Adapt or die - how do animals respond to changing environments?

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Project summary

How do animals respond to new or changing environments? Why is it that some species can adapt or move, while others face extinction?

Understanding how animals respond and adapt to new and changing environments is a fundamental question in ecology, conservation biology, and evolution. With climate change and the resulting increased frequency of extreme weather events, being able to understand and ultimately predict how some species can adapt while others face extinction is of paramount importance. However, studies that focus on a single species neglect the fact that trophic interactions, such as host-parasitoid interactions underpin food web structure and are key for ecosystem functioning.

This project takes advantage of a model system for trophic interactions; the Indian meal moth (*Plodia interpunctella)*, which is a significant pest of stored food) and its natural enemy the parasitic wasp (*Venturia cansecens*). This project will combine life-history measurements with population demographics and genetic analysis to address how these species are responding and adapting to changing environments and how this affects trophic interactions over short and long time scales.

Background and Project Description

Animals live in increasingly variable environments where conditions can change rapidly. In cases where environmental change is predictable, such as seasonal changes in temperature and precipitation, animals are adapted to cope with this variation. However, unpredictable and abrupt changes in the environment can have profound effects on species, increasing extinction risk for at-risk species that fail to adapt or move. Understanding how and why some animals become adapted to rapid changes in the environment and some don't is a key question in ecology, evolution and conservation biology, particularly in light of global climate change and the increasing frequency of extreme weather events.

Figure 1: The parasitoid wasp *Venturia cansecens* laying eggs inside the host (*Plodia interpunctella*) larvae.

Whilst there is ample evidence that individual species have adapted to recent environmental change, of particular concern is how trophic interactions, such as host-parasitoid interactions, will respond. This is because trophic interactions underpin food web structure and are key for ecosystem functioning and ecosystem services.

In this project we will examine the short and long-term effects of environmental variations (*e.g.* temperature) that mimic climate change on a well-established trophic system, the Indian meal moth (*Plodia interpunctella*) and the parasitic wasp (*Venturia cansecens*) (Fig. 1) [e.g. 1]. The Indian meal moth is a world-wide pest of stored products and is resistant to a number of commonly used insecticides.

Insects are the most abundant and species rich group of animals on the planet. They have important roles in all terrestrial and many aquatic ecosystems and a critical for ecological functions including pollination and pest control. Ambient temperature is particularly important for ectotherms such as insects and many insect species are potentially highly vulnerable to the impacts of climate change and have a high risk of extinction. Model systems, such as *Plodia*, have been used for decades to answer questions in ecology and evolution that are extremely difficult to address in the field.

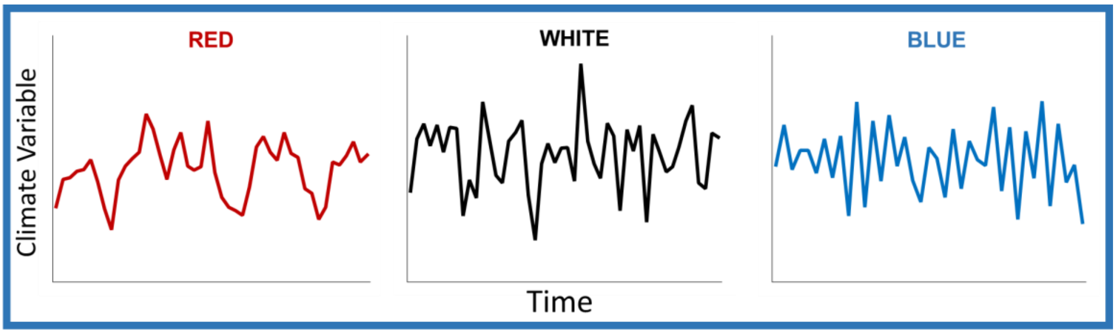

Figure 2: Environmental variation can be modelled to account for different dominant frequencies of change, analogous to different colours in the visible colour spectrum. Red is characterised by slow changes, white is purely random with no dominant frequencies, and blue by high frequency changes. Natural environmental variation is often described as reddened, but climate warming is expected to change these patterns.

