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Zoonotic Protozoan Parasites in Cattle: Emerging Issues

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Introduction

Cattle harbour a number of protozoan parasites but there is an emerging concern about the role cattle play in human giardiasis and cryptosporidiosis [1,2]. As reports of the common occurrence of *Giardia* and *Cryptosporidium* in cattle have increased, so has concern about the role of cattle as the source of waterborne outbreaks of giardiasis and cryptosporidiosis. It is now clear that the source of infections with these two enteric protozoans in humans is probably more often other humans rather than cattle. In contrast, insufficient attention has been given to the role of cryptosporidial and giardial infections as causes of disease and production losses in cattle, particularly the effects of sub-clinical, chronic infections [2].

Etiological agents and infection in Cattle

There is growing evidence that *Cryptosporidium* has more affinities with gregarine protozoa than the coccidia which may explain why most anticoccidial agents are ineffective in treating cryptosporidiosis [3]. There are currently thirteen recognised species of *Cryptosporidium* based on morphological differences, host, site of infection and genetic differences and there are an increasing number of genetically distinct intraspecific variants, or genotypes [1,2]. Molecular epidemiological studies have shown that there are at least two distinct life cycles of *Cryptosporidium* involving humans. *C. parvum* is common to humans and cattle while C. *hominis* is an anthroponotic human genotype [4]**.** Two species of *Cryptosporidium* have been identified in cattle: *C. parvum* (cattle genotype) in the intestine and *C. andersoni* in the abomasum. In addition to their site of predilection, the two species have morphologically distinct oocysts and differ genetically [4,5]. The cattle genotype of *C. parvum* also infects other mammals including humans [2]. Six species of *Giardia* are recognised on the basis of morphological characteristics and host occurrence [1]. The lack of morphological differences between the genetic variants found in mammals has resulted in an informal categorisation of these genotypes based on genetic differences. Cattle are susceptible to infection with two genotypes of *G. duodenalis*: the zoonotic genotype Assemblage A, or the livestock genotype, Assemblage E [1,2].

Infection patterns of *Giardia* and *Cryptosporidium* are provided in Table 1. *C. parvum* is less frequently identified in open range beef calves that are typical to Western Canada and the USA , however, when infection occurs in beef calves it is usually more severe than in dairy [2,6,7]. In the Canadian provinces of Alberta, Saskatchewan and British Columbia calves, mortality rates of up to 30% have been observed in beef calves. These cases of high *Cryptosporidium* mortalities are usually associated with the introduction of dairy calves to beef herds during the calving season and lack of herd immunity in certain herds, as most dairy animals have been exposed to cryptosporidium and developed natural immunity within the herd to the infection. *C. andersoni* usually infects post weaned beef and dairy calves and mature cattle, persisting for years if not life [8].

Table 1. Infection patterns of *Giardia* and *Cryptosporidium* in Cattle

	G. duodenalis	***C. parvum***	***C. andersoni***
Age of oocyst/cyst shedding	2 - 10 wks	1 - 5 wks	>7 wks
Duration of cyst Shedding	>30 wks	1 - 2 wks	5 mo - years
Age of peak shedding	Approx. 5 wks	1 - 2 wks	N/A
Age of onset of diarrhea	3 - 8 wks	1 - 2 wks	N/A
Duration of diarrhea	1 - 2 wks	1 - 3 wks	N/A
Duration of periparturient shedding	0 - 3 wks	0 - 2 wks	0 - 13 wks

C. andersoni infections can cause moderate to severe impairment of weight gain and decreased feed efficiency in feedlot cattle and a 3.2 kg per day reduction in milk production in diary cows. *Giardia* has been implicated as an etiological agent alone and in combination with other enteric pathogens in calf diarrhea [6, 9]. Concurrent infections with *Giardia* and *Cryptosporidium* were observed as the primary cause of diarrhea in calves < 30 days of age and *Giardia* alone was associated with diarrhea in calves > 30 days of age [6,9]. Giardia infection has been shown to influence performance in a number of animal species [10].

Transmission and Ecosystem Health

Transmission from one host to another is achieved by ingestion of an encysted, sporulated oocyst for *Cryptosporidium* or cyst for *Giardia*. Oocysts and cysts are discharged in the feces of infected cattle and are of primary importance for the dispersal and survival of the parasites [2]. Transmission can be direct from host to host, by ingestion of fecal contaminated food or water, or, as with other fecal transmitted parasites mechanical insect vectors are likely to play a role in transmission. Limiting factors for oocyst and cyst survival are high temperatures and desiccation. Transmission is likely to be direct between infected animals since environmental contamination on farms with oocysts and cysts would be insufficient to account for the high levels of infection seen in cattle, particularly with *Giardia*.

Although the transmission process is complex and the risk is low, there is a definite potential for *Giardia* and *Cryptosporidium* contamination of ground and surface waters from livestock operations. Management of faecal waste is crucial when water runoff can reach receiving surface water or contaminate groundwater. There are major concerns with applying fresh animal manure to fertilize agricultural land due to the potential for faecal pathogens to reach surface and/or groundwater. It is believed that the primary modes by which parasites such as *Giardia* and *Cryptosporidium* are transported to surface water are via the drainage from manure storage areas, direct contact by cows with water, runoff from fields on which manure has been spread and wash from manure-laden soil [2]. Parasites such as *Giardia* and *Cryptosporidium* have been associated with contamination of fruits and vegetables through contaminated irrigation water and manure fertilizer [2].

