Introduction

The specialized livestock industry has undergone rapid growth, not only from the joining of new producers but from intensification of existing operations. With this intensification of production and management, certain diseases such as neonatal scour of elk calves are becoming more evident. Much of our information about risk factors, prevention, and treatment of cervid calf scours has been extrapolated from the beef industry. Although the basic principles are similar, there are important differences needing exploration.

Risk factors

The term "risk" refers to the probability that an event 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. For example, an icy road is a risk factor for an automobile accident.

Likewise, there are several risk factors for fawn scours. Most are conditions associated with increased probability of an outbreak of scours in other ruminant species and it is likely that they also apply to cervids. Risk factors for scours can be complex and numerous, but identifying and understanding them is important to the development of prevention programs. Treatment of scouring calves or fawns can be unrewarding and expensive. Success in preventing outbreaks comes from managing the on-farm risk factors where possible.

Risk factors can be broken up into those involving the environment, the animal, and the pathogens or infectious agents (2).

Environmental risk factors
These refer to the various physical and biological factors in the environment of the fawn that may affect it. Ambient temperature, climate, cover or shelter, soil, and surrounding animals are environmental risk factors. When examined individually, some key risk factors can be identified:

**Livestock density.** Over-stocking or crowding for long periods of time is a well known and critical factor increasing the incidence of any disease, especially calf scours. High stocking density in a small confined area not only increases direct contact between individual animals permitting the direct spread of disease, but also increases the level of contamination in the area from animals shedding diarrhea causing organisms. High levels of organisms can challenge and overwhelm the immunity provided to the fawn by mother’s first milk, or colostrum (2,6).

**Pasture and calving management.** The severity and number of cases of scours increases when animals calve in the same area where they spent the winter. This creates increased fecal and microbiological contamination of the calving environment of susceptible neonates. In cattle, calving heifers in the same area with older cows also increases the incidence of scours. Since heifers tend to calve later than mature cows, smaller, weaker calves are being born in an area contaminated with the feces of previously born calves (2). This situation also applies to cervids (6).

Calving sheds, barns, and shelters create another opportunity for increased environmental contamination. When possible, calving should occur outdoors in large paddocks. Some producers may build shelters for calves to hide under. These are useful, but should be moved a few yards every other day or so to prevent the build up of pathogens on the ground underneath.

**Weather and ground conditions.** These are easily understood and important risk factors. Scours in calves typically follows periods of cold, wind, and precipitation. The increased stress of maintaining body temperature and other body functions during poor weather, or unsuitably wet ground conditions renders the fawn susceptible to infection. Fawns have difficulty finding dry places to hide and may crowd suitable areas of dry cover, increasing contamination in those areas.

Cervid calves may face additional risks because they are known to drink water at an early age. Elk usually calve at the end of May or early June when the environment is often very wet with rain or partial ground thaw. This creates standing water and puddles. As temperatures become warmer calves often do not get all the fluids they need from the cow. Thirsty calves may not find or drink from fresh water sources provided for the cows.
Instead, they drink from nearby pooled standing water, which is frequently contaminated with pathogens. For these reasons, low lying, poorly drained areas can precipitate scours and should not be used for calving paddocks (2,6).

**Animal risk factors**

These include important factors such as the nutritional and immune status of the dams and calves.

*Transfer of immunity.* Colostrum is the antibody enriched "first milk' provided to newborn calves by the dam. This method of supplying disease resistance to the calves is called passive transfer of immunity. Passive transfer of immunity can fail for a number of reasons. The calf may fail to suck because of behavioural or physical problems in the dam or calf. Heifers or first calf hinds have increased incidence of mismothering or abandonment, preventing suckling (2,11). The dam may provide inadequate amounts of colostrum, or insufficient amounts of antibody in the colostrum. First calf hinds often have both decreased quantity and quality of colostrum. Antibody levels to specific diseases are higher in older cows with greater exposure to various disease causing organisms.

Inadequate intake of colostrum by fawns is an extremely important risk factor in causing scours. Elk cows close to giving birth have been observed to "steal" and nurse calves from other cows before the birth of their own calf. This results in a lack of available colostrum for the cow's own calf when it finally arrives. The ability of the intestine to absorb colostrum decreases rapidly after birth. Colostral antibodies are only absorbed during the first 12 - 24 hours of life and at 6 hours after birth the level of absorption may already be decreasing. Interference with cow-calf bonding by well intended observation or intrusions by overenthusiastic producers sometimes delays important calf feeding behaviour. Calves should ingest a minimum of 10% of their body weight in colostrum in the first 12 - 24 hours of life. This is roughly equivalent to 50 ml per kilogram, taken in multiple small meals within this crucial time frame (2).

