SBS Summer Vacation Projects 2024

Project 1: The impact of avian influenza viruses on UK seabird populations.

Supervisor: Emma Cunningham (e.cunningham@ed.ac.uk)

Wildlife populations naturally experience a wide range of infections and disease. Understanding how they circulate in the environment, how they are evolving over time and how different hosts are affected is key to understanding both their impact on different animal species and their potential to spill-over into domesticated animals and humans. We are currently experiencing a major outbreak of Avian Influenza that is having a major impact both on wild birds and commercial poultry at a global scale. This is a disease caused by infection by a group of Influenza A type viruses of which water birds are the natural host. These viruses usually circulate in wild waterfowl and shorebirds with relatively little impact. However, the past two years have seen a significant change in the impact of one particular subtype of avian influenza called H5N1. Mortality reports in wild birds have been highest in seabirds with over 20,000 dead birds reported over a three-month period in Scotland alone. These are novel hosts that up until this point have been relatively unaffected so we currently lack information about how this disease is impacting in these novel host populations, hindering our ability to make informed decisions about any potential mitigation strategies that might be put in place or evaluate their likely success.

The student will join the ECOFLU consortium consisting of researchers from both University and stakeholder organisations to address the impact of the current epizootic in wild seabird populations around the UK with a view to identifying the likely future impact of the disease and whether any mitigations can be put in place. Depending on the student's interests and the timing they are available there is scope to join either field or lab teams and the student should specify which would be most of interest. If you would like to find out more ahead of applying for any project please get in touch to speak to the team in the department.

Eligible for IEE or Bill Hill schemes

Project 2: Insulin signalling and life-history variation in wild Soay sheep

Supervisors: Hannah Froy (hannah.froy@ed.ac.uk) and Sanjana Ravindran (sravindr@ed.ac.uk)

An organism's life-cycle is characterised by several stages where they grow, mature, reproduce and then die. Individuals can vary in the amount of resources they allocate towards these different traits and hormones are thought to play an important role in mediating this. Several studies in laboratory and domestic animal populations have shown the insulin-like growth factor 1 (IGF-1) hormone to have effects on growth, reproduction and survival of individuals. Only a few studies have investigated these research questions in wild animal populations. In this project, the student will combine lab work and data analysis to measure concentrations of IGF-1 hormone in wild Soay sheep plasma samples and explore its association with several life-history traits such as body weight and survival. The student will receive supervision and training to design their specific research question, perform lab work and conduct data analysis.

Eligible for IEE or Bill Hill schemes

Project 3: Host-virus interaction in Drosophila

Supervisors: Darren Obbard (darren.obbard@ed.ac.uk) and Ali Somerville (Ali.somerville@ed.ac.uk)

Drosophila melanogaster is probably the foremost model for virus-insect interaction, and *Drosophila* experiments have provided an overview of the fundamentals of antiviral immunity in insects. However, most experiments have been performed using viral pathogens that never naturally infect *Drosophila*, and host-virus coevolution may have led to quite different interactions with common natural pathogens. We have recently identified a previously uncharacterised gene that is strongly upregulated in response to two very different, but entirely natural and very common gut pathogens—a DNA virus and an RNA virus. This wet-lab project will use off-the-shelf fly knock-down or knock-out fly lines, which have reduced expression of this gene, to test whether its upregulation is involved in resistance and/or tolerance to the DNA virus.

Eligible for IEE or Bill Hill schemes

Project 4: Cemeteries as biodiversity hotspots

Supervisor: Per T. Smiseth (per.t.smiseth@ed.ac.uk)

Natural habitats are lost at an increasing rate due human impact such as urbanisation, changes in agricultural practices and deforestation. Undisturbed patches of land, such as cemeteries, can therefore play a vital role in conservation of biodiversity as havens or refugia for insects and other wildlife. This project will aim to record insect biodiversity in cemeteries, burial grounds and churchyards across Edinburgh. The project will involve training in species identification and biological recording.

Eligible for IEE or Bill Hill schemes

Project 5: Ageing in a wild mouse population

Supervisors: Tom Little (tom.little@ed.ac.uk) & Amy Pedersen: amy.pedersen@ed.ac.uk.

Wild animals do not come with birth certificates. As we often do not know the age of a wild animal, studies of the ageing, or senescence, rate in the wild have been severely limited. Thus, while we know lots about human ageing, and the lifestyle or environmental factors that cause people to be 'grey before their time', we know very little about wild populations. In this project, you will be a part of a team that follows individual wood mice over time, determining chronological age and monitoring the ageing rate with a combination of analyses, including cutting edge molecular biomarkers of age. The student will mostly participate in field work in a local woodland site, while also using molecular or photographic techniques to determine the age of wild rodents. A love of the outdoors is recommended for this placement!

