PREVALENCE AND CLINICAL IMPORTANCE OF CRYPTOSPORIDIUM AND GIARDIA IN HUMAN AND ANIMALS

M. A. Ehsan1*, M. Akter1, M. Ahammed2, M. A. Ali3 and M. U. Ahmed1

1Department of Medicine, 2Department of Pharmacology, Faculty of Veterinary Science, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh; 3Department of Pathology and Parasitology, Jhenaidah Govt. Veterinary College, Jhenaidah

ABSTRACT

The protozoan parasites Cryptosporidium and Giardia duodenalis are worldwide considered as an important cause of gastrointestinal disease in human patients and in animals. The high number of (oo) cysts excreted shortly after infection, together with the low infectious dose, results in an easy spread of infection. The aim of this literature review is to introduce Cryptosporidium and Giardia by addressing their taxonomy, life cycle, prevalence and clinical importance for both human and animals.

Key words: Prevalence, Cryptosporidium, Giardia, Clinical importance

INTRODUCTION

Access to safe drinking water and basic sanitation is a fundamental human right, but currently more than one billion people worldwide do not have access to either safe drinking water or adequate sanitation. It is estimated that almost 60% of deaths following diarrhoeal diseases in developing countries are attributable to lack of access to safe drinking water and basic sanitation, children under 5 being at the highest risk. Important water-borne diarrhoeal diseases are cryptosporidiosis and giardiasis (Xiao and Fayer, 2008; Geurden et al., 2009). These diseases are caused by the protozoan parasites Cryptosporidium and Giardia, respectively, which are able to cause disease in humans and animals. Because of their impact on socio-economic development, especially in developing countries, both Cryptosporidium and Giardia are since 2004 included in the ‘Neglected Disease Initiative’ of the World Health Organization (WHO) (Savioli et al., 2006).

However, Cryptosporidium and Giardia also pose an important risk on the safety of drinking water in developed countries. For example, in 1993 more than 400,000 people were affected by cryptosporidiosis in Milwaukee (Wisconsin, USA) due to an ineffective filtration process in the production of drinking water. Since this outbreak screening of tap water for the presence of Cryptosporidium has become compulsory in the UK, The Netherlands and the USA, but water-borne outbreaks are still reported on a regular basis.

The aim of this literature review is to introduce Cryptosporidium and Giardia by addressing their taxonomy, life cycle, prevalence and clinical importance for both human and animals.

Prevalence of Cryptosporidium in humans

In developed countries, the prevalence of Cryptosporidium generally is low in asymptomatic people (<1%) and in patients with diarrhoea (1-2%) (Current and Garcia, 1991; Guerrant, 1997; Geurden et al., 2009). In developing countries, high rates of asymptomatic carriage (10-30%) are common in comparison to patients with gastroenteritis (3-20%) (Current and Garcia, 1991; Haque et al., 2003). Among the common Cryptosporidium species in humans, C. parvum and C. hominis are responsible for >90% of human cases of cryptosporidiosis in developed nations (Xiao and Feng, 2008). The distribution of C. parvum and C. hominis in humans differs between geographic regions. In Europe, both C. parvum and C. hominis are common in humans (Leoni et al., 2006; Chalmers et al., 2009; Zintl et al., 2009). In the Middle East, C. parvum is the dominant species in humans.

*Corresponding e-mail address: amimul.med@bau.edu.bd

Copyright © 2016 Bangladesh Society for Veterinary Medicine All rights reserved 0361/2016
(Sulaiman et al., 2005; Pirestani et al., 2008). Geographic variations in the distribution of *C. parvum* and *C. hominis* can also occur within a country. For example, *C. parvum* is more common than *C. hominis* in rural areas in the United States and Ireland (Feltus et al., 2006; Zintl et al., 2009). In the rest of the world, especially developing countries, *C. hominis* is usually the predominant species in humans, responsible for 70-90% of the infections (Xiao and Feng, 2008). This suggests that zoonotic infection is much less common in developing countries than in developed countries.