*Adequate nutrition.* Nutrition plays an important role in determining calving outcome, milking ability of the hind or doe, and fawn quality. Over nutrition, especially in late pregnancy, can lead to the deposition of abdominal fat in the hind causing dystocia (difficult calving). Assisted births tend to yield weak calves and interfere with the maternal bonding needed for adequate mothering. Both can lead to insufficient intake of colostrum and poor passive immunity in the fawn.
Poor nutrition also leads to problems. Because of the seasonal nature of their metabolism, hinds or does entering the breeding season in poor condition will have little opportunity to change this situation during early to mid gestation. Fawn weight is determined by dam weight, and hinds or does with inadequate pre-rut body weights tend to have lighter and weaker calves. Animals deficient in trace minerals such as copper and vitamins such as vitamin E can exhibit gestation, calving, and milking problems. Colostrum from animals receiving inadequate nutrition is often generally poor in quantity and quality.

Sometimes the spring improvement in pasture quality does not coincide with the calving period, making supplemental feeding necessary. Milking cows need approximately twice the calories needed for maintenance. Under feeding hinds or does at this time can cause poor milk and colostrum production, starving an otherwise healthy calf of the required elements to fight off scours.

**Infectious risk factors**

There are many pathogenic microorganisms associated with diarrhea in cervid calves. These agents are quite similar to those found in cattle, but with some differences in their relative importance to cervids. Also, the ages at which cervid calves are susceptible to specific organisms are not as well defined as they are in cattle, but seem to be similar based on experience to date. When identifying organisms harmful to cervid calves it is important to remember that the mere presence of organisms often does not result in diseased animals. Additional risk factors are frequently needed for clinical disease to occur.

Some of the microorganisms associated with scours in fawns are listed below. Figure 1 shows the frequency of infectious cause of scours in beef calves at various ages. We suggest that this information may be similar in cervids.
**Enterotoxigenic E. coli** - This can be a major infectious cause of diarrhea of both cervid and beef calves less than 4 - 5 days of age. The susceptibility of calves to this type of E. coli tends to decrease beyond this age but this bacterium also causes disease when other organisms or conditions weaken calf resistance. Septicemic (generalized blood borne infection from non-enterotoxigenic E. coli) forms of E. coli can produce a low grade diarrhea in young calves, but meningitis, arthritis, and other clinical syndromes tend to be more important outcomes than diarrhea (3,6,11).

**Clostridium perfringens type D** (pulpy kidney in sheep) causes diarrhea and sudden death in young cervid calves. The age at which this occurs is not well defined, but it has been shown to be associated with a sudden change in diet to one rich in carbohydrates, causing an overgrowth of Clostridial bacteria and production of toxins. This disease is more likely to occur in slightly older calves that are starting on grain or lush pastures. In contrast, Clostridium perfringens type C is a cause of beef calf scours, usually at less than 10 days of age (3,6,11).

**Salmonella species** causing diarrhea in calves have been reported but does not seem to be a major cause of scours in elk or deer. This bacterium tends to be more common in bovine calves, especially dairy.

**Rotavirus and Coronavirus** have been identified as viral causes of elk calf scours. Based on observational evidence, these viruses appear to follow approximately the same age susceptibility patterns as they do in cattle. (See Figure1) Rotavirus causes diarrhea in bovine calves approximately 4 - 14 days of age, but can affect older calves. Coronavirus seems to be most common from 4 - 30 day old calves (11).
Cryptosporidium is a protozoan parasite and a major cause of neonatal diarrhea in cervid calves (15). This is especially true of bottle fed calves where the hygiene of equipment and handlers is of utmost importance. The incubation period of this protozoon in elk calves appears to be 4 - 5 days. Although Cryptosporidium occurs quite commonly in beef calves, mortality in affected cervid calves seems to be higher, suggesting either increased susceptibility of cervids or virulence differences in the strains affecting these species (3,6).

Eimeria is a protozoan parasite causing symptoms of diarrhea known as coccidiosis. The significance of coccidia in cervid calves is not known. Coccidia have been identified in adult deer and elk with no apparent consequences except perhaps in mule deer, where clinical disease has been experimentally induced giving chronic diarrhea and weight loss (6).

