A One Health approach to solutions in *Cryptosporidium* control

The protozoan parasite *Cryptosporidium parvum* is widespread in the environment and is well documented as a major cause of neonatal enteritis in farm livestock, particularly calves, which are considered to be the main reservoirs of the parasite. With no vaccine or cure currently available, *C. parvum* can cause serious disease, production losses and deaths in neonatal calves and occasionally in lambs. It is also a zoonotic pathogen and is responsible for almost half of the human cases of cryptosporidiosis diagnosed in the UK, usually by direct contact with animals or through water transmission. A One Health approach, involving the veterinary, medical and water industries, has been adopted to provide solutions to control cryptosporidiosis in livestock, humans and in the environment. This article will explore the management solutions available, focusing on the results of a whole catchment project, where public health and water quality were compromised by *C. parvum* contamination from livestock and wildlife. Solutions were provided, based on the project data, to assist livestock farmers to control cryptosporidiosis on farm and the water industry to reduce the levels of parasite reaching public water supplies. The impact of the project will be discussed in terms of reduction of disease in neonatal calves with associated economic and welfare benefits; reduced contamination of the public water supply and associated benefits in public health.

Introduction

The protozoan parasite *Cryptosporidium parvum* is well documented as a major cause of neonatal enteritis in farm livestock, particularly calves, which are considered to be the main reservoirs of the parasite[1]. With no vaccine or cure available, *C. parvum* can cause serious disease and production losses in neonatal calves and occasionally in lambs. Cattle are known to be the main *C. parvum* reservoirs and as such, on-farm control of the parasite, where it is present, is essential for animal health, welfare and production. Recent research has shown that clinical cryptosporidiosis in young beef calves reduced growth rates for the subsequent six months of the calves' lives, amounting to an average reduction of 34kg per calf[2] which represents a substantial economic loss. It is therefore in the interests of livestock farmers to implement best practice measures of parasite control. On-farm *C. parvum* control is important for public as well as animal health as it is a zoonotic pathogen responsible for almost half of human cases of cryptosporidiosis reported in the UK[3]. Transmission to humans is most likely to occur through direct contact with an infected animal. However, water also plays an important role in the transmission of *Cryptosporidium* to humans, as the oocysts are very tough, survive well in ambient temperatures and damp environments and are resistant to routine chemical water treatments[4]. In addition, oocyst transmission from livestock to water is an issue as livestock pasture frequently surrounds catchment areas collecting water ultimately destined for human consumption. This causes problems for the water industry and the public, illustrated by the fact that the majority of large-scale outbreaks of cryptosporidiosis worldwide have been due to the consumption of contaminated water.

A Case Study of One Health Approaches to Improve Calf Health, Water Quality and Public Health

It is evident that an approach involving veterinary, medical and environmental input is required to provide solutions to enable the control of this parasite[5] and the case study featured here provides an example of how the health of livestock, wild animals, the environment and people interconnect[6]. The project took place in a catchment with historically recurrent instances of contamination in the public water supply, resulting in human sickness, and hospitalisation in at least one patient, so a collaborative approach was adopted between the Moredun Research Institute and Scottish Water, to investigate the source of the contamination issues and to use the data collected to provide evidence-based solutions. Sampling from livestock, wild deer herds sharing livestock grazing and water courses was central to the project. The farms in the study were four upland farms situated in the catchment surrounding the public water supply in question. These were mixed livestock enterprises comprising beef cattle (indoor spring calving) and sheep (mainly outdoor lambing). All farms reported ongoing issues with *Cryptosporidium* infection in neonatal calves, including calf losses and clinical disease, although no clinical cryptosporidiosis was reported in lambs on any of the farms.

Using *Cryptosporidium* oocyst and DNA extraction methods developed at our company[7] along with a nested species-specific multiplex PCR[8], molecular typing of faecal samples from cattle, calves, ewes, lambs and wild red deer for *C. parvum* was performed. *C. parvum* prevalence was high on all the farms tested and in all livestock species, but unexpectedly high in adult cattle. High proportions of *C. parvum* have previously been reported in lambs and calves [9,10], but it is unusual to find such high *C. parvum* prevalence in adult cattle and sheep[11,12]. This, alongside the fact that high levels of the parasite were evident in red deer and the water system, indicated extensive environmental contamination with the parasite. Further genotyping of

C. parvum positive samples, using multi-locus fragment typing (MLFT)[13] indicated that the source of *C. parvum* parasites in the environment was not only livestock, but wild red deer herds were also contributing to *C. parvum* loading. Evidence of shared genotypes between farms, livestock, wildlife and water indicated that all livestock and wildlife tested potentially had a role to play in *C. parvum* contamination of the water sources and, as such, represented a public health concern. Results also illustrated that transmission of the parasite was evident between livestock and wildlife, most likely due to shared access to hill and enclosed grazing[6].

