Summer Studentships 2020 – Projects List

Host Unit: Alic lab, Institute of Healthy Ageing

Supervisor: Dr Nazif Alic

Project Title: The ability of long-lived mutants to maintain metabolic homeostasis in old age

Project outline

Alterations to metabolic homeostasis, which can result in obesity and insulin-resistance (type II diabetes) are an ever-growing concern to our society, and are at least in part due to the caloric excess of our modern diet. Both obesity and insulin-resistance have a complex interaction with a person's age. Recent exciting work in biogerontology has discovered interventions that can extend lifespan in organisms as diverse as the fruit fly and mammals. However, it remains unclear whether longevity extending manipulations can lead to better metabolic homeostasis and counteract poor diet choices, preventing obesity and insulin-resistance. This project will examine if mutations that can make the fruit fly live longer can also rescue from the effects of poor diet, using a range of techniques in fly physiology and molecular and cell biology.

***Deadline for contact*:**

10 January 2020. Applicants should send a cover letter, brief CV & contact details of a referee.

Contact: n.alic@ucl.ac.uk

Host unit: Gems lab, Institute of Healthy Ageing

Supervisor: Prof. David Gems

Project Title: Biology of Ageing in *C. elegans*

Project outline

The project will involve some aspect of the biology of ageing in *C. elegans*, to be determined closer to the date of the project.

While developmental genetics has been an area of intensive study for many years, investigation of the role of genes in determining longevity and ageing only recently began. An ideal model organism in which to study ageing is the free-living nematode *Caenorhabditis elegans*. This species has well-developed genetics, its 97,000,000 base pair genome is fully sequenced, and its life span is a mere 2-3 weeks. Most importantly, numerous mutations have been identified in *C. elegans* which alter the rate of ageing, with some mutants living more than five times as long as wild-type worms. It is hoped that by understanding ageing in a simple animal like *C. elegans* we will be able to unravel the mystery of human ageing, which increases risk of a wide range of diseases, from cardiovascular disease and type II diabetes, to Alzheimer's disease and cancer.

A major focus of current work in this laboratory is understanding the genes and biochemical processes by which reduced insulin/IGF-1 signalling and dietary restriction increase lifespan. Other interests include sex differences in the biology of ageing, evolutionary conservation of mechanisms of ageing, and bioethical implications of ageing research.

Special requirements

These projects are suited for students who are considering a possible future career in scientific research. A good grounding in genetics is helpful.

Deadline for contact

10 January 2020. Applicants should send a cover letter, brief CV & contact details of a referee.

Contact: david.gems@ucl.ac.uk

Host unit

Stalk-eyed fly research group (Ground Floor Insect Facility, Darwin Building)

Supervisors

Kevin Fowler & Andrew Pomiankowski

Project title

The interplay between natural and sexual selection in males carrying a selfish genetic element

Project description

In stalk-eyed flies, a textbook example of sexual selection, females showing strong mating preference for males with exaggerated eyespan. Some males carry meiotic drive genes causing Y-bearing sperm to malfunction - so only X-bearing sperm survive and broods are strongly female-biased. While exaggeration of the male ornamental trait is thought to have an upper limit due to costs of bearing the ornament, there is evidence from non-drive populations that natural selection favours co-adaptive changes in wing size and shape. These changes allow compensation for detrimental locomotor effects of exaggerated male eyespan in stalk-eyed flies.

Drive reduces eyespan in males but not females. It is unknown whether drive affects wing size and shape and there are two intriguing hypotheses: a) that the small eyespan of drive males uniquely leads to matched co-adaptive changes in their wing traits, b) that there are no side-effects of drive on wing size and shape in males or females. This project will use an archive of stalk-eyed flies, genotyped previously for eyespan and drive status. We will compare wing traits among drive-bearing and wild-type flies, reared at two levels of environmental stress. Differences in wing morphology between genotypes may be elevated by challenging circumstances.

Any details of particular knowledge you would like the student to have.

Interest in evolution/genetics/behaviour and a working knowledge of statistics.