A recent survey of elk producers in the Saskatoon area, identified the causative organisms in 11 cases of scours in elk calves less than 3 weeks of age (10). Of these 11 cases, 7 were attributed to Cryptosporidium, 2 were Rotavirus infections, 1 was an E. Coli, and 1 was due to Clostridium perfringens. Elsewhere, coronavirus infection has been described in elk calves with diarrhea (16). An examination of elk calf scour cases in the teaching hospital at the WCVM from 1996 - 2000, revealed non-specific enteritis in most cases, but cryptosporidiosis and E. coli enteritis were diagnosed in several. Rotavirus and coronavirus were not isolated (8). Much remains to be investigated about the causes and age related susceptibilities of elk calf scours.

Clinical signs

"Calf scours" is a syndrome, or collection of clinical signs indicating intestinal tract disease. Common presenting signs are diarrhea, fecal stained perineal area, dehydration, depression and anorexia. Note that diarrhea is a disease symptom, not a disease itself, and only one of many associated with calf scours. Cervid calves with intestinal tract disease do not have to exhibit watery diarrhea to be severely ill. With secondary complications, calves may show signs of pneumonia, omphalophlebitis (navel infection), and stiffness if joints are affected. Clinical observations made by Western Canadian practitioners during the 1999 calving season indicated that scouring cervid calves are prone to hypoglycemia (low blood sugar) causing them to become weak, recumbent, and unresponsive, occasionally showing opisthotonus (head thrown back and neck stiff). Similar to beef calves, their metabolism must deal with an excess of acid metabolic products (severe acidosis) and as a result they are typically described as appearing "drunk" (5).
Pathophysiology

Cervid calves become severely acidotic with hypernatremia (increase in blood sodium) and hyperchloremia (increase in blood chloride). This differs from beef calves who develop acidosis with hyponatremia (decrease in blood sodium) and hypochloremia (increase in blood chloride). Recent cases submitted to the WCVM revealed that hypernatremia affected approximately half the elk treated for scours (4). Therefore, the traditional approach to beef calf scour therapy is not completely transferable to cervid calves. Cervid calves experience losses of bicarbonate from the gastrointestinal tract, and rapid losses of tissue fluids which concentrates the sodium chloride in the blood stream.

Treatment

On farm
When on pasture, calves should be monitored daily (at a distance) for any sign of depression or soiled rear ends and hocks, and should be treated at the first sign of illness. If the affected calves are standing and still have a good sucking drive, oral fluid supplementation is recommended. Cervid calves will drink water on pasture when necessary. Provide fresh water in shallow conveniently located containers. Consider isolating calves for treatment to decrease pasture contamination and direct transmission to other calves. Electrolyte solutions can be forced or tube fed when needed. However, most commercially available electrolyte solutions (Enterolyte\textsuperscript{a}, Lifeguard\textsuperscript{a}, Revibe\textsuperscript{b}) are designed for bovine calves and are high in sodium. Solutions of these products should be diluted 1:2 or 1:4 with additional water to decrease the risk of inducing hypernatremia (5). Alternatively, use human pediatric electrolyte solutions such as Pedialyte\textsuperscript{c} or Infalyte which contain less sodium. WCVM case records show evidence that cervid calves treated on the farm for several days with only bovine oral electrolytes are significantly hypernatremic when brought in for intravenous fluid therapy, and are more likely to die despite hospital treatment (4). Elk calves appear to need oral fluids more than they need oral electrolytes. Some producers give oral drenches (or stomach tube) with colostrum from hinds or dairy cows, theoretically increasing the local immunity in the intestine in addition to providing fluids.

Interfering with calves or temporarily removing them from the pasture for treatment may create other problems. After 24 hour or so the hind or doe may not accept the calf again upon reintroduction. It is common for elk hinds to reject, and even kill their calves when reintroduced. Treat the calf and attempt reintroduction as rapidly as possible, preferably within 24 hours. Some success at pairing has been achieved when the dam has been placed in a paddock or pen adjoining the herd and the calf brought to the
dam. Confining the dam with her calf in the handling system usually fails. Failure to "mother-up" means that a producer will likely have to bottle raise the calf until 8 to 12 weeks of age.

If calves become appreciably depressed and will no longer suck, they should be taken to a veterinarian for treatment. This level of depression usually indicates significant metabolic acidosis needing intravenous fluid therapy for correction.

In hospital

*Intravenous fluid therapy* - Intravenous fluids therapy is aimed at restoring deficiencies and restoring the balance of glucose, bicarbonate, and body salts (see Figure 2). The status of each must be determined so that intravenous solutions can be custom-made for the needs of each patient.

Figure 2  An energy depleted elk calf on a slow intravenous fluid drip with small amounts of fresh water to drink.

