**Cryptosporidium movement in water- impact of eutrophication and climate change on the zoonotic disease agent**

**Lead Supervisor Name**

Professor Jo Cable

**Lead Supervisor Contact Details**

Cablej@cardiff.ac.uk

**Lead Supervisor Location/Student Home Institution**

Institution: Cardiff

School: BIOSI

**Full Project Description**

Cryptosporidium is a human pathogen unknown until the mid-1970s; in 1993 0.4 million people were infected in Milwaukee following a water treatment failure, and since then, large outbreaks throughout the developed world (most recently Sweden, 2010) have kept the parasite in the public eye. Infected hosts release up to 109 oocysts per day, and the discovery of a single oocyst forces closure and loss of drinking water supplies (e.g. NW England 2015, 0.3 million homes affected). In rural Wales, the main source of contamination is point source release of oocysts into water catchments from infected dairy or beef cattle farms located in rural communities. These multiple sources of contamination are difficult to diagnose and monitor, and almost impossible to eliminate due to costs of complex methodologies. The huge excess production of oocysts compared to the infective dose (only 10 oocysts can start an infection) suggests that in the natural environment, most oocysts are removed biotically, probably by grazing and suspension feeding invertebrates and protists. These interactions may be adversely affected by eutrophication (connected with land use and climate change), increasing the importance of Cryptosporidium in both the developing world and in ‘Blue Marble’ situations within the developed world. This project will test these hypotheses using a combination of Next Generation Sequencing to identify Cryptosporidium oocysts within communities of invertebrate grazing organisms in response to water eutrophication and laboratory experiments to directly establish the link between Cryptosporidium clearance and grazer community structure, linked by agent-based simulation modelling to predict the impact of eutrophication on Cryptosporidium clearance from freshwater. Laboratory experiments with oocysts grown in vitro in the Cardiff Cryptosporidium Bioreactor will establish the potential of relevant invertebrates to ingest, digest or transport oocysts. Immunofluorescence staining, qPCR and infectivity assays will be used to assess the potential of invertebrates for oocyst clearance. Functional responses, and the impact of nitrogen eutrophication and turbidity on clearance by important grazers will be established. Field studies will utilise sites in Wales (identified through Welsh Water and the Water Research Centre at Cardiff) along gradients of nitrogen eutrophication (due to e.g. different land use) established using standard techniques. NGS with environmental metabarcoding, and conventional screening of the biota samples into biologically relevant categories, will be used to establish the response of the aquatic community to eutrophication, while the environmental abundance of Cryptosporidium oocysts in these samples will be estimated from NGS data. The infectivity of Cryptosporidium oocysts from Welsh study sites will be established, and the faith of the oocysts under different environmental conditions (e.g. flooding, climate change) will be experimentally assessed. Results will be integrated using agent based modelling approaches to establish the importance of the aquatic biota in clearance of Cryptosporidium from the environment, and to develop hypotheses concerning the response of this clearance activity to human influences such as water eutrophication and to change in the environment (floods, climate change).

**Real Life challenges this project will address**

Cryptosporidium contamination of drinking water is a major challenge in the developed world, where discovery of a single oocyst may lead to closure of the water supply for substantial periods of time (e.g. NW England, United Utilities outbreak, 2015). In the developing world, prevalence may be 20% in infants (Doendenkers survey, Malawi) and the pathogen may kill up to 0.2 million infants in sub-Saharan Africa annually. In rural Wales, the risk is from point source contamination from infected cattle farms; rural communities are at risk of infection from multiple sources, and the high-tech methodologies of killing oocysts are impractical. Approaches which encourage biological removal of oocysts from the water supply represent a cost-effective approach to reduce the burden of control of Cryptosporidium in the water supply.

**What you should know about this project**

This project will suit a student who wants to learn state-of-art cell culturing techniques, next generation sequencing methodology and modelling approaches used in biology. Basic experience in working in a biological laboratory is necessary, as well as willingness to learn how to handle human pathogens during experiments. The project will involve fieldwork, so it is ideally suited for someone who likes to combine sampling in the field with laboratory work and computer analysis. The supervisory team includes parasite ecologists, Cryptosporidium epidemiologist, microbial phylogeneticist, Cryptosporidium cell culture specialist, Public Health Wales expertise and also is able to provide support in next generation sequencing analysis and modelling.

**What expertise you will develop**

Expertise in environmental metagenomics, a cutting-edge technology using NGS methodologies; Expertise in laboratory experimentation, using experimental microcosms set up in a laboratory flume to evaluate predation on Cryptosporidium oocysts by particulate-feeding protists and invertebrates; Expertise in Cryptosporidium viability testing, Cryptosporidium quantification and appropriate sampling methodologies, appropriate for subsequent employment in the water industry. Knowledge of benthic invertebrate community structure and dynamics in a variety of welsh riparian ecosystems. Knowledge of agent based modelling, Bayesian modelling and bioinformatic analyses.

**Why this project is novel**

Tens of millions of Cryptosporidium oocysts are produced in every infection and as few as 10 can start a new infection. The majority of oocysts must therefore be removed from the environment or inactivated by the particle-feeding community within riparian ecosystems, but the precise range of organisms involved is not known, and their response to environmental challenges such as climate change, increased flooding or eutrophication can only be guessed at. This project will be the first to follow the fate of Cryptosporidium oocysts as they enter aquatic food chains in Welsh riparian ecosystems. Using cutting-edge molecular technologies (e.g. environmental barcoding) it will identify for the first time the main sinks for Cryptosporidium oocysts in the aquatic environment, and by incorporating these data into agent-based models of the Cryptosporidium life cycle, will for the first time allow prediction of the possible outcomes of environmental challenge, including climate change and flooding, on the risk of contracting Cryptosporidiosis.

**Rest of Supervisory Team:**

**Stakeholder Organisation** Public Health Wales

**Stakeholder Supervisor** Rachel Chalmers

**Co-Supervisor 1** Dr Anna Paziewska-Harris

Affiliation: Cardiff

Email: Paziewska-HarrisA@cardiff.ac.uk

**Co-Supervisor 2** Dr Tom Williams

Affiliation: Bristol

Email: tom.a.williams@bristol.ac.uk