Foras na Mara
Marine Institute

Cullen Scholarship: Population genetics of the Irish white-clawed crayfish (*Austropotamobius pallipes*) using traditional and non-invasive eDNA methods and investigation into potential resistance to the crayfish plague pathogen *Aphanomyces astaci* (PhD Award)

Background

White-clawed crayfish is the only crayfish native to Ireland and is protected under the Wildlife Act (1976) and the EU Habitats Directive (Annex II and V). It is also listed as endangered in the IUCN Red list. Historically Ireland hosted the healthiest population of white-clawed crayfish (WCC) in Europe (Reynolds, 2020). However, since the emergence of crayfish plague in 2015, their numbers have been in decline.

Crayfish plague is caused by the invasive pathogenic water mold *Aphanomyces astaci* (Oomycota). It is believed to have been introduced in Europe in the 19th century with the translocation of the first North American crayfish, which are chronic carriers and natural vectors of the pathogen (Holdich, 2003; Unestam, 1972, 1969). Its spread and impact across Europe has led to it becoming a notifiable disease, listed by the World Organisation for Animal Health (WOAH), causing up to 100% mortalities and resulting in genetic bottlenecks (Martínez-Ríos et al., 2023; Martín-Torrijos et al., 2021).

As a result, captive breeding has become essential for the conservation of European crayfish species. Rescuing healthy individuals from upstream regions of affected rivers and reintroduction to ARK sites requires careful consideration of the populations genetic structure. Early molecular studies indicated that the genetic structure of Irish WCC populations was highly homogeneous, with French ancestry (Grandjean et al., 1997; Souty-Grosset et al., 1997). However, in 2018, Brady showed previously undescribed genetic diversity in three out of 15 special areas of conservation (SACs) populations (Brady, 2018). Using the 16S rRNA mitochondrial marker, this study identified haplotypes that showed genetic variation and structure among the Irish WCC populations, in contrast to those previously described by Grandjean et al., 1997 and Souty-Grosset et al., 1997.

In October 2024, the first rescue mission took place in the River Awbeg in the Munster Blackwater catchment. Healthy individuals found upstream of crayfish plague-affected sites were quarantined and prepared for future translocation to ARK sites or captive breeding and reintroduction programs. This is the first conservation initiative for Irish WCC since the reintroduction at White Lake (Reynolds et al., 2000). Although the number of rescued crayfish was small, the mission proved the concept viable, paving the way for further rescue efforts with a long-term vision of rolling out a nationwide conservation program.

Given the low numbers of remaining WCCs, the use of non-invasive methods is crucial and should be explored in-depth. Environmental DNA (eDNA) presents a promising approach for monitoring and studying population genetics. While eDNA has been successfully used for population genetic studies of marine mammals in Ireland, invertebrates such as crayfish shed DNA at different rates. A detailed

analysis of shedding rates across life stages could help determine optimal eDNA sampling strategies for crayfish population genetics.

Since the first confirmed case of crayfish plague in Ireland in 2015, at least three different pathogen genotypes have been detected, indicating multiple introductions and further spread across catchments. Additionally, the origin and vectors of crayfish plague in Ireland remain unknown. If reintroduction programs are to succeed, it is critical to determine the most likely routes of introduction and transmission through epidemiological investigations, with a view to reducing the spread of the disease.

Some European WCC populations have been found to be carriers or survivors of crayfish plague (Martínez-Ríos et al., 2022; Martín-Torrijos et al., 2017), and recent research in Ireland suggests that some individuals may also be persisting in previously affected waters. Identifying potential resistance or immunity within these populations is crucial for future conservation strategies as it could open the possibility of breeding crayfish resistant or immune to the disease in the future.

Proposal

We propose a **structured four-year PhD** project focused on the molecular ecology (genetics and environmental DNA analyses) of WCC. The research will:

- Examine the shedding rates of eDNA at different life stages of the WCC and throughout various times of the year, to optimize the use of non-invasive eDNA sampling methods.
- Analyze the genetic structure of Irish WCC populations across 15 SACs using mitochondrial markers (COI and 16S) and microsatellites.
- Investigate the immune resistance mechanisms that contribute to the survival of Irish WCC populations exposed to previous crayfish plague outbreaks by characterizing their immune proteins.
- Assess the conservation status of Irish WCC populations and evaluate the potential for their captive breeding to support long-term conservation efforts.
- Investigate the epidemiology and dissemination of crayfish plague in Ireland to pinpoint transmission pathways and develop improved strategies for controlling the disease's spread

Location of Scholar

The scholar will be based for circa 50% of their four years at the Marine Institute HQ Rinville, Galway.

The scholar will be trained in molecular biology techniques.

Outcome

The outcome of this project will enhance the understanding of the population genetic structure of white-clawed crayfish in Ireland and the epidemiology of crayfish plague, facilitating informed decisions regarding translocation, ARK site stocking, and potential reintroductions and captive breeding programs. The development of methods to understand the immune response of white-clawed crayfish to a notifiable disease, crayfish plague, is crucial for the Fish Health Unit in its role as the National Reference Laboratory for crustacean diseases. Additionally, this research will support captive breeding programs for animals potentially immune or resistant to the disease and contribute to the broader knowledge of immune responses in crustaceans.

Marine Institute Corporate Strategy 2023-2027

This research aligns with the Marine Institute's strategic priority "Delivering Impact Through Research and Innovation" under its corporate strategy Ocean Knowledge that Informs and Inspires.

It also connects with strategic priorities such as "Transform Our Knowledge, Advice & Services" and "Inspiring Our Stakeholders and Society" by providing vital knowledge to governmental agencies and conservation organisations.

Specific Requirements

The scholar should have a primary degree or postgraduate qualification in biological sciences with a strong component in molecular biology or biochemistry. The host institute should have a proven capability in population genetics studies and/ or immune response resistance studies.

Financial Details

Scholarships will be up to €34,000 per annum (maximum funding PhD of €136,000 over four years. This amount comprises a maintenance award of €25,000 to the student as well as payment of fees to the host higher education institution (HEI). The maximum fees payable to the HEI will be €6,000 per annum. The scholarship award also includes a budget of up to €3,000 per annum for eligible research costs (travel & subsistence, publication costs, consumables and other costs, such as minor kit purchase e.g. camera) for the sole use of the student and are payable on a reimbursement basis direct to the host institution where the postgraduate student (scholar) is registered. There are no overheads payable on the scholarship.

Publication costs are intended to cover publications on which the scholar is listed as first author and are published under Open Access.

Scholars can also supplement this funding by applying to the Marine Institute's Networking & Marine Research Communication Awards annual call.

In addition, the cost of a laptop will be covered by the Marine Institute (purchased via the Research Funding Office).

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