Recent work in the Sait lab has shown that different frequencies of environmental variation (Fig. 2) cause phenotypic changes over short time scales in these species, affecting population dynamics of the host and parasitoid. Using microcosm experiments (Fig. 3) we can simulate these different environments and examine the effects on key life history traits and population dynamics in the host and parasitoid. This is important as natural environmental variation is said to be positively auto-correlated (red) in this case consecutive observations are similar. In general, marine environments are more reddened than terrestrial ones. Terrestrial temperature variation expected to be "less red" with climate warming.

Understanding how different species respond to these different frequencies of environmental information is crucial to predict how species will respond to climate change, as well as determining how species interactions and trophic webs may be affected. Ultimately, this is crucial and for management and conservation of natural populations, fisheries management and pest control.

The response of individual species to environmental change can potentially depend on a number of factors including; generation time, population size, traits and life stages (e.g. juvenile vs. adult) that are affected. This makes some species more vulnerable to extinction for a given type of environmental change than others. However, little is known about how animals are able to adapt to new environments, and the mechanisms involved [2].

Model systems, such as *Plodia*, are being used to answer these fundamental questions in ecology and evolution that are extremely difficult to address in the field. Recent work in the Sait lab has shown that relatively small fluctuations in temperature causes phenotypic change in *Plodia* and *Venturia* over very short time scales, affecting overall population dynamics. Using this model system we will combine measures of host and parasitoid life history traits with molecular methods [e.g. 2, 3, 4] to understand how the host and parasitoids adapt to changing environments over both short and long-time periods.

This project will be based in the School of Biology at the University of Leeds and combines the skills of both supervisors (Sait; Population, community and evolutionary ecology and Duncan; developmental biology, phenotypic plasticity, molecular evolution) to amalgamate ecological studies with molecular studies of short and long term adaptation. The exact nature of the experiments will be designed in collaboration with the PhD student and supervisors to take into account the individuals' research interests.

In the context of the current biodiversity crisis, slowing, and ideally halting biodiversity loss is of paramount importance. A key aspect of this is identifying factors that predict resilience of species to environmental perturbation. This project will begin to address how species adapt to short- and long-term environmental change, and whether these mechanisms can act as predictors for adaptability to global change in other species.

Figure 3: An example of a microcosm with adult parasitic wasps (*V. cansecens*) visible and moth (*P. interpunctella*) larvae present in the bottom of the box. These microcosms are a powerful way of investigating the effect of environment on life history demographics in these species.

Expected outcomes

This project is using molecular and ecological tools to address fundamental and crucial questions relevant to climate change biology, conservation biology, evolution and adaptation. The project will produce several publishable papers, with at least one expected to be high impact as the questions being addressed are of wide scientific interest. The candidate will also be expected to present their research at a both of national and international conferences.

Requirements

A strong undergraduate (and ideally Masters) degree in ecology, genetics, biology or zoology is expected. However, training will be provided in all techniques relevant for the project. If you are not sure if you have the relevant background please feel free to contact the supervisors to discuss the project.

Training

This project will provide students with a broad range of training in a range of techniques associated with population monitoring, phenotypic measurements, life history measurements and molecular / genetic analysis. The work blends ecology and global change biology with genetics, providing a broad foundation for a future career. The PhD student will have access to a range of training courses designed to facilitate skills development and will be expected to present the outcomes of this project at both national and international conferences.

Research context and partners

Both Dr. Duncan and Dr. Sait have active research groups and strong records of relevant research in molecular mechanisms of phenotypic plasticity and population, community and evolutionary ecology respectively. The student will be involved in fortnightly team meetings, as well as having access to both formal (Faculty) and informal (Ecology & Evolution group) seminar series through the School of Biology. There will be significant interactions between the Duncan and Sait laboratories, ensuring that the PhD student graduates with a broad view of not only their field, but also the wider fields of evolution, development and ecology. Co-supervision will involve meetings between all participants and the co-supervisors will provide guidance on the overall direction of the project.

Bibliography

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4) Davey, et al., (2010), *Brief Funct Genomics*. 9(5-6): p. 416-23.