

## Chapter 2

# Transmission Routes and Factors That Lend Themselves to Foodborne Transmission

Transmission of *Cryptosporidium* infection occurs when an appropriate number of infectious *Cryptosporidium* oocysts are ingested by a susceptible host. Transmission can be hand-to-mouth and may be associated with unhygienic conditions or high-risk behaviour. Although sporadic cases of cryptosporidiosis in the community can be of individual clinical significance, particularly if the infected person is immunocompromised, the major public health importance of *Cryptosporidium* lies in the potential for outbreaks to occur when drinking water, recreational water or food become contaminated with infectious *Cryptosporidium* oocysts. Such contamination can result in several individuals becoming infected via the same transmission vehicle, and, for drinking water in particular, this can be of considerable community and economic importance, with tens, hundreds or even thousands of people at risk of infection (Clancy and Hargy 2008). Additionally, when a large-scale outbreak occurs, with many infections occurring simultaneously in a particular community due to contamination of a common vehicle, then, due to the excretion of yet more oocysts into the environment, the potential for subsequent environmental contamination increases accordingly and thus the potential for secondary spread.

Particular factors in the biology of *Cryptosporidium* mean that this parasite is particularly suited to foodborne or waterborne transmission. These are:

- The large numbers of infective oocysts that are excreted by an infected individual into the environment (calves infected with *C. parvum* may produce as many as  $6 \times 10^7$  oocysts per gram of faeces, and a single infected calf may excrete  $4 \times 10^{10}$  oocysts during its second week of life and  $6 \times 10^{11}$  oocysts during its first month of life; Uga et al. 2000; Nydam et al. 2001)
- The relatively low infectious dose
- The robustness of the oocyst and its ability to survive in the environment; experimental results suggesting that oocyst viability is retained for at least a month in damp conditions and in the absence of freeze-thaw cycles (Robertson et al. 1992; Robertson and Gjerde 2006) and that oocysts are to some extent resistant to commonly used disinfectants such as chlorine (King and Monis 2007)

- The relatively small size of the oocysts (3–5  $\mu\text{m}$  in diameter) that enables penetration of sand filters used in the water industry
- The possibility for zoonotic transmission for some species of *Cryptosporidium*—this means that there is greater potential for environmental spread and contamination
- The possibility for onward contamination or transfer by transport hosts such as insects; promiscuous-landing synanthropic flies have been particularly associated with the carriage of protozoan parasites to food (Conn et al. 2007)

Taken together, not only do these factors mean that there is a high potential for possible vehicles of infection such as food or water with *Cryptosporidium* oocysts but also that they will probably survive on such vehicles in sufficient quantities to pose an infection risk to susceptible hosts.

It is worth noting that in a recent risk ranking of foodborne parasites (<http://www.fao.org/food/food-safety-quality/a-zindex/foodborne-parasites/en/> and <http://www.who.int/foodsafety/micro/jemra/meetings/sep12/en/>; see also Robertson et al. 2013), *Cryptosporidium* was ranked as number 5 out of 24 potentially foodborne parasites in terms of importance as a foodborne pathogen, exceeded only importance by *Taenia solium*, *Echinococcus granulosus* and *Echinococcus multilocularis* and *Toxoplasma gondii*. This relatively high ranking (compared with, e.g. *Giardia duodenalis* that was ranked in position 11) reflects not only our increasing awareness of cases and outbreaks of foodborne cryptosporidiosis, but also the lack of an effective treatment and the importance of cryptosporidiosis as a significant cause of morbidity and mortality, particularly in children in developing countries (Kotloff et al. 2013). In this risk-ranking exercise, fresh produce, fruit juice and milk are listed as the food commodities that are most likely to act as transmission vehicles for *Cryptosporidium*, with these choices based on the documented outbreaks of cryptosporidiosis recorded in the literature (Robertson et al. 2013).

Cryptosporidium as a Foodborne Pathogen

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2014, VI, 90 p.,

ISBN: 978-1-4614-9378-5