Temporal and age-associated differences in the distribution of *C. parvum* and *C. hominis* infections have been reported. Peaks in *Cryptosporidium* infections have been observed in spring and late summer (Casemore, 1990). *C. parvum* was more prevalent in spring (in Ireland, the United Kingdom and New Zealand) and *C. hominis* was more prevalent in autumn (in the Netherlands, the United Kingdom and New Zealand) (McLauchlin et al., 2000; Learmonth et al., 2003, 2004; Hunter et al., 2004; Wielinga et al., 2008; Chalmers et al., 2009; Zintl et al., 2009). In The Netherlands, *C. hominis* was more commonly found in children and *C. parvum* more in adults (Wielinga et al., 2008). In the UK, *C. hominis* was more prevalent in infants less than one year, females aged 15-44 years and international travelers (Chalmers et al., 2008, 2009). *C. viatorum* was identified among travellers with gastro-intestinal symptoms returning to Great Britain from the Indian subcontinent (Elwin et al., 2012). In South American countries, a relatively high proportion of *C. meleagridis* infections has been identified in children and in immunocompromised patients (Cama et al., 2007, 2008; Meireles, 2010).

**Clinical importance**

*Cryptosporidium* is reported to infect people in at least 106 countries (Fayer, 2008). The most common clinical feature of *cryptosporidiosis* is diarrhoea. Characteristically, the diarrhoea is profuse and watery; it may contain mucus but rarely blood and leucocytes and it is often associated with weight loss. Other less common clinical features include abdominal pain, nausea, vomiting and low-grade fever. Occasionally, nonspecific symptoms such as myalgia, weakness, malaise, headache and anorexia occur (Current and Garcia, 1991).

The severity of a *Cryptosporidium* infection can vary from an asymptomatic shedding of oocysts to a severe and life-threatening disease. The duration and the severity of the symptoms and the outcome may vary with host factors such as the immune status of the person. Most immunocompetent persons experience a short-term illness with complete and spontaneous recovery (Current and Garcia, 1991). However, for immunocompromised patients, cryptosporidiosis can be a critical illness with persistent symptoms leading to dehydration and wasting (O’Donoghue, 1995; Chen et al., 2002; Blackburn et al., 2004), and eventually leading to death (Juranek, 1995; Manabe et al., 1998). In addition, *Cryptosporidium* infections can cause atypical manifestations in immunocompromised patients, such as biliary tract disease, respiratory tract disease and pancreatitis (Hunter and Nichols, 2002).

The severity of the infection is also related to the age of the patient. Diarrhoea is a leading cause of illness and death among children aged <5 years in developing countries and *Cryptosporidium* is one of the most important diarrhoeal pathogens (Shirley et al., 2012). Children are more likely to be infected with *Cryptosporidium*, which can be explained by a lack of an effective immunity at this age. In a study of 191 children with *C. parvum* in Uganda, 13% died, compared with 6% for children without *C. parvum* (Tumwine et al., 2003). Wielinga et al. (2008) found that the majority (80%) of the human cases were children aged between 0 and 9 years and >70% of these were caused by *C. hominis*. *C. hominis* is more common than *C. parvum* in children and is associated with heavier infections and greater growth shortfalls, even in the absence of symptoms (Bushen et al., 2007). Patients >25 years of age were infected mainly with *C. parvum*.

The clinical symptoms may also depend on the parasite species involved. Infections with *C. hominis* are associated with diarrhoea, nausea, vomiting, malaise and non-intestinal sequelae such as joint pain, eye pain, recurrent headache and fatigue, whereas infections with *C. parvum*, *C. meleagridis*, *C. canis* and *C. felis* cause only diarrhoea (Bouzid et al., 2013).

**Prevalence of Cryptosporidium in animals**

Cattle are commonly infected with *C. parvum*, *C. andersoni*, *C. bovis* and *C. ryanae* (Xiao, 2010). In dairy cattle, *C. parvum* is mostly found in pre-weaned calves, *C. bovis* and *C. ryanae* in weaned calves and *C. andersoni* in yearlings and adult cattle (Fayer et al., 2006b, 2007; Santin et al., 2008). Parasite prevalence varies from 1% (Kváč et al., 2006) to 59% (Olson et al., 1997) in individual calves and up to 100% on farm level.
Prevalence and clinical importance of Cryptosporidium and Giardia

(Santín et al., 2004). The highest prevalence is observed in calves under the age of 5 weeks (Quiñez et al., 1996). The prevalence of Cryptosporidium in flocks of small ruminants varies considerably, ranging from 5% to 70% for sheep and from 5% to 35% for goats. This difference in prevalence results can be explained by differences in age of the animals, management, and diagnostic methods applied (Robertson, 2009). C. xiao,C. ubiquitum and C. parvum are the predominant species in small ruminants (Ryan et al., 2005; Goma et al., 2007; Santín et al., 2007; Geurden et al., 2008a; Mueller-Doblies et al., 2008; Pritchard et al., 2007, 2008; Quiñez et al., 2008; Yang et al., 2009; Díaz et al., 2010; Wang et al., 2010; Tzanidakis et al., 2014).