Implementing Management Changes to Control *C. parvum* on Farm

As livestock were deemed to be the main source of *C. parvum* oocysts, the central focus to enable livestock management changes was on knowledge exchange between researchers, farmers, vets, land managers and the water industry. At the farm level, the data confirmed that *C. parvum* was one of the main causes of diarrhoea in neonatal calves, which reflects data from the UK as a whole as provided by the Veterinary Investigation Diagnosis Analysis reports (http://apha.defra.gov.uk/vet-gateway/surveillance/scanning/vida.htm). Well attended on-farm and evening meetings were held between researchers, farmers and farm vets to discuss management options to improve calf health, particularly with regard to *Cryptosporidium* control. As there is currently no vaccine and only two licensed products available to alleviate the symptoms of cryptosporidiosis, control relies heavily on hygiene, biosecurity, nutrition and effective colostrum management. Information was given in the form of presentations, discussions and a fact sheet which included best practice advice for parasite reduction, including:

- Good hygiene: Thorough mucking out, steam cleaning and disinfecting calving sheds and all pens and gates before calving, using a disinfectant effective against *Cryptosporidium*. This is critical as many of the common farm disinfectants will NOT kill *Cryptosporidium*
- Keep calving sheds as clean as possible throughout calving including frequent deep bedding with clean straw to break the faecal oral route of parasite transmission
- Ensure all calves obtain the full amount of maternal colostrum as soon as possible after birth – follow the 3Qs advice: Quick, quality, quantity, as this is the most important thing you can do for the health of your calf
- Ensure good, balanced nutrition of the dam in pregnancy – consult an animal nutritionist to formulate a ration for your cattle including attention to micronutrient levels
- Vaccinate dams to protect calves against other scour causing pathogens such as rotavirus and coronavirus
- Reduce calf-to-calf transmission by separating calves into age groups within a 2/3 week age range if at all possible. Older calves may be immune to this disease but can still shed *C. parvum* oocysts and are a risk to young calves
- Practice strict biosecurity when buying in or mixing groups of calves
- See www.moredun.org.uk/research/diseases/biosecurity and

- www.msd-animal-health-hub.co.uk/DNOMF/ Biosecurity for further information

Each participating farm received a report on their individual farm results, highlighting where best practice was not being followed and improvements to calf management could be made. Follow-up discussions with the farmers resulted in all four farms implementing at least one of the above recommendations. Feedback from farm visits in the subsequent spring noted a reduction in clinical disease in the numbers of scouring calves that required treatment, thereby illustrating an improvement in animal health and welfare.

Implementing Land Management Changes at the Source of the Public Water Supply to Improve Water Quality

As a first step, it was crucial to try and reduce, as much as possible, the *Cryptosporidium* oocysts being shed by livestock in to the environment and hence to water courses, but there were also potential improvements that could be made to the infrastructure in the catchment surrounding the public water supply intake. The landowners and tenant farmers involved, in partnership with Scottish Water, applied for and were awarded Payment for Ecosystem Services (PES) to enable land management improvements of the catchment immediately surrounding the water supply intake. Water troughs were provided in each field surrounding the water supply intake and livestock fencing was erected, resulting in grazing exclusion and subsequent creation of riparian woodland. This had the effect both of keeping faecal material from livestock away from the intake and also reducing the overland flow of oocysts from the grazed fields into the water course. Prior to fencing the catchment, animals were able to access the water course above the water supply intake, resulting in high turbidity and parasite contamination. Once the fences were erected, turbidity and water quality improved as reported by Scottish Water. Historical records from this public water supply recently provided by Scottish Water illustrated that in the six months before the water supply improvements, there were **21 raw water** *Cryptosporidium* oocyst positive samples obtained from routine sampling and **16 final water** positives, compared to the **two years** following improvements when there was a significant reduction in contaminated samples to only **two raw water** positives and **one final water** positive. Updated figures for 2018 show that there were no *Cryptosporidium* positive samples identified in either the raw or final water samples. There also has been no further reported human illness from cryptosporidiosis in the area following the catchment land management improvement scheme and no further condemnation of the supply due to *Cryptosporidium* contamination. It is evident that this PES scheme reduced water treatment costs; improved water quality and fish habitat and enhanced biodiversity with associated landscape benefits. Reduction in oocyst burden in this catchment led to healthier livestock and increased production efficiency, improved food security and reduced risk to the human population. This project illustrates that engaging and collaborating with all stakeholders involved in catchment land-use is crucial to satisfactory outcomes. When this involves **Cryptosporidium**, management options frequently have benefits for all.

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