Deadline for contact

10 January 2020. Applicants should send a cover letter, brief CV & contact details of a referee.

Contact: k.fowler@ucl.ac.uk; a.pomiankowski@ucl.ac.uk

Fly host lab: Prof. Andrew Pomiankowski
Metabolics host lab: Prof. Nick Lane
Postdocs: Dr Lara Meade (stalk-eyed flies) and Dr Enrique Rodríguez (metabolics)
Project title: The metabolic costs of an exaggerated sexual ornament in stalk-eyed flies

Male stalk-eyed flies have highly exaggerated eyespan. This is a classic example of sexual selection, as females have been shown to have strong mate preferences for males with wider eyespan (Figure 1). We know this trait imposes aerodynamic costs on males (they take-off at a lower angle, due to the extra head weight), it slows development (males take 1-2 extra days to emerge from pupae) and is a highly condition-dependent trait (being very sensitive to environmental and genetic stress). But we know very little about the energetic cost of this exaggeration. In this project, the student will use the Oroboros O2k machine to measure a range of metabolic parameters in males, in particular oxygen consumption and reactive oxygen species (ROS) flux. By introducing different substrates, the performance of mitochondrial complexes I-IV can also be assessed.


Fig. 1 Male (bottom) and female (top) stalk-eyed flies

These features of the energetic state will be compared across males with different eyespan exaggeration (from very large to extremely small), and with females which have much smaller eyespan. The student will compare different tissues (head, thorax and reproductive organs) in adults, as well as larvae and pupae at different stages of development – as this is when eyespan size is determined. They will also investigate the effect of adult food stress as this has differential effects on male and female reproductive fitness.

Stalk-eyed flies are also of interest as they harbour “SR” X-linked meiotic drive. SR causes the destruction of Y-sperm, resulting in female only broods. Males carrying SR have reduced eyespan but increased testis size. We have recently shown that SR is associated with survival deficits, both in males and females. The summer student will investigate whether SR causes detectable reduction in metabolic performance, and if so, in which tissues and stages of development.

Student profile. We are looking for a committed, hard-working student. They should have interests in evolutionary biology, sexual selection, genetics and metabolism. The student will be taught animal husbandry, use of genetic markers to identify larval/pupal sex and the X-linked SR genetic complex (DNA extraction and PCR), they will become familiar with measuring metabolic activity on the Oroboros O2k machine and gain knowledge of statistical analysis.

References

Finnegan, S.R., White, N.J., Koh, D., Camus, M.F., Fowler, K. and Pomiankowski, A. 2019 Meiotic drive reduces egg-to-adult viability in stalk-eyed flies. **Proceedings of the Royal Society London B** 286, 20191414.

Meade, L., Finnegan, S.R., Kad, R., Fowler, K. and Pomiankowski, A. 2019 Maintenance of fertility in the face of meiotic drive. **American Naturalist** *in press.* https://www.amnat.org/an/newpapers/Apr-Meade.html

Doerrier, C., Garcia-Souza, L.F., Krumschnabel, G., Wohlfarter, Y., Mészáros, A.T. and Gnaiger, E. (2018). "High-Resolution FluoRespirometry and OXPHOS protocols for human cells, permeabilized fibers from small biopsies of muscle, and isolated mitochondria." In, *Mitochondrial Bioenergetics: Methods and Protocols,* eds. C.M. Palmeira & A.J. Moreno. (New York, NY: Springer New York), pp31-70.

Deadline for contact

10 January 2020. Applicants should send a cover letter, brief CV & contact details of a referee.

Contact: Prof. Andrew Pomiankowski (ucbhpom@ucl.ac.uk)

Host unit: Centre for Biodiversity and Environment Research (CBER)

Project supervisor: Prof Kate Jones

Project title

Biome Health Project – assessing the impact of human pressure on local biodiversity

Short project description

Wildlife and wild places face a variety of environmental and human-induced challenges, with catastrophic declines documented in both invertebrate and vertebrate populations across the world. Critical to change this scenario is a better global understanding of how species in different biomes respond to different threats and the effectiveness of conservation actions. To address this question, UCL with WWF UK is deploying terrestrial and marine sensors at a landscape-level across four different biomes to understand different species-biome-threat responses (Biome Health Research Project - https://www.biomehealthproject.com). During the placement the student will develop a small project embedded in the larger **Biome Health Research Project** and will work with camera trap data collected in either Kenya or Nepal to investigate the effect of human pressure on wildlife. The activities conducted will involve tagging a subset of camera trap images from the study location and running preliminary statistical analysis. By the end of the placement the student will have developed skills on species identification, data management and processing, basic data analysis.

Requirements

No particular knowledge required; experience using R would be a plus.

Deadline for contact

10 January 2020. Applicants should send a cover letter, brief CV & contact details of a referee.

Contact: kate.e.jones@ucl.ac.uk

Host unit: Centre for Biodiversity and Environment Research

Project supervisor: Alex Pigot

Project title: Slippery slope or cliff edge - will climate driven biodiversity losses occur gradually or abruptly?