The best and most accurate way of determining the acid/base status of the calves uses a blood gas analyser. Unfortunately, these sophisticated analysers are not widely available in practice and most veterinarians must base treatments on estimations of body chemistry conditions like acidosis. Experienced practitioners can estimate the degree of acidosis by the strength of the sucking drive, degree of limb weakness and age of the calf. Body temperature and degree of hypoglycemia (low blood glucose) are measured with simple instruments. Dehydration can also be determined from blood samples or roughly gauged by the sunken appearance of the eyes and the loss of skin elasticity on the neck or the eyelid.
Initial fluid therapy in cervid calves is aimed at restoring blood sugar levels and decreasing the level of acidosis. Warming the calf to restore body temperature and providing intravenous fluids will usually bring about rapid improvements in condition, but complications can occur. Calves previously treated with oral bovine electrolyte replacers are likely to have high serum sodium levels. Rapid lowering of serum sodium through body fluid replacement can cause the brain to absorb water, leading to cerebral edema (brain swelling) and neurologic signs such as inability to rise, nystagmus (side-to-side movements of the eyes), blood from the nose, and severe depression. WCVM has had success with avoiding this problem using slow administration of fluids and offering small amounts of water orally every hour or so.

**Antibiotics** - There is some controversy over whether or not antibiotics are indicated for cervid calf scours, mainly because the cause of the scours is usually unknown. Some case fatalities at the WCVM have been attributed to *E. coli* septicemia, presumably due to intestinal wall injury allowing the bacteria to enter the blood stream (5). In this instance, it is thought that antibiotics aren’t actually treating the diarrhea, but preventing secondary complications. The *E. coli* cultures taken at the WCVM have been susceptible to cefiofur, florfenicol, trimethoprim-sulfa, ampicillin, Synergistin™ and tetracyclines.

New Zealand has seen a high incidence of scours due to cryptosporidiosis. Veterinarians have found these cases extremely difficult to treat. Some have had success with a drug named totrazuril, given orally as a 1.25% solution (7). Cryptosporidium is also found in Canada and has been found responsible for intestinal disease in elk and white-tailed deer. With this in mind, it is important to wear gloves when handling calves with scours. These organisms are transmissible to, and cause disease in humans. Other suggestions from New Zealand include giving the calves serum from mature hinds to boost calf immunity.

**Prevention**

There are five basic management principles that should be followed to prevent and control cervid calf scours. Each principle should be adapted the individual herd as required. The principles are:

- Remove sources of infection from the calf's environment.
- Isolate the calf from contaminated environments.
- Reduce sources of stress to the calf.
- Increase the nonspecific (colostrum) resistance of the calf.
- Increase the specific immunity of the calf.
Removing sources of infection. Most scour causing micro organisms are carried by the dam and transmitted to the calf at, or soon after calving. Also, some bacteria and viruses can survive for long periods of time in manure, bedding, or water in the calving environment. High infection pressure from a heavily contaminated environment is the major risk factor on many deer and elk farms. Reduce contamination to a level that will not overwhelm the natural defence mechanisms of the calf. Ways to achieve this are as follows:

- Avoid overcrowding. It is well understood that overcrowding increases the incidence of scours in beef herds, and this has also been demonstrated in elk herds. There is an increase in "cross mothering" or calf swapping in more heavily populated calving paddocks, which can leave some calves with less colostrum. The amount of space needed depends on the quality of the calving grounds, but certainly more space is better than less.
- Provide a suitable calving environment. Calving areas should be dry and well drained. Potholes and puddles holding water can be a source of infection. Drain standing water by trenching or by pump rather than waiting for evaporation. Leave the calving area clean and dry in the hot summer months to reduce bacteria numbers in the soil.
- Avoid using the same calving grounds year after year. This is especially important if calf scour problems have occurred previously on the farm. Scour causing bacteria and viruses can be very hardy, surviving in the soil for a long time. Moving cows into the calving grounds one to two weeks prior to calving will prevent excessive accumulation of manure, and decrease the pathogen loads.

Isolating the calf from the contaminated environment. This is not as important a factor in elk herds as it is in beef herds, mainly because elk are usually calved in open paddocks. However, several measures warrant consideration.

Split up the calving herd. Early calving cows, the late calving cows, and heifers should be separated and calved in different pens. If this is too difficult, separation of the heifers from the cows is the minimum necessary. There are three general reasons for separating early and late calves. Older calves can shed pathogens harmful to naive younger calves, who have variable immunity levels. Older calves have declining colostrum immunity, making them more susceptible to pathogens spread by stressed cows at calving. Finally, the older calves will compete for milk through cross mothering and decrease vigour in the young calves through physical aggression.
Studies in beef cattle show that herds calving heifers and cows together have an increased incidence of scours in all calves (2). A likely cause is an inadequate intake of colostrum in the calves born of heifers, resulting in diarrhea and shedding of pathogens, increasing infection rates in all calves. This is true for cervids as well.