Giardia cysts have been shown to be viable for up to 84 days in cold river and lake water but are eliminated within a week when frozen or dessicated [11,14]. *Cryptosporidium parvum* oocysts are more environmentally resistant than are *Giardia* cysts. Oocysts can survive for several months in temperate climates in agricultural soil and are not inactivated until frozen below -4°C. *Cryptosporidium* oocysts are strongly resistant to most of the commonly used disinfectants, and chlorination of drinking water is not sufficient to prevent an infection [11,12]. Cattle manure requires careful management as *C. parvum* oocysts in agricultural soils and in manure pose a threat to surface water.

Public health significance

There is evidence of zoonotic cryptosporidiosis associated with farms and exposure to infected livestock, particularly young cattle, animal manure and contaminated water. Conclusions were often only circumstantial, with presumptions being made that run-off from pasture used for cattle, was the pre-disposing factor. With the advent of appropriate PCR-based molecular tools that could discriminate between different species/genotypes of *Cryptosporidium*, cattle have not been conclusively identified as the source of any waterborne outbreak within the USA and only one case in Canada [1,2]. Outbreaks caused by the bovine genotype in North America linked to direct contact with animals or contaminated food. There has been a steady accumulation of epidemiological data during 1998 to 2003 in which isolates of *Cryptosporidium* from human cases have been genotyped. Although *Cryptosporidium parvum* (Type 1, bovine genotype) is the most common zoonotic species other Cryptosporidium species have also been identified including *C. meleagridis*, *C. canis*, *C. felis* and *C. muris* [1,2]. In Europe Zoonotic sources of infection appear to be more common in Europe than North America or Australia.

Although beef and dairy cattle are commonly infected with *Giardia*, there is no evidence to support their role as reservoirs of infection in humans [2,14,15]. Studies which compared the prevalence and genotypes of beef and dairy in different geographical locations demonstrated >90% of cattle harbouring infections with the non-zoonotic livestock genotype (Assemblage E) of *G. duodenalis*.

Control and Treatment

Vaccination has been proposed a method to control cryptosporidiosis in animal populations. Immunodominant *Cryptosporidium* antigens have been identified from natural infections and subunit vaccines have been prepared and vaccination trials have been conducted in calves [16]. Using active and passive immunization approaches, vaccines have been shown to reduce clinical signs, but, in most cases, have not eliminated or reduced oocyst shedding. Many chemotherapeutic agents have been tested *in vitro* and *in vivo* for the treatment of cryptosporidiosis, but few agents have shown promise. Halfuginone lactate (Halocur®, Intervet) has recently been registered in Europe as a chemotherapeutic agent for cryptosporidiosis in domestic cattle. It has been shown to reduce incidence and severity of diarrhea but does not prevent oocyst shedding. Currently, there have no studies that have investigated the treatment of *Cryptosporidium andersoni* in the abomasum of feedlot or dairy cattle. Certainly, the impact of this infection on performance and production would warrant such studies.

Giardia duodenalis infection is able to produce humoral immunity that results in self-limiting infection in many animal species, but it has been shown that it takes greater than 100 days for the host to produce protective antibodies [17]. Lactating cows produce colostrum and milk with anti-*Giardia* activity thereby protecting young calves from infection [17]. A vaccine may have potential application in beef and dairy cattle. Benzimidazoles (fenbendazole, albendazole) have been shown to be effective in elimination of *Giardia* from confined and range calves [18]. Fenbendazole was also able to improve the mucosal microvillus structure and function within 7 days of initiating treatment [19]. Although these agents are highly effective reinfection frequently occurs if the sources of environmental contamination are not eliminated. The use of chemotherapeutic agents for the control of giardiasis in cattle provides the opportunity to enhance performance, reduce clinical signs and prevent environmental contamination.

Abstract

Cattle are frequently parasitized with an number of protozoan parasites but *Giardia duodenalis*, Cryptosporidium *parvum* and *Cryptosporidium andersoni* are of major zoonotic concern. These parasites case diarrhoea and impair body weight gain. *Giardia* and *Cryptosporidium* from cattle are potential zoonotic pathogens and contact with animals, manure or contaminated water is believed to lead to infections in humans. Molecular epidemiology has suggested that cattle are not as significant of a reservoir for human infections as was once believed. Most *Giardia duodenalis* from cattle (Assemblage E) is different from that found in humans (Assemblage A and B) and *Cryptosporidium andersoni* does not infect humans. Molecular tools have shown that humans can be infected with zoonotic *C. parvum* as well as anthroponotic *C. hominis.*

Résumé

Les ruminants sont souvent parasités par des protozoaires mais *Giardia duodenalis, Cryptosporidium parvum* et *Cryptosporidium andersoni* sont sans doute les plus importants du point de vue zoonotique. Ces parasites causent des diarrhées et des pertes de poids chez les bovins et les humains peuvent être infectés par contact avec les animaux, leurs déjections et l'eau. L'épidémiologie moléculaire suggère toutefois un impact minime sur les infections chez l'homme. Les types moléculaires (assemblages A et B) retrouvés chez les *Giardia duodenalis* isolés des bovins et ceux de *Cryptosporidium andersoni* ne sont pas retrouvés chez l'homme alors que celui-ci peut être atteint des cryptosporidioses causées par *C. Parvum* et *C. hominis.*

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