3.1	1.7-5.5	14.3	<0.001
	<6hrs	19	164				
BC	Dystocia	18	27	3.8	1.9-7.5	15.1	<0.001
	Normal	46	263				
MCF	Suck	51	215	1.4	0.7-2.7	0.85	>0.05
	Hand	13	75				
BS	Same	45	222	0.72	0.39-1.3	1.1	>0.05
	C pen	19	68				
SC	Pooled	40	244	0.31	0.17-0.57	14.5	<0.001
	Own	24	46				
Age at onset of Morbidity	<=3 months	61	95	41.7	12.7-137.0	38.1	<0.001
	>3 months	3	195				

Annex 10. Multivariate analysis of risk factors of crude mortality

Variable	Component	Died	Survive	OR	95% CI	X^2	p-value
STP	FPT	44	63	3.1	1.4-9.2	12.32	<0.001
	APT	20	227				
Sex	Male	44	121	2.7	1.25-5.65	6.48	<0.05
	Female	20	169				
Parity	1&2	38	84	1.09	0.45-2.62	0.03	>0.05
	>2	26	206				
BT	Night	32	99	0.35	0.13-0.92	4.51	<0.05
	Day	32	191				
Attendant	Absent	20	40	0.36	0.15-0.87	5.16	<0.05
	Present	44	250				
AFCI	>6hrs	45	126	1.32	0.46-3.78	0.27	>0.05
	<6hrs	19	164				
BC	Dystocia	18	27	1.53	0.60-3.86	0.81	>0.05
	Normal	46	263				
MCF	Suck	51	215	2.10	0.88-5.03	2.80	>0.05
	Hand	13	75				
BS	Same	45	222	1.19	0.53-2.68	0.18	>0.05
	C pen	19	68				
SC	Pooled	40	244	1.12	0.46-2.69	0.06	>0.05
	Own	24	46				
Age at onset of Morbidity	<=3 months	61	95	27.24	7.64-97.13	26.14	<0.001
	>3 months	3	195				

Annex 11. CRRICULUM VITAE

1. Personal identification

Name: Ahmed Ibrahim Mussa

Date of birth: 16 June 1967

Place of birth: Dire Dawa

Sex: Male

Marital status: Married with 3 children

Nationality: Ethiopian

Language:

Language	Hearing	Speaking	Reading	Writing
Oromiffaa	✓	✓	✓	✓
Amharic	✓	✓	✓	✓
Somali	✓	✓	✓	✓
English	✓	✓	✓	✓
Arabic	✓	✓	✓	
French	✓	✓	✓	

Occupation: Animal health team leader, Oromia Agricultural and Rural Development Bureau

Address: hrvl@telecom.net.et

2. Education

Education level	Year	Schools	Awards
Primary education	1975-1978	Afata isa Primary School, Dire Dawa	Primary school certificate
Junior education	1979-1980	Laga harre junior secondary school, Dire Dawa	Junior school certificate
Secondary education	1981-1984	Dire Dawa comprehensive secondary school, Dire Dawa	ESLCE certificate
Higher education	1985-1990	Faculty of Veterinary Medicine, AAU, Debre Zeit	DVM degree
Post graduate education	2006-2007	Faculty of Veterinary Medicine, AAU, Debre Zeit	Msc degree in TVE

3. Work experience

3.1. From 1991-1993: Field veterinarian and district animal health team leader, Mi`eso woreda agricultural office, Western Hararghe, Oromia region.

3.2. From 1994-1996: Zonal animal and fisheries resources development team leader, Western Hararghe Zonal Agricultural Development Department.

3.3. From 1997-2000: Pathology department head, Asella Regional Veterinary Laboratory, Oromia Agricultural Development Bureau.

3.4. From 2001-2006: Head, Hirna Regional Veterinary Laboratory, Oromia Agricultural and Rural Development Bureau

3.5. From 2007- Regional animal health team leader, Oromia Agricultural and Rural Development Bureau, Addis Ababa.

4. Scientific papers

4.1. Prevalence of *Cysticecus bovis* in animals slaughtered in Nekemt municipality slaughter house (1991), DVM thesis.

4.2. Mass death of game birds around Lega dambi gold mining project (1999), Proceeding of Annual Conference of Ethiopian Veterinarians Association, EVA, June, 1999. Addis Ababa, Ethiopia.

4.3. Epidemiology of *Bovine Cysticercosis* in Eastern Wollega zone (2000), Proceeding of Annual Conference of Ethiopian Veterinarians Association, EVA, June, 2000. Addis Ababa, Ethiopia.

4.4. Epidemiology of dairy calves diseases (2006), Seminar on current topics on livestock production and development, Faculty of Veterinary Medicine AAU, Debre Zeit.

4.5. Effect of failure of passive transfer of immunity on crude morbidity and mortality in dairy calves (2007), MSc thesis, Faculty of Veterinary Medicine, AAU, Debre Zeit.

5. Reference:

Dr. Alemayehu Lemma:	Faculty of Veterinary Medicine AAU, Debre Zeit.
Dr. Muktar Rashid:	FAO, Addis Ababa
Profs. Getachew Abebe:	FAO, Addis Ababa

Annex 12. 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 _____

Signature _____

Date of submission _____

Advisors

3. Prof. G. Gupta _____
4. Dr. Alemayehu Lemma _____

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

_____

_____

_____