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**Cryptosporidium and Cryptosporidiosis**

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## Summary

- *Cryptosporidium* causes diarrhoea in young livestock and is also infective to man.
- Transmission is via the faecal-oral route.
- Older livestock do not show clinical signs of infection, but nevertheless can act as a reservoir of infection.
- Following infection, calves are known to develop good immunity to *Cryptosporidium* and are resistant to a subsequent infection.
- Oocysts survive well in cool, moist conditions and are resistant to standard water disinfection processes such as chlorination.
- Rehydration is the most effective therapy available for all livestock species. Halofuginone lactate (Halocur<sup>TM</sup> produced by Intervet Animal Health) can also be very effective for the therapeutic and prophylactic treatment of cryptosporidiosis in calves when used in conjunction with rehydration therapy. However, this product is only licensed for use in calves.
- Control is through animal management and hygiene procedures.
- Ammonia based disinfectants or steam cleaning are the most effective methods of cleaning contaminated pens or utensils.
- Correct disposal of animal wastes will reduce environmental contamination with viable oocysts.
- *Cryptosporidium* is easily spread from livestock to people so it is important to observe good occupational hygiene and wash hands thoroughly before eating to help prevent transmission of infection.

## Introduction

Cryptosporidiosis is the disease caused by infection with the small protozoan parasite *Cryptosporidium parvum*. The parasite can infect a wide range of animal species including humans. Affected livestock species include cattle, sheep, goats, pigs, horses, deer and camelids. Clinical infections tend to occur in neonatal animals, whereas infections in adult animals tend to be subclinical.

The parasite was first described in 1912 by Tyzzer who observed the organism growing in the guts of mice. The pathogenic importance of *Cryptosporidium* was not discovered until the 1970's when it was shown by veterinary workers to cause diarrhoea in calves in the UK. The first reports of human cryptosporidiosis were in 1976 at the John Hopkins School of Medicine in the USA. More recently, the emergence of diseases such as AIDS, that compromise the immune response, have resulted in severe cases of human cryptosporidiosis leading to wider awareness of the disease and the parasite globally.

*Cryptosporidium* is recognized as a contaminant in drinking and recreational waters and is a major problem to control due to its resistance to standard water disinfection processes. The parasite has a thick outer wall which enables it to resist chlorine and other harsh conditions. A major outbreak was reported in Milwaukee, Wisconsin in 1993 where 403 000 people were infected due to faulty filtration of water supplying the area. The average duration of illness in people was 12 days although some people were ill for 8 weeks or more and some immuno-compromised individuals died. In the UK, outbreaks are regularly reported in many different areas of the country resulting in hundreds of clinically affected people and tens of thousands having to boil tap water to make it safe to drink.

## Clinical Symptoms

Clinical disease mainly manifests in neonatal farm livestock around 2-10 days old. Clinical symptoms of cryptosporidial infection, termed cryptosporidiosis, include a profuse watery diarrhoea, inappetance, gastrointestinal discomfort, abdominal tension, nausea and a mild fever. This occurs 3-7 days after infection, and the onset of diarrhoea usually coincides with the shedding of oocysts in the dung, which are fully developed and infectious when shed, allowing rapid dissemination of infection throughout the herd or flock. At peak shedding, there may be as many as 10 million oocysts per gram of faeces and oocyst excretion may persist for several days after clinical signs have diminished. Severe infections may lead to dehydration and in some circumstances lambs may die within 2-3 days following the onset of diarrhoea. In otherwise healthy livestock, the diarrhoea will usually resolve without intervention after 4-7 days, but oocyst shedding often continues after this, the animal still being infectious to other livestock. During a clinical infection, the total numbers of parasites shed may exceed 10(10) over a 7-10 day period.

Adult animals can also become infected, though these infections are without symptoms (asymptomatic), and the numbers of oocysts shed are comparatively small. However, the small infective dose means that an infected dam can act as a reservoir of infection for her offspring, and persistent low level excretion of oocysts can generate as much contamination over the course of a year as a clinical episode in a young animal.

*Cryptosporidium* lacks host specificity among mammals, unlike other related coccidians which are species specific. Lambs, calves, goat kids, foals and deer calves are all susceptible to clinical infection, while piglets can become asymptotically infected. Since infection can occur immediately after birth, cryptosporidial diarrhoea may appear from 3-4 days of age onwards. Profuse diarrhoea and a reluctance to feed can rapidly lead to dehydration in such young animals.

Goat kids and deer calves seem especially vulnerable to cryptosporidial infection, and mortality rates amongst these animals can be quite high, rapid dehydration being the most probable cause of death.

Lambs tend to survive infection somewhat better, but losses can be high if the animals become stressed, for example from hypothermia if the infection coincides with turnout during a cold or wet spell.

Calves, while becoming depressed and experiencing severe diarrhoea, often continue to feed quite well during infection, and mortality rates are usually low.

Foals, if very young, can be severely affected by cryptosporidial infection, suffering acute diarrhoea and dehydration, but older foals have been found to shed moderate numbers of oocysts with no obvious symptoms.

