Keeping your Calves Healthy

Ken E. Leslie and Cynthia G. Todd

Department of Population Medicine, University of Guelph, Guelph, ON N1G 2W1
Email: keleslie@ovc.uoguelph.ca

■ Take Home Messages

- Success of the calving event
  - Calves that survive a difficult calving are at an increased risk of common health problems.
  - Increased emphasis on calving ease is needed

- Appropriate colostrum management
  - Approximately 40%of dairy calves have failure of successful transfer of immunity from the colostrum
  - Improvements in the timing, quantity, quality and cleanliness of colostrum delivery are greatly needed
  - Monitoring of calf serum total solids levels in the first week of life is an effective means of evaluating colostrum management

- Minimize pathogen and environmental exposure
  - Colostrum handling is a critical step in the prevention of exposure to pathogens
  - Risk factors for exposure to Cryptosporidia parvum have been well described

- Provide sufficient nutrition
  - *Ad libitum* feeding of acidified milk shows considerable promise for appropriate nutrition of dairy calves

- Management of the sick calf
  - Programs for the early recognition and treatment of calf disease need continual review and enhancement
  - Appropriate intervention with oral electrolyte, antibiotic and non-steroidal anti-inflammatory drug therapy is essential

- Avoid multiple stressors
  - Reduction of stressors at dehorning, weaning and grouping can result in significant reductions in disease

▪ Introduction

Successful raising of dairy calves is a challenge. Many dairy producers struggle with keeping their young calves healthy. The high-risk period for calf morbidity and mortality occurs during the first three weeks of life (Waltner-Toews *et al.*, 1986; Curtis *et al.*, 1988; Wells *et al.*, 1996). The neonatal period is a critical time in the life of a dairy calf, as they are adapting to a new environment and facing exposure to several disease-causing pathogens. Furthermore, the adaptive immunity of neonatal calves has not yet been established. Thus, newborn calves are reliant on maternal immunoglobulins in colostrum for protection against infectious disease.

There are several management, environmental, and nutritional factors that influence calf morbidity and mortality. The aim of this paper is to provide insight on how to keep your calves healthy, with a specific focus on the young calf. First, major diseases of neonatal dairy calves will be described. Recent research findings relating to management of the young dairy calf will be reviewed. Finally, several specific management practices and tips that will improve calf health are discussed.

▪ Neonatal Calf Disease

The major health problems of young dairy calves include neonatal calf diarrhea complex, respiratory disease, umbilical infections, joint problems and septicemia. Several large-scale studies have described the incidence risk and calf mortality for these common calfhood diseases (Waltner-Toews *et al.*, 1986; Curtis *et al.*, 1988; Wells *et al.*, 1996; Donovan *et al.*, 1998; NAHMS, 2002; Svensson *et al*. 2003) (Table 1).

The main diarrhea-causing pathogens include enterotoxigenic *Escherichia coli* (ETEC) K99 (F5), *Salmonella*, rotavirus, coronavirus, and *Cryptosporidium parvum*. Calves are at highest risk of ETEC K99 (F5) diarrhea during the first few days of life. Salmonellosis can occur in calves throughout the neonatal period and is often associated with a high mortality rate. Viral infections and cryptosporidiosis are very common in calves and typically occur between one and three weeks of age. In addition, it is well recognized that outbreaks of calf diarrhea are usually associated with more than one pathogen (Constable, 2004). Respiratory disease is typically seen shortly after weaning or during the introduction to group housing, but can also be a health problem among

Table 1: Incidence risks for mortality, diarrhea, respiratory disease, umbilical and joint problems, and septicemia

		Incidence Risk (%)				
	Study Period	Mortality	Diarrhea	Respiratory Disease	Umbilical/Joint Problems	Septicemia
Waltner-Toews et al. (1986)	**pre-weaned**	3.76 %	20.5 %	15.4 %	**not reported**	**not reported**
Virtala et al. (1996)	**0 to 3-mths**	5.6 %	28.8 %	17.3 %	0.002 to 15.1 %	**not reported**
Donovan et al. (1998)	**0 to 6-mths**	11.7 %	35.0 %	21.0 %	11.0 %	24.0 %
NAHMS (2002)	**pre-weaned**	8.7 %	**not reported**	**not reported**	**not reported**	**not reported**
Svensson et al. (2003)	**0 to 3-mths**	3.0 %	9.8 %	7.0 %	0.6 to 13.0 %	**not reported**

neonatal calves. Table 1 suggests that 10 to 20% of young calves develop respiratory disease.