In pigs, herd prevalences range from 8% to 100% with individual animal infection rates of between 1% and 34%. C. suis (36-83%) and C. scrofarum (formerly Cryptosporidium pig genotype II) (9-61%) are the major Cryptosporidium spp. (Kváč et al., 2009; Chen et al., 2011; Budu-Amoako et al., 2012). C.suis preferentially infects suckling piglets, whereas C. scrofarum is more frequently found in weaners (Langkjaer et al., 2007; Johnson et al., 2008; Kváč et al., 2009; Yin et al., 2013; Zhang et al., 2013). Occasionally, C. muris (Kváč et al., 2009; Budu-Amoako et al., 2012; Němeč et al., 2013) or C. tyzzeri (Kváč et al., 2012) are found in pigs. With the exception of one study where C. parvum was the predominant species (Farzan et al., 2011), this species less frequently found in pigs, suggesting that pigs are not an important source of zoonotic transmission (Chen and Huang, 2007; Zintl et al., 2009; Budu-Amoako et al., 2012; de la Fé Rodríguez et al., 2013; Němeč et al., 2013).

Low prevalences of Cryptosporidium have been reported in horses in the USA (7%) and Italy (8%) (Burton et al., 2010; Veronesi et al., 2010). Both C. parvum and Cryptosporidium horse genotype were found in horses (Ryan et al., 2003; Chalmers et al., 2005; Grinberg et al., 2008; Veronesi et al., 2010) and rarely the hedgehog genotype (Laatamna et al., 2013). These findings support a potential role of infected horses in zoonotic transmission.

A Cryptosporidium prevalence ranging from 0% to 13% has been reported in privately owned and stray dogs (Chermette and Blondel, 1989; Grimason et al., 1993; Diaz et al., 1996; Giangaspero et al., 2006; Claerebout et al., 2009; Yoshiuchi et al., 2010; Bajer et al., 2011). Most infections in dogs are caused by the host-specific C. canis. In addition to C. canis, other Cryptosporidium spp. were detected occasionally in dogs such as C. Muris (Lupo et al., 2008; Ellis et al., 2010), C. Parvum (Hajdušek et al., 2004; Giangaspero et al., 2006; Sotiriadou et al., 2013) and C. Meleagridis (Hajdušek et al., 2004). Thus the risk of zoonotic transmission from Cryptosporidium-infected dogs is low (Lucio-Foster et al., 2010; Uehlinger et al., 2013).

Cryptosporidium has been detected in cats with a range of 2% to 25% (Rambozzi et al., 2007; Hoopes et al., 2013). In addition to the cat specific species, C. felis, C. parvum and C. muris were also identified (Palmer et al., 2008; Yoshiuchi et al., 2010; FitzGerald et al., 2011; Scorza et al., 2011; Sotiriadou et al., 2013).

Veterinary importance

C. parvum is a well-known cause of diarrhoea in neonatal ruminants. Clinical symptoms are most frequently observed in calves between the age of 5 days and 1 month and include profuse watery diarrhoea with acute onset, lethargy, anorexia and dehydration, which is usually self-limiting within 2 weeks (O’Handley et al., 1999; Schnyder et al., 2009). Mortality is variable and is most often observed in calves with multiple infections and in certain beef breeds, such as the Belgian Blue and White (de Graaf et al., 1999) and it can be as high as 30% (Olson et al., 2004). However, morbidity in endemic herds can be as high as 100% (Santín et al., 2008). Abomasal cryptosporidiosis, caused by C. andersoni, does not result in any visible clinical signs (Kváč et al., 2008). Infections with C. andersoni do not cause diarrhoea and follow a more chronic course than infections with C. parvum (Kváč and Vitovec, 2003). C. andersoni infections may result in a decrease in daily weight gain, decreased feed efficiency and less milk production (Anderson, 1987; Esteban and Anderson, 1995; Ralston et al., 2003).