Project outline: The student will make use of a recently developed framework for modelling the temporal dynamics of projected biodiversity responses to future climate change. Using information on species environmental niches and climate model simulations they will quantify when and how abruptly species niche limits are likely to be exceeded and how this varies across different spatial scales. The project will be desk based and use the R programming environment and so provides a good opportunity to improve modelling and coding skills.

Deadline for contact

10 January 2020. Applicants should send a cover letter, brief CV & contact details of a referee.

Contact: a.pigot@ucl.ac.uk

Host lab: Drosophila research group

Project Supervisor: Max Reuter

Project 1: Investigating the effects of diet on mito-nuclear incompatibilities

Mitochondria generate the energy and many of the molecular precursors required for life. The protein machinery that carries out cellular respiration is encoded by two genomes, mitochondrial (mtDNA) and nuclear (nuDNA). Mitochondrial and nuclear proteins must cooperate with nanoscopic precision to ensure optimally efficient energy production. This cooperation is made more difficult by the fact that mtDNA and nuDNA have radically different rates of evolution, with higher mitochondrial substitution rates. As a consequence, we expect rapid coevolution between mitochondrially- and nuclearly-encoded respiratory proteins to occur within populations. Gene flow or hybridisation lead to deleterious mismatches of mitochondrial and nuclear genomes from different populations. Such mito-nuclear incompatibilities affect fundamental evolutionary processes, including local adaptation and reproductive isolation between populations and species.

How coadaptation of the two genomes interacts with nutrients to determine metabolic health and organismal performance has been little explored. This project will address this question by examining how mito-nuclear genotypes and diet will affect fitness across a panel of Drosophila melanogaster lines. Using the fly model, we can manipulate the mitochondrial and the nuclear genomes and measure how components of male and female fitness vary across different mito-nuclear genotypes and dietary compositions.

Project 2: The effect of stress dosage in cross-protection to future stressors

The question that we will investigate in this proposal lies at the core of our understanding of the effect of global change on the biodiversity and evolutionary fate of organisms, as well as global health issues such as evolution of drug-resistance, and conservation. We will investigate the relationship between cross-protection and cellular stress responses and how this relationship might affect biodiversity. Cross-protection occurs when cells that are exposed to an initial stress become better protected against future novel stressors. When exposed to an environmental stressor, many organisms (e.g. fission yeast, *Schizosaccharomyces pombe*) may respond to stressors by initiating specific responses to individual stresses and/or a core environmental stress response (CESR) that provides protection against a wide range of stresses.

While this phenomenon is well-described, it is unknown if the level of cross-protection depends on the intensity of the initial stress and whether it is the specific or the general gene expression programmes that results in cross-protection. During this research project we seek to answer this fundamental question: does induction of cross-protection against future stressors depend on the dosage of the initial stress and through which gene expression programme?

Project 3: Investigating adaptive conflicts at the *Drosophila fruitless* gene

Phenotypic plasticity evolves whenever different external circumstances favour distinct phenotypes. Classic example include anti-predator responses in waterfleas or morphological variation in aquatic plants. But phenomena analogous to plasticity also underlie sexual dimorphism—distinct phenotypes are expressed by the largely identical genome of males and females.

While sexual dimorphism is ubiquitous, recent work has highlighted adaptive conflicts between the sexes. Divergent selection on male and female phenotypes, in combination with genetic coupling between their traits, can lead to so-called sexual antagonism, where populations are polymorphic for genetic variants that are beneficial to one sex but detrimental to the other.

Here, we propose to investigate a potential example of such an antagonistic polymorphism in the *fruitless* gene of *Drosophila melanogaster* that plays a major role in the regulation of sexual differentiation. This gene shows elevated genetic polymorphism across populations, compatible with the action of balancing selection, such as that generated by the opposing selection pressures underlying sexual antagonism.

In this project, we will work with lines that carry one or the other allelic variant at *fruitless*. We will use these lines to measures the effects of these alleles on survival and adult fitness, as well as phenotypes that may underlie these fitness effects.

Project 4: Inferring evolutionary responses to environmental selection in global fruit fly populations

Adaptation to the environment is critical for the survival of individuals and the persistence of populations. To understand this process, we must identify the genetic targets of selection and establish how genetic change relates to environmental conditions. This is now possible, by scanning the hundreds of genomes that are now publicly available from many species for the recognisable signatures that adaptive responses leave in the genome.