Eligible for IEE or Bill Hill schemes

Project 6: What makes a parasite superspreader?

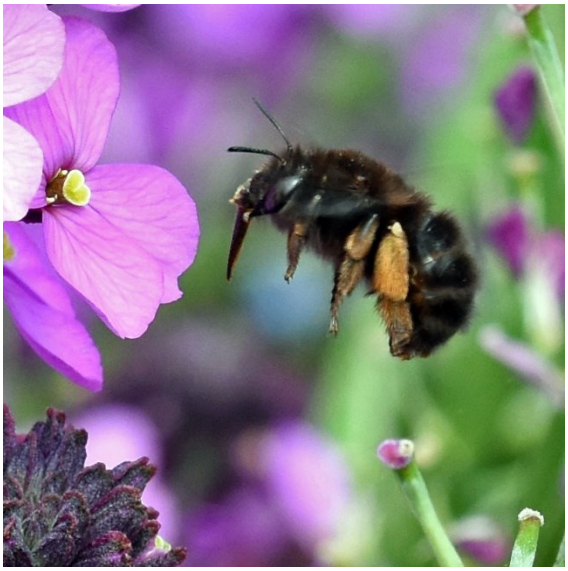
Supervisor: Amy Pedersen: amy.pedersen@ed.ac.uk

Parasitic helminths play vital roles in natural ecosystems, driving host dynamics and structuring ecological communities, and are a major health and economic concern worldwide. A ubiquitous feature of helminths is their overdispersed (aggregated) distribution, where most parasites (~80%) infect a minority of hosts (~20%). These highly infected individuals may act as ‘superspreaders’, driving transmission by releasing large numbers of infective stages into the environment. However, the significance of superspreaders in natural systems remains poorly understood. In this project, you will join our research team who will be conducting a large-scale field experiment in which we are testing how individual-level heterogeneities in parasite shedding and social-spatial contacts may drive population-level transmission in a wild rodent system. This student will participate in the field work on wild rodents, learn parasitological analysis, and use our spatial loggers to determine mouse contacts to infer which individuals may be potential superspreaders.

Eligible for IEE or Bill Hill schemes

Project 7: Pollination Bioacoustics: Do Bees or flowers determine the frequency of buzz pollination?

Supervisor: Graham Stone (graham.stone@ed.ac.uk) and Alix Prybyla (a.n.prybyla@sms.ed.ac.uk)



Usually, smaller bees beat their wings at a higher frequency than larger bees, i.e., they have a higher pitched buzz. This project will look at another application of bee flight muscles – harvesting pollen from plants. Known as sonication or buzz pollination, bees use vibrations from their flight muscles to, literally, shake the pollen out of flowers. Bees learn to tune the frequency of their buzz to match the resonant frequency of a particular flower. When a bee buzzes at this exact frequency the flower also vibrates and pollen shoots out onto the bee. Messy, but effective! Because the resonant frequency is a property of the flower's structure, we predict that sonication frequencies observed in nature will be determined by the type of flower visited, and not the species or size of the visiting bee.

This project will test these predictions using sonication buzz recordings for two bee species - *Anthophora plumipes* (shown in the image) and *Bombus pratorum* - visiting four species of lungwort (*Pulmonaria*). The project will involve analysis of some existing recording data using Audacity acoustic analysis software, and fieldwork with a team in the Edinburgh botanical gardens to record new buzz recordings using a specialised parabolic microphone.

Eligible for IEE or Bill Hill schemes

Project 8: Testing conservation of gene function over 475 million years

Supervisor: Sandy Hetherington (sandy.hetherington@ed.ac.uk)

The success of land plants was underpinned by the origin of key genetic and anatomical innovations. The evolution of a specialised sugar transport tissue, termed the phloem, was one of these innovations and played an essential role in supporting the rapid increase in plant size from tiny moss-like species to towering trees. The phloem is a characteristic feature of all living vascular plants today and we know about the genetic network that underpins it from work on the model flowering plant Arabidopsis. In Arabidopsis the MYB coiled-coil transcription factor Altered Phloem Develop (APL) is known to play a key role in phloem development. However, it is unclear when this transcription factor evolved and if protein function is conserved in all land plants.