Cryptosporidium is a major cause of neonatal diarrhoea in lambs, usually within the first 2 weeks of life and diarrhoea can be mild to severe. Cryptosporidiosis outbreaks in lambs are most common in crowded flocks and are associated with a decrease in liveweight, dressing percentage, growth rate and carcass productivity (Angus et al., 1982; Alonso-Fresín et al., 2005; Sweeney et al., 2011; de Graaf et al., 1999; Sari et al., 2009). Caprine cryptosporidiosis is characterised by diarrhoea and mortality in kids. Morbidity can reach 100% and mortality 50% in some herds (Vieira et al., 1997; Johnson et al., 1999; Sevín, et al., 2005; Paraud et al., 2010; Santín, 2013).
Diarrhoea is the major clinical sign in foals affected by cryptosporidiosis. Foals are more susceptible to the infection than older animals (Grinberg et al., 2003; 2009; Veronesi et al., 2010) and most Cryptosporidium infections in adult horses are asymptomatic (Majewska et al., 2004; Sturdee et al., 2003). Inappetance, depression, vomiting and/or diarrhoea developed in piglets experimentally infected with C. parvum, whereas mild or no clinical signs developed with C. suis (Enemark et al., 2003). However, an association between diarrhoea and infections with C. suis and C. scrofarum in nursing piglets has been described (Hamnes et al., 2007). In contrast, other studies did not find any significant association between diarrhoea and cryptosporidial infections (Quilez et al., 1996; Maddox-Hyttel et al., 2006, Vitovec et al., 2006).

Cryptosporidiosis in dogs has been reported in both asymptomatic and diarrhoeic dogs (Santin and Trout, 2008). Infections with C. canis are usually asymptomatic but severe diarrhoea, malabsorption, weakness and weight loss have been reported (Irvin, 2002; Miller et al., 2003). Dogs infected with C. muris showed chronic vomiting and profuse diarrhoea in one study (Ellis et al., 2010) but in another study no gastrointestinal signs were observed (Lupo et al., 2008).

Cryptosporidium oocysts were detected more frequently in cats without diarrhoea than in cats with diarrhoea (Sabshin et al., 2012) and shedding of Cryptosporidium oocysts without the presence of clinical signs was reported in experimentally and naturally infected cats (Mtambo et al., 1991; Nash et al., 1993; Fayer et al., 2006c). However, oocysts were also detected in the faeces of cats with persistent diarrhoea (Goodwin and Barsanti, 1990; Lent et al., 1993; Morgan et al., 1998).

Prevalence of Giardia in humans

In developed countries Giardia is detected in up to 14% of symptomatic patients and 2% in asymptomatic humans (Geurden et al., 2009; Homan and Mank, 2001). In developing countries, the prevalence of giardiasis in patients with diarrhoea is around 20%, ranging from 5-43% (Islam, 1990; Haque et al., 2005). Giardia infections are very common in children in developing countries (Farthing, 1994; Rabbani and Islam, 1994). Giardia assemblages A and B are considered more infectious for humans, with the latter being more prevalent. Sub-assemblage AII is more prevalent in humans than AI and is distributed globally, except in Asia and Australia. Assemblage AIII has not yet been detected in humans (Sprong et al., 2009). The geographic distribution of sub-assemblages BIII and BIV in human shows marked difference between continents. In Africa, infection with BIII is more prevalent (81%) than with BIV, whereas the opposite is found in North America where 86% of infections are associated with BIV and 14% with BIII. A more balanced distribution was found in Australia and Europe (Sprong et al., 2009). To a much lesser extent, assemblage C, D, E and F were identified in human samples (Gelanew et al., 2007; Foronda et al., 2008). However, it remains unclear whether the presence of these assemblages in human stool is due to patent infections or merely represents passage through the intestinal tract.