It should be noted that concurrent bacterial and viral infections can result in much more severe symptoms, with proportional increases in mortality.

Infections in companion animals (dogs and cats) or pets (rabbits, hamsters, guinea pigs) do not normally result in clinical symptoms, but oocysts shed will be infective to other livestock.

In humans, clinical symptoms include profuse watery diarrhea, inappetance, abdominal discomfort and dehydration. In addition, nausea, vomiting and a mild febrile response may be experienced. Vulnerable groups include the very young, the elderly and those that are immuno-compromised. Individuals infected with HIV are particularly at risk as there is no effective chemotherapy available that will target intracellular stages of the parasite.

## **Disease Epidemiology and Transmission**

*Cryptosporidium* parasites primarily infect the small intestine and are transmitted directly between hosts by the faecal-oral route. Infection occurs as a result of ingestion of oocysts, the environmentally resistant form of the parasite, which are shed in the faeces of infected individuals. Oocysts are very small, approximately 5 $\mu$  in diameter (150,000 would just cover the head of a pin) and are shed in very large numbers by susceptible hosts – a young calf or lamb can shed up to ten thousand million oocysts in the space of 7-10 days. An infectious dose can be as few as 5 oocysts, so a single infected individual has a huge potential to infect other livestock.

Each oocyst contains four infective motile organisms, the sporozoites, which normally invade epithelial cells lining the distal part of the small intestine, but infection can also spread down into the caecum and colon. In these sites the parasite undergoes rapid multiplication, establishing a large burden of infection and in the process damaging the gut lining.

Once the infection is well established, 3-5 days after initial infection, oocyst production commences, by which time damage to the gut is frequently so severe that marked diarrhoea results.

*Cryptosporidium*, as with so many other parasites, bases its survival strategy on the production of very large numbers of infective stages, of which only a few need to successfully infect susceptible hosts to maintain the parasite population. Modern farming practices, with high stocking densities and synchronized calving or lambing, provide large numbers of susceptible hosts and favour rapid parasite transmission.

The oocysts shed in the faeces are very resistant to environmental stresses and because they are excreted from the animal fully infectious, they are capable of direct transmission by the faecal-oral route from lamb to lamb or ewe to lamb particularly in communal housing or via contaminated water.

Animals show an age related susceptibility to infection with *Cryptosporidium*, so the older they are before exposure to the parasite, the less severe the clinical symptoms are likely to be, although they will still become infected and shed infectious oocysts. Following infection calves are known to develop good immunity to *Cryptosporidium* and are resistant to secondary challenge.

This age related susceptibility does not seem to occur in people, who may become clinically infected at any age if they have not been previously exposed to the parasite, though the majority of infections do occur in the young. Humans tend to become infected by two main routes, either direct contact with faeces from an infected individual, or through environmental contamination, with drinking or recreational water a frequent source of infection. The increasing popularity of farm parks for recreational visits has led to a number of *Cryptosporidium* outbreaks, particularly where the opportunity exists for members of the public to feed or have direct contact with young animals. Often, whole families will become infected, the first member directly from exposure to an infected animal, while subsequent members contract infection from the initial contact due to poor hygiene practices in the home. While cryptosporidiosis in immunocompetent individuals can be unpleasant, with diarrhoea and stomach pains often lasting for 7-10 days, in the immunocompromised, such as HIV sufferers, or hospital patients on immunosuppressive therapies, it is potentially fatal.

## **Diagnosis**

Diagnosis of infection is usually by microscopic examination of stained faecal smears to look for the presence of *Cryptosporidium* oocysts. A commonly used stain is the modified Ziehl-Neelsen method (MZN) where the oocysts appear pink-red against a blue-green counterstained background. This procedure is undertaken routinely by the Veterinary Investigation Service. Faecal swabs or 1-2g of faeces from each of several scouring animals is sufficient for diagnostic purposes. Since diarrhoea in neonates may be due to bacterial or viral infections as well as *Cryptosporidium*, these organisms should also be checked for as possible causes of diarrhoea. If oocyst numbers are low, as for example in screening adult animals, concentration techniques such as sucrose floatation can be employed to improve detection.

*Cryptosporidium* parasites may also be detected in faeces using enzyme-linked immunosorbant assays (ELISA) or immunofluorescent (IFA) assays which can offer greater specificity and sensitivity than conventional staining procedures.

New molecular biology techniques have been applied to help distinguish strains of *Cryptosporidium* parasites and have proved useful tools in tracing outbreaks.

At post mortem, the gut of infected animals may appear distended with gas, and contain yellowish fluid contents.

## **Treatment, Prevention and Control**

Supportive therapy consists of oral rehydration, using proprietary electrolyte solutions, and housing of affected animals – infected neonates are very susceptible to chilling, so should be maintained in warm conditions. Affected animals may require considerable encouragement to drink for several days, after which appetite should return. Small volume of electrolytes offered frequently is the best course of action to follow. Very weak animals may benefit from stomach tubing. Administration of appropriate antibiotics, under veterinary supervision, can be helpful if concurrent bacterial infections of damaged gut are suspected. Diarrhoeic lambs should be isolated and clean bedding provided to reduce the spread of infection and, if possible, newborn lambs should be kept separate from older lambs that may be infected. Disinfection of lambing pens and feeding troughs using an ammonia-based disinfectant or steam cleaning will reduce the number of oocysts in the environment.