In this project you will investigate the conservation of APL protein function using a cross-species genetic complementation experiment. You will establish if the APL orthologue from Marchantia polymorpha, a species of liverwort that diverged from Arabidopsis over 475 million years ago, can restore a wildtype phenotype in the Arabidopsis apl mutant. Your project will therefore shed light on the origin of the phloem genetic toolkit in land plants

Eligible for Bill Hill scheme

Project 9: Mapping the causal mutations in classic Barley mutants

Supervisor: Annis Richardson (aricha14@ed.ac.uk)

Cereal crops provide more than 50% global calories, making investigation of cereal genetics key to future food security. One approach to understand the genetics underpinning cereal productivity is to analyse the effect of mutations on yield and grain quality. Barley is the leading Scottish cereal crop, accounting for >10% of farm outputs and worth >£300 million per year. Malting barley, required for the scotch whiskey industry, is of extremely high quality and understanding the genetics that control barley grain quality is of strategic importance for scottish agriculture. In this project you will investigate the effect of the classic calcaroides mutants on barley grain shape and quality traits such as skinning. The mutations responsible for the calcaroides phenotypes have been coursely mapped, and you will use PCR fine mapping and next-generation sequencing techniques to identify the causal mutation for one of the calcaroides mutants. This project will teach skills in cereal genetics, phenotyping, molecular biology and bioinformatics.

Eligible for Bill Hill scheme

Project 10: Testing the roles of structure and surface chemistry on the ability of plant hairs to nucleate dew condensation and ice formation.

Supervisor: Andrew Hudson (andrew.hudson@ed.ac.uk)

Eligible for EPSRC or Bill Hill schemes

Project 11: Characterising the Role of E3 Ligases in Immune Response Activation

Beatriz Orosa Puente (beatriz.orosa@ed.ac.uk)

Plant diseases pose a significant threat to agriculture, causing substantial crop losses and global food security concerns. Pests impact almost half of the world's food crops annually, resulting in yield losses ranging from 10% to 40%. Current strategies to mitigate disease-related losses primarily involve developing resistant crop varieties and new chemicals for pest prevention and control. However, these approaches face challenges as pathogens quickly mutate, rendering current strategies less effective over time. To address this issue, a deeper understanding of host-pathogen interactions is crucial for developing sustainable resistance by regulating entire immune pathways rather than targeting a single component. Ubiquitination of regulatory immune proteins plays a pivotal role in ensuring the proper activation of immune defences. Ubiquitination achieves plasticity and specificity primarily through E3 ligases responsible for the ubiquitination of immune proteins to modulate their function. Therefore, unravelling the role of ubiquitin in plant immune responses is essential to leverage this system for establishing long-lasting pathogen resistance. This exciting summer project aims to characterise immune E3 ligases that can be used to develop innovative tools for manipulating plant-pathogen interactions by harnessing proteolytic systems to activate immune pathways on demand. To accomplish these goals, the student will employ cutting-edge techniques encompassing sequence analysis, genomics, and proteomics. Additionally, they will enhance their presentation skills, networking, and teamwork by collaborating with other students in the Institute of Plant Sciences.

Eligible for EPSRC or Bill Hill schemes

Project 12: Evaluating the potential of novel antimicrobial peptide derivatives to disrupt *P. aeruginosa* biofilms

Maddie Moule (maddie.moule@ed.ac.uk)

Pseudomonas aeruginosa is an opportunistic pathogen known for causing acute and chronic infections in immunocompromised individuals, particularly in hospital settings. The bacterium's ability to form biofilms contributes significantly to its multi-drug resistance and persistent survival, especially in chronic infections. It is listed as one of the priority pathogens in a group of ESKAPE pathogens (Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacter species).

This project explores an alternative approach to conventional antibiotics- the application of synthetic antimicrobial peptoids. These peptoids mimic naturally occurring cationic host defence peptides, but have increased stability and bioavailabilty. We have previously demonstrated efficiency against methicillin-susceptible and resistant Staphylococcus aureus with minimal cytotoxic effects to the host. The project's primary focus will be testing the effectiveness of antimicrobial peptoids against *P. aeruginosa* biofilms. The student will learn bacterial handling, culturing, and growing biofilms using microtiter dish assays. They will then quantify the biofilms using crystal violet assays under different dosages of peptoids to test for the peptoids' efficacy in preventing and detaching *P. aeruginosa* biofilms. This research contributes to the urgent need for alternatives to antibiotics against multidrug-resistant pathogens, specifically addressing biofilm-associated infections.

Eligible for EPSRC or Bill Hill schemes

Project 13: Computational design of minimal photoenzymes

Chris Wells Wood (chris.wood@ed.ac.uk)

The student would be learning some programming and statistics before performing computational design of de novo protein scaffolds that bind cofactors required to perform photobiocatalysis. These minimal photoenzymes will teach us more about the fundamental aspects of photobiocatalysis as well as having potential applications in green chemistry. The student does not need to have prior experience of programming to apply as they will be well supported in learning these skills by the lab.

Eligible for EPSRC or Bill Hill schemes