Joint and umbilical problems are also noteworthy causes of neonatal illness and calf death. Septic arthritis occurs in young calves as a result of a bacterial infection in the joint. The route of infection is often via the umbilicus or umbilical veins. The risk of septic arthritis is quite low, as less than one percent of young calves develop this health problem. However, approximately 10 to 15% of young calves develop umbilical infections (Table 1). Calves can also suffer umbilical hernias, in that the umbilicus fails to close after birth. In dairy heifer calves less than three months of age, Virtala *et al.* (1996) reported that the risk of umbilical hernia was 15.1%. The authors of this study acknowledged that a few of the participating farms were high-risk herds for umbilical hernia and this may have contributed to the elevated incidence of hernia in this study. As a follow-up to this research, Steenholdt and Hernandez (2004) conducted a case-control study to determine risk factors for umbilical hernia in calves less than two months of age. The case and control calves for this study were obtained from a university dairy research herd that had historically had hernia problems among their young calf population. This study demonstrated that there is a hereditary component to umbilical hernias. Calves sired from bulls that had more than two within-herd progeny with herniated navels had a 2.31-fold greater risk of developing a hernia. The risk of umbilical hernia was also 5.65 times greater among calves with an umbilical infection. In addition, a German study of calves at auction houses reported that there is a higher incidence of umbilical hernia in male calves and calves of multiple births (Hermann *et al.,* 2001).

Septicemia is a condition that is commonly observed in calves with diarrhea or umbilical infections, as pathogenic organisms can gain entry to circulation via the damaged intestinal mucosa or the umbilicus. Calves are at highest risk of developing septicemia during the first week of life. Donovan *et al.* (1998) followed a population of dairy calves until six months of age and found that 24% of calves developed septicemia. Among this cohort of calves, septicemia was a significant health problem and the primary cause of calf death. However, anecdotal evidence would suggest that typically less than 5% of young dairy calves develop septicemia.

▪ Success of the Calving Event

Dystocia and stillbirths have become a major concern to the dairy cattle industry. Various studies have documented the actual rates for stillborn calves. It is also clear that this problem exists on a worldwide basis. Most reports are somewhere between 10% and 20% stillbirth with first calf-heifers, especially in the Holstein breed.

A few studies have examined the behavioural changes that occur in periparturient cows. In the 12 hours before calving, cows show an increase in semilateral recumbency, as well as an increase in the frequency of lying down and standing, with short duration of standing and lying bouts. Cows that show prolonged restlessness, cessation of labour or lack of appearance of the calf's feet are more likely to present with a difficult delivery. Also, the calves born during difficult deliveries take longer to stand, and subsequently nurse. Preliminary research in Colorado has examined the effects of dystocia on subsequent calf health. Calves born during a difficult calving had a higher rate of morbidity and mortality from neonatal calf disease.

▪ Appropriate Colostrum Management

Ruminants are unique in that the placenta of the dam does not permit the transfer of immunoglobulin from the bloodstream of the cow to the fetus. As such, the newborn calf is born with a functionally immature immune system and is unable to mount an adaptive immune response. Thus, for the first few weeks of life, until the calf's own immune system is able to develop, the neonatal calf is dependent on passive immunity to protect against disease challenge. Passive immunity is acquired by the calf through ingestion and absorption of a sufficient quantity of colostral immunoglobulins.

Colostrum is the first secretion from the mammary gland after parturition, and is a rich source of immunoglobulins, nutrients, leukocytes, enzymes, growth factors, and hormones. The single most important factor in calf management is ensuring that newborn calves consume good quality colostrum within a few hours of birth. Wells *et al.* (1996) reported that the risk of mortality was many times higher among calves that received no colostrum versus those that consumed greater than 2 L of colostrum within 6 hours of birth.

Timing of colostrum feeding is also extremely important. The newborn calf must receive colostrum as early as possible after birth because the capacity of the gastrointestinal tract to absorb immunoglobulins decreases very rapidly. The calf's immunoglobulin absorptive capacity at 6 and 8 hours after birth has a reduced capacity of 50% and 33%, respectively. By 24 hours after birth, the gastrointestinal tract has closed and is no longer permeable to immunoglobulin and other macromolecules (Rischen, 1981, as cited by Cortese, 2005). McGuirk (2002) recommends that it would be ideal for each calf to be fed 3 to 4 L of good quality colostrum within the first hour of life. Although this recommendation is not feasible to achieve in all dairy herd management situations, it is becoming clear that achieving this thumb rule represents a great opportunity for improvement in calf health.