Clinical importance

Approximately 200 million people in Asia, Africa and Latin America have symptomatic infections with about 50,000 cases reported each year (Xiao and Fayer, 2008). In symptomatic patients, mostly children, the severity of symptoms and the duration of Giardia infection are highly variable. In some patients, symptoms last for only 3 or 4 days, while in others the symptoms last for months. Higher prevalence of chronic Giardia infection in patients with immunodeficiency supports that the failure to develop an effective immune response against Giardia may account for the chronicity of the infections (O’Handley et al., 2003). In developed countries, the incidence rate peaks at the age of 1-4 years (Flannagan, 1992); a second peak is observed at the 20-40 age groups, partly due to the care for the young children and partly due to travelling (Medema, 1999). The main symptoms include diarrhoea, abdominal pain, nausea, vomiting, flatulence, anorexia and fever (Nash et al., 1987; Farthing, 1996; Katz et al., 2006). In most instances the diarrhoeal illness is short-lived and self-limited. However, a proportion of individuals develop persistent diarrhoea (Farthing, 1996; Katz et al., 2006), sometimes accompanied by malabsorption of sugars and fat and by weight loss. There is evidence that infection with Giardia results in ‘failure to thrive’ in children, by impairment of the uptake of nutrients (Farthing, 1994; Hall, 1994). A high prevalence of chronic fatigue syndrome has been reported as a post-infection sequel in patients (Naess et al., 2012; Wensaas et al., 2012; Mørch et al., 2013).
The relation between clinical symptomatology and the Giardia genotype is controversial. In a study in The Netherlands, assemblage A isolates were solely detected in patients with intermittent diarrhoeal complaints, while assemblage B isolates were present in patients with persistent diarrhoeal complaints (Homan and Mank, 2001). A strong correlation between infection with assemblage B and diarrhoea was observed in Saudi children (Al-Mohammed, 2011). An association between assemblage B and flatulence in children was reported by Lebbad et al. (2001). A strong correlation between infection with assemblage B and diarrhoea was found (Guerrant et al., 1983; Schorling et al., 1990; Hollm-Delgado et al., 2008; Boeke et al., 2010). In both volunteers and outbreak situations, a sizable proportion of the infected subjects are asymptomatic, often exceeding the proportion with manifest clinical illness (Muhsen and Levine, 2012). It has been estimated that between 50% and 75% of Giardia-infected persons may be asymptomatic (USEPA, 1998a). Children with asymptomatic Giardia infection serve as unidentified carriers and may be responsible for transmission of the infection. Secondary transmission among family members may occur. Asymptomatic infections may last for months or years (ICAIR, 1984).

Prevalence of Giardia in animals

In calves younger than six months, the prevalence varies between 17% (Muhid et al., 2012) and 73% (Olson et al., 1997) and on farm level it can be as high as 100% (Olson et al., 2000; Geurden et al., 2010, 2012). In cattle the livestock specific assemblage E is most prevalent, although up to 59% zoonotic assemblage A isolates and mixed infection with both A and E have been reported (Geurden, 2010, 2012). In contrast, Read et al. (2002) found that assemblage B genotypes were more prevalent in asymptomatic children than those of assemblage A and according to Haque et al. (2005, 2009) only assemblage A was an important cause of diarrhoea in children in Bangladesh. A systematic review and meta-analysis confirmed that Giardia infections of both assemblages A and B can cause acute or persistent diarrhoea (Muhsen and Levine, 2012).

However, Giardia infections are often asymptomatic. In some studies no significant association between Giardia and diarrhoea was found (Guerrant et al., 1983; Schorling et al., 1990; Hollm-Delgado et al., 2008; Boeke et al., 2010). In both volunteers and outbreak situations, a sizable proportion of the infected subjects are asymptomatic, often exceeding the proportion with manifest clinical illness (Muhsen and Levine, 2012). It has been estimated that between 50% and 75% of Giardia-infected persons may be asymptomatic (USEPA, 1998a). Children with asymptomatic Giardia infection serve as unidentified carriers and may be responsible for transmission of the infection. Secondary transmission among family members may occur. Asymptomatic infections may last for months or years (ICAIR, 1984).

The prevalence of Giardia in pigs ranges from 1% to 51% (Armson et al., 2009; Farzan et al., 2011; Budu-Amoako et al., 2012). The herd prevalence was 18%, 22% and 84% for sows, piglets and weaners in Denmark (Maddox-Hyttel et al., 2006) and 12% in Zambia (Siwila and Mwape, 2012). DNA sequencing demonstrated that assemblage E was the most common genotype in Australia and the UK (Armson et al., 2009; Minetti et al., 2013), while in Canada assemblage B was predominant (Farzan et al., 2011). Assemblage A was found in both weaners and piglets in Denmark (Langkjaer et al., 2007) and in pigs in Australia (Armson et al., 2009). Unexpectedly, the canine-specific assemblages C and D and the feline-specific assemblage F were also found occasionally in pigs in different countries (Langkjaer et al., 2007; Armson et al., 2009; Minetti et al., 2013). As for humans, it remains unclear whether the presence of these assemblages represents a patent infection or merely indicates carriage.