We propose to perform such an analysis using sequences from different populations of fruit flies *Drosophila melanogaster*. We want through the analysis of population genomic sequence data, since natural selection leaves to investigate two different types of natural selection: local adaptation and balancing selection. Local adaptation results from directional selection in specific populations and leaves characteristic sweep patterns of reduced genetic variability and population differentiation. In addition, we are interested in identifying regions under balancing selection, where genetic diversity is actively maintained by molecular processes leading to heterozygosity advantage, temporal fluctuations in directional selection (e.g. seasonal variation) or divergent selection on the two sexes.

This is a computational project that gives hands-on experience in the analysis of population genomic sequence data. It will involve running analyses of large datasets using command-line tools. As a consequence, it will require some levels of familiarity and interest in computational approaches.

***Deadline for contact*:**

10 January 2020. Applicants should send a cover letter, brief CV & contact details of a referee.

Contact: m.reuter@ucl.ac.uk

Host unit: Centre for Biodiversity and Environment Research

Project Supervisor: Seirian Sumner

Project 1*:* Mapping the Diversity and Distributions of Social Wasps across the UK: Big Wasp Survey

The Big Wasp Survey (BWS) is a citizen science programme which harnesses the power of the public to sample social wasps across the UK. Citizens are asked to hang a home-made wasp trap in their gardens for a week in August and send the contents of their trap to UCL for identification. From these data, we are able to better understand the diversity and distributions of these pest-controllers, across different land-use types in the UK. An important part of this work is engaging the public with these much maligned insects, and raising awareness about the important ecosystem services they provide us with. Now in its third year, one of our biggest challenges is identifying all the wasps that are sent in. The student will join the BWS team during summer 2020, helping to identify the wasps and contributing to the running of the 2020 sampling events.

www.bigwaspsurvey.org

Sumner, S. *et al.* (2018) Why we love bees and hate wasps. *Ecol. Entomol.* 43, 836–845 1

Sumner, S. *et al.* (2019) Mapping species distributions in 2 weeks using citizen science. *Insect Conserv. Divers.* DOI: 10.1111/icad.12345

1Southon, R.J. *et al.* (2019) Social wasps are effective biocontrol agents of key lepidopteran crop-pests. *Proc. R. Soc. B R.* DOI: http://dx.doi.org/10.1098/rspb.2019.1676

Any details of particular knowledge you would like the student to have.

Students do not need any prior knowledge as they will be trained. However, an aptitude for microscope work and an imperviousness to working with rather smelly, dead insects is essential. An interest in ecology and ecosystem services and citizen science is desirable.

Project 2: Social interaction and queen succession dynamics in a tropical paper wasp.

In simple eusocial species, non-reproductive workers retain the ability become reproductive and succeed the current queen. Once the queen has died, a power vacuum exists in the colony: at this stage, wasps compete for dominance. Inheriting the colony represents a huge potential increase in fitness for these competing individuals, particularly in tropical species where colony lifespan is not limited by strong seasonality as it is in temperate regions, yet the dynamics of queen succession in these species is not as well understood.

In Trinidad, queens were experimentally removed from 40 colonies of the simple eusocial paper wasp *Polistes lanio*, and the ascension of new queens post-removal was documented. Video observational data was collected before and after queen removal. The student will have the opportunity to obtain social network information from these field videos by observing dominance interactions, and build profiles of individual wasps based on their behaviours, interactions and characteristics. They will then use this information to assess the impact of queen removal on behaviour, and identify which factors determine dominance hierarchy and the identity of the next queen. The student will work alongside other members of the Sumner Lab.

Strassmann, J.E. et al. (2004) The Cost of Queen Loss in the Social Wasp *Polistes dominulus* (Hymenoptera: Vespidae). *Journal of the Kansas Entomological Society* 77, 343–355. https://doi.org/10.2317/E-15.1

Jandt, J.M. et al. (2014) Polistes paper wasps: a model genus for the study of social dominance hierarchies. *Insectes Sociaux*. 61, 11–27. https://doi.org/10.1007/s00040-013-0328-0

Any details of particular knowledge you would like the student to have.

Students do not need any prior knowledge as they will be trained. An interest in behavioural ecology and social evolution is desirable.

***Deadline for contact*:**

10 January 2020. Applicants should send a cover letter, brief CV & contact details of a referee.

Contact: s.sumner@ucl.ac.uk