A number of factors influence colostrum quality, such as breed and age of cow. However, colostral immunoglobulin content is highly variable, even between animals of the same breed. Compared to multiparous cows, first and second lactation animals tend to produce colostrum with lower immunoglobulin concentrations (Tyler *et al.,* 1999; Moore *et al*., 2005). Grusenmeyer *et a*l. (2005) have studied the effect of dry period length on colostrum quality and reported no significant difference in immunoglobulin G content of colostrum from cows with a 40-day versus 58-day dry period. However, cows with the shortened dry period produced 2 kg less colostrum than those with the longer dry period. There is also an association between colostrum quality and timing of collection. Moore *et al.* (2001) found that mean colostral immunoglobulin G concentrations at 2, 6, 10, and 14 hours after calving were 113, 94, 82 and 76 g/L, respectively. In order to ensure maximum colostral immunoglobulin content, it is important to harvest colostrum early, if not immediately, after parturition.

Dairy producers should strive to feed newborn calves only good quality colostrum. As such, on-farm methods are needed for assessing colostrum quality rapidly and accurately. Colostrum appearance is not predictive of colostrum quality. Some individuals support the '18 Pound Rule', in which the volume of colostrum from the first milking is used as an estimate of colostrum quality. This guideline suggests that there is a dilution effect, in that cows producing more than 18 lb of colostrum are more likely to have poor quality colostrum than lower-yielding animals. However, the utility of this rule of thumb is very debatable. The results of two recent studies provide evidence against the dilution concept (Grusenmeyer *et al.* 2005 and Moore *et al.* 2005). The hydrometer and the Midland Quick Test are two products available for colostrum quality assessment. The hydrometer is an inexpensive instrument that measures specific gravity as an indicator of colostral immunoglobulin concentration. However, Morin *et al.* (2005) have established that colostral specific gravity is more strongly correlated with colostral protein concentration than immunoglobulin concentration. In addition, temperature can greatly influence the accuracy of the hydrometer, as colostrum must be tested at room temperature. Development of a validated instrument for the rapid, inexpensive determination of colostrum immunoglobulin content would be very useful.

The success of passive transfer of maternal immunoglobulins and the colostrum management program can be monitored by testing neonatal calves for serum total solids (TS) concentrations. Refractometry can be used to measure serum TS concentration, which provides an indication of the level of immunoglobulin in the blood of the calf.

Recently, a large-scale research effort was completed to determine the levels of passive immunity, as measured by serum TS concentrations, in 422 calves up to one week of age on 119 southern Ontario dairy farms (Trotz-William *et al*, 2006). In this study, 39.8% of calves showed failure of passive transfer (FPT) (Figure 1). Failure of passive transfer was defined as a TS concentration less than 5.2 g/dL. In addition, a calf-level study of 1383 calves on 11 farms was used to identify management practices that are associated with lower and higher TS levels in dairy calves. Several management factors were significantly associated with calf serum TS concentrations (Table 2).

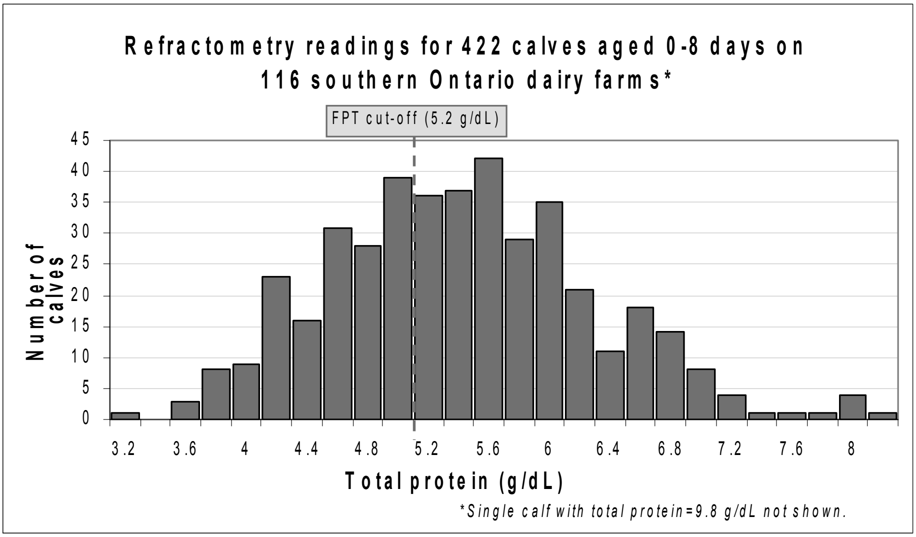

Figure 1: Refractometry results for 422 calves on 116 southern Ontario dairy farms.