The prevalence of Giardia in horses was 1% in Brazil (De Souza et al., 2009), 9%-23% in Italy (Veronesi et al., 2010; Traversa et al., 2012) and 17% in Colombia (Santín et al., 2013). G. duodenalis isolates from horses belonged predominantly to the zoonotic assemblages A and B (Traub et al., 2005; Traversa et al., 2012; Santín et al., 2013) and to a lesser extent to assemblage E (Veronesi et al., 2010; Traversa et al., 2012). In dogs, the prevalence of Giardia infections varies from 1% to 55% (Itoh et al., 2005; Jafari Shoorijeh et al., 2008). The most prevalent assemblages in dogs are the dog-specific assemblages C and D (Beck et al., 2012) but other sub-assemblages such as AI, AII, BII and BIV are also detected in dogs worldwide (Souza et al., 2007; Palmer et al., 2008; Claerebout et al., 2009; Sprong et al., 2009), sometimes in higher frequencies than the dog-specific assemblages (e.g. Leonhard et al., 2007; Claerebout et al., 2009; Covacin et al., 2011).

Worldwide the prevalence of Giardia in cats ranges from 1%-40% (De Santis-Kerr et al., 2006; Itoh et al., 2006; Gow et al., 2009; Muhsen and Hossein, 2009; Mircean et al., 2011; Sabshin et al., 2012). Assemblage F and sub-assemblage AI are predominant but assemblage D and sub-assemblages AIH, AIIH were also detected in cats (Papini et al., 2007; Souza et al., 2007; Palmer et al., 2008; Sprong et al., 2009).
Veterinary importance

Although *G. duodenalis* is recognised worldwide as the most common parasitic cause of gastrointestinal disorder in human patients, the relevance of infection in production animals is open to debate (Geurden et al., 2010). The clinical signs may vary considerably between animals and animal species due to the involvement in the pathogenesis of giardiosis of both parasite and host factors. This lack of consistency in clinical outcome resulted in the perception that *Giardia* is not a major cause of clinical disease in ruminants. However, several studies reported clinical signs caused by *Giardia* both in natural infections (St. Jean, 1987; O’Handley et al., 1999; Aloisio et al., 2006; Geurden et al., 2006b) and in experimental infections (Olson et al., 1995; Geurden et al., 2006a). Infection can result in diarrhoea that does not respond to antibiotic or coccidiostatic treatment. The excretion of pasty to fluid faeces with a mucoid appearance may be indicative for giardiosis, especially when the diarrhoea occurs in young animals.

A study in dairy calves showed that calves did not begin to excrete *Giardia* cysts until approximately 1 month of age. Passive immunity through colostrum may have the potential to provide initial protection against *Giardia* infections as colostrum contains a high level of anti-*Giardia* antibodies. Failure to develop a humoral immune response from natural infections by these calves could account for the high prevalence and chronic duration of the infections (O’Handley et al., 2003).

In pigs, a significant association was found between the presence of assemblage E and soft to diarrhoeic stool, whereas assemblage A was not correlated with diarrhoea (Armsn et al., 2009). This is in contrast to previous studies that have reported no association between *Giardia* infections in pigs and diarrhoea (Maddox-Hytte et al., 2006, Hamnes et al., 2007; Langkjaer et al., 2007). Next to diarrhoea, there is an economic impact of giardiosis for farmers. In goat kids and lambs an experimental infection resulted in a decreased feed efficiency and subsequently a decreased weight gain (Olson et al., 1995; Sweeney et al., 2011, 2012). Infections with *Giardia* in dogs and cats are common. Clinical signs vary from asymptomatic to small bowel diarrhoea and associated discomfort (Fiechter et al., 2012).

**REFERENCES**

Prevalence and clinical importance of Cryptosporidium and Giardia


Prevalence and clinical importance of Cryptosporidium and Giardia


Prevalence and clinical importance of Cryptosporidium and Giardia


