Understanding the spatial and temporal dynamics of environmental DNA for monitoring and management of priority invasive species

Project partners: Dr. Lori Lawson Handley and Dr. Bernd Hänfling, University of Hull; Dr. Alison Dunn, University of Leeds; Dr. Ben Aston, Yorkshire Water (CASE partner); and Dr. Kat Bruce, Nature Metrics.

Background and Rationale:

Invasive non-native species (INNS) are one of the five global drivers of biodiversity loss and the rate of biological invasions is increasing. Dreissenid mussels (zebra mussels *Dreissena polymorpha* and quagga mussels *D. rostriformis bugensis,* Fig. 1) are INNS that are high on the UK priority list for monitoring and management, due to their potential for rapid spread and negative impacts to biodiversity, infrastructure and human health (e.g. Karatayev et al. 2015). Dreissenids can rapidly colonise hard surfaces, causing major problems for the water industry and power companies by clogging pipes and encrusting other artificial structures (Fig. 2). In Yorkshire alone, removal of zebra mussels from pipework currently costs £600K per annum.

Fig. 1 Zebra mussel (left) and quagga mussel (right)

Fig. 2 Zebra mussels encrusting Yorkshire Water water pipes

Early detection is key to preventing establishment and further spread of INNS, but this is particularly challenging for species that have microscopic life stages. Environmental DNA (eDNA) is a sensitive new method that is starting to revolutionise how we monitor INNS (Lawson Handley 2015; Blackman et al. 2018a). We have recently developed eDNA assays for Dreissenid mussels that are highly sensitive for detection of both adult and larval stages (Blackman et al. 2018b; Stroud 2018). The successful student will use these tools to obtain novel insights into the dynamics of Dreissenid eDNA and to improve understanding of the species' distribution and impact. Methods and data generated during the studentship will be critical for facilitating Dreissenid monitoring, management and mitigation.

Project Objectives:

Objective 1: to understand the temporal dynamics of Dreissenid eDNA and inform future sampling campaigns. eDNA production and degradation rates are likely to vary throughout the year due to differences in Dreissenid activity and population dynamics, and environmental factors such as water mixing and UV. How these factors interact to influence detection probability of Dreissenid eDNA is currently unknown. The studentship will use site occupancy modelling (a powerful statistical tool for eDNA analyses, see e.g. Buxton et al. 2018) to generate eDNA detection probabilities at different times of the year, determine which seasonal variables influence detection, and inform future sampling campaigns.

Objective 2: to understand the spatial dynamics of eDNA distribution and determine which key environmental variables influence the probability of detection of Dreissenid eDNA. The detection of eDNA is influenced by the physical, chemical and biological properties of the environment (Barnes & Turner 2015). The studentship will investigate how environmental variables (e.g. substrate type, dissolved Oxygen Concentration, chlorophyll, pH etc) effect Dreissenid populations, eDNA production and persistence. The impact of different environmental variables on the probability of eDNA detection, will be investigated using site occupancy modelling.

Objective 3: to use eDNA to identify key pathways and vectors for Dreissenid spread. Identification of high risk vectors and pathways for INNS spread is essential for drafting management plans, but research into pathways is often limited by the low power of current methods to detect species at low density. The studentship will use eDNA methods to investigate the relative importance of different pathways and inform a pathway management plan, and also explore the use of *in situ* detection methods for rapid, cost-effective and sensitive monitoring.

Objective 4: to evaluate the impact of Dreissenid mussels on the structure and function of invaded ecosystems. Dreissenid mussels are thought to have wide-ranging impacts on invaded communities, with positive effects on some species but reductions in others (Churchill 2013; Ward & Ricciardi 2013), but their impacts have not yet been comprehensively investigated at the whole ecosystem level. The studentship will generate data over time and space on entire communities, using DNA metabarcoding, which together with comprehensive environmental metadata, will allow unique insights into impact of Dreissenids on the structure and function of invaded ecosystems.

Training:

You will be supervised by Dr. Lori Lawson Handley and Dr. Bernd Hänfling from the EvoHull Group at the University of Hull, Dr. Alison Dunn from the School of Biology, University of Leeds and our CASE partner, Dr. Ben Aston from Yorkshire Water. You will also collaborate with Nature Metrics, the leading UK consultancy for DNA based monitoring. The project will provide specialist training in:

- Environmental DNA sampling, capture and analysis
- qPCR and High Throughput Sequencing (metabarcoding)
- Bioinformatics
- Statistical modelling (including site occupancy modelling) in R

EvoHull is one of the most experienced groups in the UK for eDNA analyses, has dedicated eDNA facilities, and currently supports 6 PhD students working on eDNA. Alison Dunn's team are UK leaders on biosecurity and work closely with the water industry and other partners to reduce the spread of INNS. Yorkshire Water has extensive experience of supervising PhD students and offers a supportive environment to enable students to improve career prospects. You will have the opportunity to work alongside the YW Environment Assessment team and access training programmes, an industry mentor, and work space. Collectively, we have an excellent track record in training PhD students, publishing high impact research, and are highly active in national and international networks that will help you to develop external contacts and career prospects.

Entry Requirements:

We are looking for a motivated student who has a keen interest in molecular ecology and biodiversity, and is equally happy in the field, lab or behind a computer! You should be interested in both basic and applied science, and keen to work with our CASE partner and disseminate information to external networks. Experience with molecular tools (e.g. PCR), using R, and/or bioinformatics would be useful. You must hold an Honours (2.1. or higher) or Masters degree in a related subject, such as Biology, Ecology, Genetics or Zoology.

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References and suggested reading:

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