■ Minimize Pathogen and Environmental Exposure

Producers need to recognize that a good colostrum delivery program cannot completely overcome poor environmental conditions and management. Good environmental hygiene of the calving area, as well as early separation of the calf and dam, can reduce the calf challenge from disease-causing organisms. Removal of bedding material and disinfection of maternity pens between uses are best management practices that decrease the risk of build-up and spread of infectious pathogens (Davis and Drackley, 1998). An optimum time for separation of the calf and cow has not been established, but it is recommended that the calf be removed from the maternity pen as soon as possible after birth.

Table 2: Calf management practices statistically associated with calf serum TS levels

Management method	P value	Nature of association
Time of calf's birth	<0.01	Calves born 6 am to 12 noon had the **highest** serum total protein levels. Levels in calves born 6 pm to 12 midnight were lower, whereas levels were **lowest** in calves born 12 midnight to 6 am and those born 12 noon to 6 pm.
Time calf allowed to remain with dam	<0.001	Calves allowed to remain with their dams for 1 hour or more after birth had significantly **higher** total protein readings than calves that were separated from their dams within 1 hour of birth
Quantity of colostrum given to calf within 6 hours of birth	<0.001	Calves reported to have been given more colostrum within the first 6 hours of birth were found to have significantly **lower** serum protein levels than those given less.
Feeding of colostrum from mother	<0.001	Calves fed colostrum taken from their mothers had significantly **higher** levels of serum total protein than calves that had not been fed colostrum from their mothers.
Feeding of pooled colostrum	<0.001	Calves fed pooled colostrum had significantly **lower** total protein readings than those that had not been fed pooled colostrum
Feeding of fresh colostrum	<0.001	Calves fed fresh colostrum had significantly **lower** levels of total serum protein than those that had not been fed fresh colostrum
Feeding of frozen colostrum	<0.001	Calves fed frozen colostrum showed significantly **higher** serum protein levels than calves that had not been fed frozen colostrum
Feeding of colostrum by esophageal tube	<0.001	Calves fed colostrum by tube had significantly **lower** serum protein readings than those that had not been fed colostrum by tube.
Feeding of colostrum by bottle	<0.001	Calves fed colostrum by bottle had significantly **higher** levels of serum total protein than those that had not been bottle-fed.

Colostrum can be a major way of transmitting infectious organisms to calves. Hence, colostrum bacterial quality cannot be overlooked. A number of management practices should be adopted in order to limit the potential for pathogen contamination of colostrum. Appropriate udder preparation techniques should be used during colostrum collection. Furthermore, colostrum should be harvested using sanitized milking equipment and storage containers. Storage conditions greatly impact colostrum bacterial quality. Colostrum stored at temperatures greater than 17^0C will support bacterial growth, and coliforms can double in number every 20 minutes (Bertoldo, 2005). As such, freshly collected colostrum needs to be cooled very rapidly. Bertoldo (2005) recommends that frozen water jugs be placed in the colostrum collection containers to help facilitate the cooling process and to limit pathogen growth. Pasteurization has been presented as an alternative technology to reduce the concentration of viable pathogens in colostrum. Nevertheless, there are several drawbacks associated with this technology. First, pasteurization of colostrum results in a thicken end product, making cleaning the feeding and mixing equipment difficult. Furthermore, pasteurized colostrum has significantly lower immunoglobulin content than fresh colostrum, as the pasteurization process degrades important immune factors. The loss of colostral immunoglobulin is reduced when colostrum is pasteurized in smaller (such as 57 L versus 95 L) batches (Godden *et al.*, 2003). More recently, Godden (2005) recommends that dairy producers should only consider implementing an on-farm colostrum pasteurization program if good colostrum management practices are in place, a supply of high quality colostrum is always available, and the program/end product can be monitored on an on-going basis. Hence, pasteurization has more utility for biosecurity purposes that for limiting bacterial contamination.

As described above, there are several pathogens that can cause disease in young calves. Neonatal calf diarrhea complex is a leading cause of disease in young calves. A major research focus of the University of Guelph dairy research program has been on neonatal calf diarrhea complex and cryptosporidiosis in calves. *Cryptosporidium parvum* is an important zoonotic pathogen among dairy calves. A prevalence study conducted in southwestern Ontario during 2002 indicated that approximately 41% of dairy calves (n=500) between 7 and 21 days of age were shedding *C. parvum* oocysts in the feces (Trotz-Williams *et al.*, 2005_a). The within-herd prevalence of cryptosporidiosis was highly variable, as zero to 70% of dairy calves on the study farms were shedding *C. parvum* oocysts. Furthermore, calves shedding *C. parvum* were three times more likely to present with clinical signs of diarrhea.

