**Antibiotic exposure impacts on fish health in natural freshwaters**

**Lead Supervisor Name**

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**Lead Supervisor Location/Student Home Institution**

Institution: Exeter

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**Full Project Description**

Microbiomes (the microbes associated with a host) are a fundamental component of human and animal health. Stressors that induce shifts in microbial communities, such as antibiotic exposure, in turn can increase the likelihood of infection, but almost nothing is known in this regard for fish. Much attention on antibiotics has been focused on their implications for human health through antimicrobial resistance (AMR) but far less attention has been focused on the wider environmental implications of antibiotic impacts to environmental health. This studentship will undertake a combination of field and laboratory based studies to advance understanding on fish skin and gill mucosal microbiomes in natural waters and assess how exposure to antibiotics that are widespread in the environment affect the skin and gill microbiomes and how, in turn, this affects susceptibility to disease infection. The two pathogens for the disease challenges will be the oomycete Saprolegnia parasitica, a fungal-like pathogen that is endemic to freshwater ecosystems and associated with global declines in wild populations of freshwater species, and monogenean parasitic worms that attach to the skins and/or gills, which have widespread fitness consequences across fishes. The fish study species is the roach (Rutilus rutilus) fundamental in lowland ecosystem function and the services they provide (coarse angling nationally, for which roach is one of the most important, has a GVA of £800 million; EA, 2009) This studentship will focus on achieving the following objectives: Objective 1. Characterise skin and gill microbiomes (16S, metagenomes; via MiSeq and MinION sequencing) for profiling microbial (and viral) communities in wild roach at different locations along selected river reaches and with differing pollution loads (effluent levels from sewage treatment works) and assess for animal variation and 'location signatures'. Investigate possible associations between skin and gill micro-organisms assemblages and disease and parasite loads. Objective 2. Undertake in situ translocations of roach (caged studies) between clean and polluted sites to study shifts in the skin and gill microbiome and whether this relates to change in disease organism burdens. Objective 3. Establish impacts on the skin and gill microbiomes in roach of exposure to the antibiotics, clarithromycin and erythromycin separately and in combination, for concentrations including those relevant to natural UK freshwaters in laboratory controlled exposures. Conduct sequential analyses on the skin and gill over a period up to 3 months to study the microbiome based changes over time. Objective 4. Establish the susceptibility of antibiotic treated roach with altered skin and gill microbiomes to infection challenges with Saprolegnia parasitica and/or Gyrodactylus vimbi to assess infection rates and subsequent disease progression. The student will receive training in an exceptional wide range of techniques, including ecotoxicology, disease biology, molecular biology, evolutionary ecology and genetics, microbiomes, bioinformatics and the analysis of large complex datasets, under expert tuition and they will experience different institutional environments, including with the stakeholder Cefas. The studentship provides an opportunity to strengthen links between Exeter, Cardiff and Cefas for advancing research in freshwater environmental protection.

**Real Life challenges this project will address**

Freshwater fish are subject to multiple stressors that can impact on individual health with population level impacts. Most research however focuses on individual stressors, and it is likely that combinations that occur in natural systems will result in very different outcomes. This has been recognised in recent NERC funding Calls and more widely in the science community. Antibiotics are widespread in the environment and in our freshwater environments and are likely to impact adversely on bacteria (microbiomes) in the skin and gills of fish that have a health protection role. Antibiotics exposure may alter important eco-evolutionary dynamics in UK freshwater systems but almost nothing is known in this regard. This PhD studentships will advance understanding on the interactions between the skin and gill microbiomes, antibiotics of environmental concern and susceptibility to disease infection in a species of fish (the roach, Rutlius rutilus) that has a fundamental role in the functional ecology of UK lowland rivers and the ecosystems services they provide.

**What you should know about this project**

Microbial communities that populate external facing (and gut) surfaces are fundamental to health and stressors that induce shifts in these microbial communities can increase infection risk and disease status, but almost nothing is known in this regard for fish. Antibiotics, designed to kill bacteria, are widespread in the environment and are causing international concern because of the emergence of antimicrobial resistance (AMR) affecting our ability to combat human diseases. Antibiotics can also adversely affect bacteria that play vital roles in the protection of animals from disease infection though the disruption of animal associated microbiomes, but again this has not been investigated in freshwater fish. This studentship will harness cutting edge DNA sequencing technologies to better understand the microorganism assemblages in the skin and gills of a common freshwater fish (the roach, Rutilus rutilus) living in UK clean and polluted rivers, and assess how exposure to selected antibiotics at environmentally relevant concentrations and mixtures affects skin and gill microbiomes and susceptibility to infections with diseases that are known to impact wild fish populations. This is a truly multi-disciplinary project assembling a highly experienced team with all the relevant expertise to ensure a successful studentship outcome together with end-user engagement, through the participation of the Centre for Environment, Fisheries and Aquaculture Sciences, and the technology company, Oxford Nanopore Technologies. The supervisory team includes a fish physiologist/ ecotoxicologist (Tyler, University of Exeter), a parasitologist (Cable, Cardiff University), a computational biologist with expertise in multivariate statistical analysis of microbial community data and viral genomics (Temperton, University of Exeter), and an expert in microbial organisms and their evolution (Bass, Cefas). The associated laboratories are exceptionally well equipped and resourced to make this project possible, and facilitate this studentship. All of the required molecular, in-life, and bioinformatics requirements are established in the partner laboratories and will be made available to the student. The student will be further benefit in both support and experience from their integration into the large associated research teams with extensive external partnerships (e.g. with large pharmaceutical and DNA technology companies). The wider collaborators within each institution include: University of Exeter: Karen Moore (MinIon access programme) a sequencing specialist who has been involved in the MinION access programme since its inception; Cefas: Drs David Bass and Verner Jefferies – experts in microbiomes and the environmental impacts of antibiotics, including AMR

**What expertise you will develop**

1. Field sampling skills
2. Laboratory skills in ecotoxicology, especially as applied to antibiotics
3. Expertise in disease and infection biology
4. Expertise in microbiology techniques
5. Expertise in advanced molecular and bioanalytical techniques, including PCR, DNA sequencing – MiSeq, MinIon etc., and analytical chemistry
6. Computational skills and multivariate statistical analysis especially as applied to microbial community data (and viral) genomics
7. Operational understanding of Cefas as a government advisory body

**Why this project is novel**

This studentship will undertake some of the very first work to establish the interrelationship between skin and gill microbiome profiles, environmental pollutant exposures (to antibiotics) and susceptibility to disease infection in fish.

**Rest of Supervisory Team:**

**Stakeholder Organisation** cefas

**Stakeholder Supervisor** David Bass

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