Reducing stress in the calves. As with all aspects of raising elk and deer, stress is a major factor in disease. Handle the calves as little as possible in their first 30 days. Excessive human contact can be very stressful, and can greatly increase the incidence of disease. Check the cows no more than three times a day from the outside of the pen. Other than tagging shortly after birth there should be no human contact. Splitting the early and late calving animals will reduce the amount of stress placed on the younger calves by older herd mates.

Increase the nonspecific resistance of the calf. Colostrum intake is essential in preventing both morbidity and mortality due to scours in cervid calves. Absorption of colostrum from the gut ceases as early as 12 to 15 hours postpartum (6). Therefore it is important to ensure, as much as is possible, that each calf gets at least 50 mls per kilogram of body weight in the first 12 hours after birth. If it is suspected that the dam has not provided colostrum to the calf, alternate sources of colostrum for the calf should be considered. Powdered products such as Headstart are available and should be given to the calf as per directions supplied with the product.

In elk and deer calves destined for bottle feeding because of separation from mother for scours treatment, colostrum or serum can be added to every feeding for 1-2 weeks postpartum. In beef calves, colostrum provides a local immunity in the gut wall for about 3-4 days, which is perhaps why rotavirus is not a problem until about 4 days postpartum (see figure 1). However, except in vaccinated cows, there are few colostrum antibodies to E.coli, making E.coli scours a major cause of problems in the first 4 days of life. It is unknown how long this local immunity lasts in cervids, but we can assume that a similar mechanism of immunity exists in young elk calves and deer fawns. Therefore adding elk or deer serum to each feeding for the first few days, and then bovine colostrum after that may be beneficial in providing a local intestinal immunity.

Increasing the specific immunity of the calf. Immunity to specific pathogens varies between and within herds, depending on the history of exposure to infectious agents. Vaccines are a planned, safe means of exposure used to boost immunity to specific pathogens. In the case of cervid calves, we suspect that important pathogens include E. coli, rotavirus, coronavirus, Cryptosporidium spp, Clostridium perfringens type D, and sometimes Salmonella spp. Current vaccines are targeted at E. coli, rotavirus and coronavirus, and Clostridium perfringens. These vaccines
are designed for administration to beef and dairy cows prior to calving, so that the antibodies produced in the cow are passed onto the neonate in the colostrum. Colostrum intake by the calf remains a limiting factor in specific immunity.

Many elk and deer producers are using vaccines in attempts to reduce scour problems and there are many anecdotal reports of reduced morbidity and mortality in elk herds using scour vaccine. Unfortunately there have been no formal trials using these vaccines in elk or deer, so their true effectiveness is unknown. In western Canada the most commonly used scour vaccine is Eco-star™. This vaccine has been proven effective in reducing *E. coli* diarrhea in field trials with beef calves (9). However, its ability to reduce diarrhea in bovines due to rota and coronaviruses is questionable, even though it does produce a good serum antibody response (1). This is likely due to the lack of local immunity in the gut wall. There is some evidence of long-term beneficial effects due to decreased shedding of virus by cows (2).

There are no vaccines specifically designed for use in cervids. Using cattle or sheep vaccine in cervids is an unlicenced or "off-label" use, and we know very little about their safety or usefulness. These vaccines have only been tested for safety and effectiveness in cattle and sheep and the user assumes all risk for any losses that may occur from adverse reactions. There are apparently no reports of serious adverse reactions to the vaccines, making them at least harmless.

We lack good information on what causes scours in cervid calves and on the relative importance of bovine pathogens in elk and deer. For instance, cryptosporidiosis is much more severe in red deer than in bovine calves (14). It appears to be an important pathogen in elk calves too (10). There is no vaccine available for the control of cryptosporidiosis. The incidence of enterotoxemia caused by *Clostridium perfringens* appears to be a significant in cervids (11). This pathogen is not a component of Eco-star™ or any of the common scour vaccines. If these two pathogens are as important as they appear to be, then currently available vaccines will not be effective in controlling the major causes of scours in cervids. Since the effectiveness of widely used vaccines against rota and coronavirus is questionable, especially in the short term, the only real value of vaccine may be against scours caused by *E.coli*. However, the real importance of *E. coli* in causing cervid calves scours has not been determined.

In spite of these uncertainties producers will continue to use vaccines, with variable success. It is important to realize that calf scours in any species is largely a management disease. With good management in the calving season, the incidence of this disease can be greatly reduced in most herds.
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