Two follow-up studies were conducted to investigate calf-level risk of *C. parvum* shedding and diarrhea, as well as farm characteristics and management practices associated with within-herd prevalence of cryptosporidiosis (Trotz-Williams et al., 2007_a; Trotz-Williams et al., 2007_b). In the calf-level risk factor study (Trotz-Williams et al., 2007_a), 78% of calves less than 30 days of age were detected as shedding *C. parvum* (n=1045 calves from 11 farms). The within-herd prevalence of *C. parvum* shedding ranged from 35% to 100%. Calf factors significantly associated with *C. parvum* infection included feeding of milk replacer, maternity pen facilities and calf scour prophylaxis in cows (Table 3). Furthermore, factors associated with diarrhea in calves included season of birth, shedding of *C. parvum* oocysts, intensity of *C. parvum* shedding, time to separation from dam, and colostrum source (Table 3).

In the herd-level risk factor study (Trotz-Williams et al., 2007b$_b$), 30% of calves were shedding *C. parvum* oocysts in the feces and at least one positive calf was detected on 77% of the study farms (n=1089 calves from 119 herds). The within-herd prevalence of *C. parvum* infection ranged from zero to 80%. Factors that were significantly associated with increased risk of cryptosporidiosis included the use of scour prophylaxis in cows and calves, as well as the feeding of milk replacer during the first week of life. Concrete flooring in calf housing areas and the use of soap or detergent to wash calf feeding utensils were associated with a reduced risk of *C. parvum* infection.

▪ Provide Sufficient Nutrition

Providing for the calf's nutritional requirements is an important aspect of successful calf management. As early as one to two days of age, calves should be offered *ad libitum* calf starter ration. High quality feedstuffs, such as calf starter ration, are very appealing and palatable to the young calf. These feedstuffs are a rich source of non-structural carbohydrates, which are rapidly fermented to volatile fatty acids and promote ruminal development. Establishment of the rumen microbial population and ruminal development are also dependent on the availability of free water (Quiqley, 2001). As such, calves should have *ad libitum* access to fresh water at an early age.

Milk is the main source of nutrients for the calf during the first weeks of life. Historically, conventional milk feeding programs have been based on restricted feeding of milk twice daily. The impact of both the frequency and volume of milk that is provided to dairy calves has recently become a matter of considerable debate. Some individuals believe that conventional milk feeding practices result in hungry calves. Moreover, there is growing evidence that feeding larger volumes of milk in an *ad libitum* fashion is advantageous in promoting growth, development and health in dairy calves. Jasper and Weary (2002) found that compared to conventional twice daily restricted feeding practices, *ad libitum* nipple-feeding of milk to dairy calves supported a significant increase in milk intake and improved preweaning weight gain.

Table 3: Calf factors statistically associated with *Cryptosporidium parvum* infection and diarrhea

Calf Factor	P value	Nature of association
Feeding of milk replacer	<0.001	OR=3.98; The odds of *C. parvum* infection was **298% higher** among calves fed milk replacer compared to those calves that were fed milk.
Birth in multi-cow calving area versus individual calving pen	<0.001	OR=0.62; The odds of *C. parvum* infection was **38% lower** among calves born in a multi-cow calving area compared to calves born in individual maternity pens.
Use of calf scour prophylaxis in cows	0.001	OR=0.40; The odds of *C. parvum* infection was **60% lower** among calves born to cows receiving with calf scour prophylaxis compared to those receiving no prophylaxis.
Season of birth	<0.001	OR=1.86; The odds of diarrhea was **86% higher** among calves born in during the summer months compared to those calves born during the winter.
Shedding of *Cryptosporidium parvum* oocysts	<0.001	OR=4.65; The odds of diarrhea was **365% higher** among calves shedding *C. parvum oocysts* compared to those calves not shedding oocysts.
Number of oocysts: high ($>2.16 \times 10^5$) versus low	<0.001	OR=2.64; The odds of diarrhea was **164% higher** among calves shedding a high number of *C. parvum* oocysts compared to those calves shedding low number of oocysts.
Time to separation from dam	<0.001	OR=1.54; The odds of diarrhea was **54% higher** among calves that remained with the dam for greater than one hour after birth compared to those separated within an hour of birth.
Colostrum fed from dam only	<0.021	OR=0.77; The odds of diarrhea was **23% lower** among calves that were fed colostrum taken from their dam compared to those calves fed colostrum from other sources.