As infections are initiated by ingestion of oocysts, control strategies must be aimed at reducing the numbers of oocysts in the environment. It is not possible to control oocyst contamination on pasture but, as *Cryptosporidium* parasites are not host-specific, it is recommended that cattle slurries and manure are well fermented or composted prior to application on to pasture, as *Cryptosporidium* parasites are killed by heat above 55-60 degrees centigrade and increasing ammonia concentration. Oocysts are also killed by drying out.

Partial activity against *Cryptosporidium* has been reported for the following substances; sulfaquinoxaline, halofuginone, lasalocid and paromomycin in experimentally infected neonatal ruminants. Halofuginone lactate (Halocur<sup>TM</sup> produced by Intervet Animal Health) is licensed for therapeutic and prophylactic treatment of cryptosporidiosis in calves, but not for use in small ruminants. Treatment reduces clinical signs and reduces oocyst shedding in animals but does not eradicate infection. Animals should be weighed accurately to achieve the recommended 0.1mg/kg dose, since this drug has demonstrable toxicity at only twice the recommended therapeutic dose and its use in severely dehydrated or inappetant animals is contraindicated.

## Recommendations

The following recommendations are designed to limit the impact of cryptosporidial disease on the farm:

- 1) Where young replacement stock are purchased (preferably from reliable, disease-free sources) they should be placed in quarantine, well away from other stock, for at least 7 days to see if scouring occurs. Any animals which scour should be kept indoors in isolation, which should continue for at least 1 week after the diarrhoea has ceased to ensure oocyst shedding has stopped. Market purchased animals are often a prime importer of infections, including *Cryptosporidium*. Bought in calves should have their own feeding bucket which is regularly disinfected.
- 2) Animals about to give birth should be cleaned of faecal contamination before their offspring are born. Adequate fresh bedding should be provided in the delivery area. All new born livestock should receive colostrum, as weaker animals are generally more susceptible to infections. The risk of infecting the offspring should be minimised by ensuring teats are clean, and calves should be allocated disinfected individual feeding utensils. Scouring or quarantined animals should be handled after the healthy stock to prevent transmission of oocysts on soiled clothing or equipment.
- 3) Where possible, an 'all in all out' policy should be employed, whereby pens and feeding troughs are either steam cleaned or treated with an appropriate disinfectant. If this is not possible, placing newly born animals in clean disinfected pens may help reduce the risk of transmitting infection. Individual penning of calves, avoiding animal to animal contact, can be helpful. Calf pens should be liberally bedded with straw to minimize seepage of wastes.
- 4) The housing area for adult animals should be cleaned and disinfected annually when the animals are moved to grazing.
- 5) Good hygiene and disinfection remain the most effective strategy to reduce contamination.
- 6) Disinfection of contaminated premises, pens and feeding utensils can be problematic since *Cryptosporidium* oocysts are resistant to commercial agricultural disinfectants, such as ionophores (FAM) and even formalin. Ammonia based products, such as 'Oocide', originally developed to kill coccidia in poultry houses, are extremely effective, but cannot be used where livestock are still present because of the caustic ammonia fumes generated. Disinfectants based on hydrogen peroxide are also effective, but can be inactivated by organic material at temperatures above 60°C, steam cleaning can be an effective way of sterilizing buildings, pens and feeding troughs.
- 7) Oocysts can survive for many months under favourable conditions – they prefer a cool, moist environment, and do not survive drying out.

- 8) Because *Cryptosporidium* is a zoonosis, (able to infect man) correct disposal of wastes from infected animals is also important, particularly where agricultural land forms a catchment area for reservoirs and rivers used to supply potable water. Many documented outbreaks of human cryptosporidiosis have resulted from contaminated water supplies. Oocysts are resistant to chlorination, the standard treatment for disinfecting drinking water, so water providers are reliant on physical filtration to remove oocysts from drinking water. If this barrier breaks down, viable oocysts can enter the water distribution network. Once in the cool, stable environment of a watercourse, oocysts may survive for up to a year.
- 9) Farmyard manure and slurries act as a large reservoir for *Cryptosporidium* infection, and if the oocysts are viable when disposed of onto land they will pose an environmental contamination risk not only to animals but ultimately to the human population through percolation into water sources.
- 10) Because of the sensitivity of the oocyst to elevated temperatures, properly composted farmyard manure represents a minimal threat of contamination, since the heat generated during composting will kill the majority of oocysts. Turning the heap during composting will improve the die off rate. Similarly, the ammonia generated in cattle slurries during storage is sufficient to kill most of the oocysts present. The largest threat of environmental contamination comes from fresh animal wastes, either washed down drains from farm yards and dairy parlours or deposited on pastures close to watercourses. If reasonably fresh material has to be spread, it should not be applied to a slope, particularly if heavy rain is expected.

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