Ad libitum feeding programs provide calves with the benefits of unrestricted access to milk. New technologies, such as computer and automated feeding systems, have allowed for the adoption of *ad libitum* feeding of milk replacer on several Canadian dairy farms. The main drawback of this technology is that the equipment is expensive. For the past nine years, Finlanders have been preserving milk with formic acid, thus enabling practical and economical application of *ad libitum* feeding systems in dairy calf management (Kemppi, 2005; Anderson, 2006). A number of Ontario dairy producers have recently implemented *ad libitum* acidified milk feeding programs for their calves. Unfortunately, there is limited controlled research to support anecdotal evidence that *ad libitum* feeding using acidified milk at a pH less than 4.5 is a superior management system. Reports that *ad libitum* acidified milk feeding will effectively reduce diarrhea and use of medications, ameliorate abnormal suckling behaviours, and promote growth in the calf need to be scientifically verified. Further research on *ad libitum* acidified milk feeding is needed.

■ Management of the Sick Calf

Infection and disease evoke several changes in behaviour, including reduced appetite, decreased social activity, increased sleep, and increased thermoregulation (Hart, 1988). Sick animals also experience malaise, a negative affective state that includes feelings of lethargy, depression, pain and anhedonia. This sickness response is mediated by pro-inflammatory cytokines, specifically interleukin-1 (IL-1), interleukin-6 (IL-6) and tumor necrosis factor alpha (TNF-α), and is a component of a highly evolved strategy for dealing with infection.

Cattle are a stoic species, and accordingly young calves will not vocalize when they are experiencing sickness or pain. Thus, dairy producers should use these distinct behavioural changes to help identify sick calves. The early recognition of illness allows for appropriate intervention and supports the recovery process.

Treatment goals for neonatal calf diarrhea complex include the correction of acid-base, electrolyte, and water abnormalities, providing nutritional support, aiding the reparation of the intestinal mucosa, and preventing bacteremia (Constable, 2004). These goals are aimed at reducing mortality associated with calf diarrhea due to septicemia, acidemia, hyperkalemia, prolonged malnutrition, and hypothermia (Constable, 2004). Treatment has traditionally focused on ameliorating these sequelae. Administration of oral and/or parenteral replacement fluid therapy is the cornerstone of most neonatal calf diarrhea complex treatment protocols. Replacement fluid therapy helps to restore fluid volume; while body homeostatic mechanisms are called on to correct other problems. Calves with diarrhea must be closely monitored for dehydration. Antibiotic treatment is only necessary in cases of bacterial infection, such as colibacillosis or salmonellosis. In a recent study, calves with neonatal calf diarrhea complex that were treated with meloxicam had improved recovery from the effects of the episode of diarrhea over placebo-treated calves, as evidenced by increased activity over time, and improved starter intake. Furthermore, meloxicam-treated calves were weaned earlier. These results are evidence of improved calf well-being following an episode of calf diarrhea with this non-steroidal anti-inflammatory therapy (Todd, 2006).

Dairy producers should continue to provide sick calves with milk, as well as free-choice water and calf starter ration. Sick calves will often benefit from additional warmth. Thus, wool-over calf blankets may be good investments. Bedding material must be kept dry and should be replenished frequently. Calves with respiratory disease require antibiotic therapy. Meanwhile, septicemic calves require aggressive antibiotic and fluid therapy.

Treatment plans should be directed at the causative agent of infection. However, this information is not always available or cannot be obtained quickly enough to influence treatment decisions. Historically, veterinarians and dairy producers have relied on laboratory diagnostic methods to identify causative agent(s) of infection. Laboratory results are not immediate; hence this information has generally been restricted to use as a monitoring tool. There is a need for on-farm diagnostic tests to assist producers with treatment decisions. Recently, a new lateral immunochromatography test (BioX Diagnostics, Belgium) for detection of *C. parvum*, ETEC K99 (F5), rotavirus and coronavirus in calf feces became available in Canada. The BioX Diagnostic Test System is an on-farm method that allows for rapid and inexpensive identification of the pathogen profile for calf diarrhea. A formal evaluation of the BioX test against the laboratory gold standard (polymerase chain reaction-restriction fragment length polymorphism) for detection of *C. parvum* in calf feces has been completed (Trotz-Williams, et al, 2005_b). There was a high level of agreement between the BioX and gold standard tests (Cohen's kappa statistic, κ=0.73). Furthermore, the sensitivity and specificity of the BioX test was 78.3% and 93.3%, respectively. Thus, the BioX test has been deemed a suitable test for use in a clinical setting, as it is a cheap, quick and accurate method of detecting infection in young calves. Furthermore, recent investigations have shown that this test performs equally well on previously frozen fecal samples.

■ Avoid Multiple Stressors

Dairy replacement heifers undergo several challenges throughout their life with one of the biggest occurring right at or shortly after weaning. Dairy heifers are raised primarily in individual housing until they are weaned off milk. At this time they are moved into a group-housing environment for the first time in their lives. This is a very stressful time for calves and disease outbreaks are common. One of the diseases that calves are susceptible to at this time is enzootic pneumonia. Studies have shown that morbidity associated with this disease can reach 100%. In a Minnesota study, the rate of mortality was about 9% for each case of pneumonia (Sivula et al., 1996). In a 1986 study of 104 herds in Ontario, 2.3% calves were treated each week for pneumonia (Waltner-Toews et al., 1986). Long-term effects of this disease include an increased risk of culling, slow entry into the milking herd and an increased risk of death. (Waltner-Toews et al., 1986) For every month that a calf is delayed in growth past 24 months it is an estimated loss of $30 per calf per month, and in Michigan, producers estimate costs of approximately $14.71 per calf per year (Ames, 1997).

▪ Conclusions

In conclusion, raising healthy calves is a considerable challenge for dairy producers. Traditional approaches to the housing, feeding and general management of calves are often met with lack of success. However, improvements in management of calving, colostrum handling and delivery, minimizing environmental exposure to pathogens, enhanced feeding strategies, and provision of appropriate care to sick calves can result in significant improvements in the ability to keep calves healthy.

▪ References

Ames, T. R. 1997. Dairy calf pneumonia. the disease and its impact. The Veterinary Clinics of North. America Food Animal Practice. 13:379-391.

Anderson, N. (2006) Mimicking nature's way for milk-fed dairy calves: Free-access feeding with acidified milk. Available: http://www.grobernutrition.com/Yamrap/Pdf/Mimicking%20Natures%20Way.pdf

Bertoldo, G.R. (2005) Colostrum - don't be born without it! *In:* Proceeding from "Dairy Calves and Heifers: Integrating Biology and Management". Natural Resource, Agriculture, and Engineering Service Cooperative Extension, Ithaca, pp.257-265.

Constable, P.D. (2004) Proceedings of the Dairy Health Management Certificate Program Update Meeting, University of Guelph, May 2004.

Curtis, C.R., H.N. Erb, and M.E. White. (1988) Descriptive epidemiology of calfhood morbidity and mortality in New York Holstein Herds. Prev. Vet. Med. 5:293-307.

Davis, C.L. and J.K. Drackley. (1998) The development, nutrition, and management of the young calf. Iowa State University Press, Ames, pp.165-177.

Donovan, G.A., I.R. Dohoo, D.M. Montgomery, and F.L. Bennett. (1998) Associations between passive immunity and morbidity and mortality in dairy heifers in Florida, USA. Prev. Vet. Med. 34:31-46

Grusenmeyer, D., C. Ryan, and T. Overton. (2005) Keeping colostrum in mind when shortening dry periods. The Manager, Northwest Dairy Business–PRO-DAIRY. Available: http://www.ansci.cornell.edu/prodairy/index.html

Godden, S.M., S. Smith, J.M. Feirtag, L.R. Green, S. Wells, and J. Fetrow. (2003) Effect of on-farm commercial batch pasteurization of colostrum on colostrum and serum immunoglobulin concentrations in commercial dairy calves. J. Dairy Sci. 86:1503-1512.

Godden, S., J. Fetrow, J. Feirtag, S. Wells, and L. Green. (2005) A review of issues surrounding the feeding of pasteruized non-saleable milk and colostrum. *In:* Proceeding from "Dairy Calves and Heifers: Integrating Biology and Management". Natural Resource, Agriculture, and Engineering Service Cooperative Extension, Ithaca, pp. 266-282.

Hart, B. (1988) Biological basis of the behaviour of sick animals. Neurosci Biobehav Rev. 12(2):123-137.

Hermann, R., J. Utz, E. Rosenberger, K. Doll, and O. Distl. (2001) Risk factors for congenital umbilical hernia in German Fleckvieh. Vet. J. 162:233-240.

Jasper J. and D. Weary. (2002) Effect of ad libitum milk intake in dairy calves. J. Dairy Sci. 85:3054-3058.

Kemppi, H. (2005) Milk feeding of calves. Valio Dairy. Available: http://www.valio.fi/maitojame/tuotteet/hapanjuotto.htm.

McGuirk, S.M. (1998) Colostrum: Quality and Quantity. Cattle Pract. 6:63-66.

McGurik, S.M. (2002) Raising Calves – The 5 C's of a healthy start. Available: http://www.johnes.org/handouts/files/5Cs.pdf

McGuirk, S.M and M. Collins. (2004) Managing the production, storage, and delivery of colostrum. Vet Clin. Food Anim. 20:593-603.

Moore, M., J.W. Tyler, M. Chigerwe, M.E. Dawes, and J.R. Middleton. (2005) Effect of delayed colostrum collection on colostral IgG concentration in dairy cows. J. Am. Vet. Med. Assoc. 226:1375-1377.

Morin, D.E., P.D. Constable, F.P. Maunsell, and G.C. McCoy. (2001) Factors associated with colostral specific gravity in dairy cows. J. Dairy Sci. 84:937-943.

NAHMS. (2002) Changes in the United States dairy industry, 1991-2002 USDA:APHIS:VS,CEAH, National Animal Health Monitoring System, Fort Collins, CO #N388.0603.

Quigley, J.D. (2001) Calf Note #04 – Water, Water Everywhere. Calf Notes.com. Available: http://www.calfnotes.com

Rischen, C.G. (1981) Passive immunity in the newborn calf. Iowa State Veterinarian. 2:60-65, as cited by Cortese, V.S. (2005) Neonatal Immunology.
Available: http://www.cvm.umn.edu/img/assets/9090/cortese%20proc.pdf

Sivula, N. J., T. R. Ames, W. E. Marsh and R. E. Werdin. 1996. Descriptive epidemiology of morbidity and mortality in Minnesota dairy heifer calves. Prev. Vet. Med. 27:155-171.

Steenholdt, C. and J. Hernandez. (2004) Risk factors for umbilical hernia in Holstein heifers during the first two months after birth. J. Am. Vet. Med. Assoc. 224:1487-1490.

Svensson, C., K. Lundborg, U. Emanuelson, and S. Olsson. (2003) Morbidity in Swedish dairy calves from birth to 90 days of age and individual calf-level risk factors for infectious diseases. Prev. Vet. Med. 58:179-197.

Todd, C., K. Leslie, S. Millman, and R. Tremblay. The efficacy of meloxicam as an adjunct therapy in the treatment of neonatal calf diarrhea complex. Proceedings of the American Association of Bovine Practitioners Annual Meeting. St. Paul, Minnesota. September 2006

Trotz-Williams, L.A., B.D. Jarvie, S.W. Martin, K.E. Leslie, and A.S. Peregrine. (2005_a) Prevalence of Cryptosporidium parvum infection in southwestern Ontario and its association with diarrhea in neonatal dairy calves. Can. Vet. J. 46:349-351.

Trotz-Williams, L.A., S.W. Martin, D. Martin, T. Duffield, K.E. Leslie, D.V. Nydam, F. Jamieson, and A.S. Peregrine. (2005_b) Multiattribute evaluation of two simple tests for the detection of Cryptosporidium parvum in calf faeces. Vet. Pars. 143:15-23.

Trotz-Williams, L., Leslie, K.E., and Peregrine, A. (2006) Passive immunity in dairy calves and influence of calf management practices. Proceedings of the Ontario Veal Association Healthy Calf Conference.

Trotz-Williams, L.A., S.W. Martin, K.E. Leslie, T. Duffield, D.V. Nydam, and A.S. Peregrine. (2007_a) Cryptosporidiosis in Ontario dairy calves I: Calf-level risk factors for infection and diarrhea. Prev. Vet. Med. *In press.*

Trotz-Williams, L.A., S.W. Martin, K.E. Leslie, T. Duffield, D.V. Nydam, and A.S. Peregrine. (2007_b) Cryptosporidiosis in Ontario dairy calves II: Herd-level risk factors for shedding of *Cryptosporidium parvum*. Prev. Vet. Med. *In press.*

Tyler, J.W., B.J. Steevens, D.E. Hostetler, J.M. Holle, and J.L. Denbigh. (1999) Colostral immunoglobulin concentrations in Holstein and Guernsey cows. Am. J. Vet. Res. 60:1136-1139.

Virtala, A.K., G.D. Mechor, Y.T. Grohn, and H.N. Erb. (1996) Morbidity from nonrespiratory disease and mortality in dairy heifers during the first three months of life. JAVMA. 208:2043-2046.

Waltner-Toews, D, S.W. Martin, and A.H. Meek. (1986) Dairy calf management, morbidity and mortality in Ontario Holstein herds. IV. Association of management with mortality. Prev. Vet. Med. 4:159-171.

Wells, S.J., D.A. Dargatz, and S.L. Ott. (1996) Factors associated with mortality to 21 days of life in dairy heifers in the United States. Prev. Vet. Med. 29:9-19.