

PhD title: Migration and Disease Ecology of Lepidopteran Crop Pests

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Abstract:

Migration/dispersal and disease are intimately linked: the risk of disease may drive the evolution of migration; disease may limit the capacity to disperse; and the spatial distribution of disease may be governed by patterns of migration. Despite this, we know remarkably little about the relationship between migration and disease, especially insect crop pests. This studentship aims to address this gap in our knowledge, focussing on Lepidopteran crop pests (especially African armyworm, *Spodoptera exempta*, and the silver-Y moth, *Autographa gamma*). This study is particularly topical given that (i) the use of microbial biopesticides is likely to grow due to European legislation limiting the use of chemical pesticides; and (ii) environmental change (climate, land-use, etc.) is likely to result in changing dispersal patterns of insect crop pests. This studentship will take an experimental approach using pathogen bioassays, molecular genetic characterisation of infections and the use of flight mills to quantify dispersal capacity.

Background:

Migration/dispersal and disease are intimately linked, since the risk of infectious disease may drive the evolution of migration; disease may limit the capacity of infected individuals to disperse; and the spatial distribution of disease may be governed by patterns of migration, as infected individuals vector disease between sub-populations. Despite this, we know remarkably little about the relationship between migration and disease, especially insect crop pests.

This is an important gap in our knowledge because environmental change (climate, land-use, etc.) is generating changes in the migration patterns and spatial distribution of insects (including the silver-Y moth, *Autographa gamma*, studied by Chapman and colleagues) potentially taking infectious insect diseases into new areas; for generalist pathogens this may have knock-on effects for other species in the community. Moreover, with new European legislation, the use of microbial biopesticides (baculoviruses, entomopathogenic fungi, and bacteria such as Bt) is likely to increase, yet the consequences of this for the spread of infectious disease to non-target organisms has not previously been considered; this is especially important because many insect pathogens can be vectored by migrating insects and transmitted to subsequent generations via vertical transmission. One system that is particularly well understood in this regard is the African armyworm, *Spodoptera exempta*, and Wilson and colleagues have been developing an endemic baculovirus, SpexNPV, as a biopesticide against this migratory pest. However, we currently know very little about the role of migration in determining the nature of the interaction between African armyworm and this baculovirus, or indeed the interaction between any crop pest and its microbial infections. This studentship aims to address this gap in our knowledge.

The student will use *A. gamma* and *S. exempta* as model organisms – the former because its migration and biology is readily studied in the UK and Europe, where it is a migratory crop pest; the latter because its interaction with SpexNPV (naturally and as a biopesticide) has been studied intensively in Tanzania for the past 15 years. The studentship will focus on the interaction between these two host species and their baculoviruses, using a combination of laboratory experiments (bioassays using sub-lethal doses of baculovirus and migration behaviour using automated flight mills) and laboratory analysis of field-collected samples (moths collected across the insect's migratory range will be assayed for the intensity of microbial infections they carry using quantitative PCR). Together, these complementary approaches will allow the student to test a number of specific hypotheses.

Hypotheses:

- 1) Exposure to low doses of baculovirus at the larval stage will increase the propensity for migration in the adult stage;
- 2) Infection with sub-lethal doses of virus as larvae will: (i) reduce the capacity to migrate as adults; (ii) increase the capacity to vertically-transmit virus infection to offspring; and (iii) reduce adult fecundity and/or lifespan, and hence the insect's intrinsic rate of increase, r ;
- 3) Flight during the adult stage will: (i) increase the potential of the moth to vertically transmit virus to its offspring; and (ii) reduce its fecundity and/or lifespan, and hence r .
- 4) Pathogen infection levels will: (i) decline during the migration cycle as infected individuals drop out of the population (due to sub-lethal or lethal effects of flight), or (ii) increase during the migration cycle as infection spreads through the larval population.

Experimental approaches:

- 1) The student will quantify levels of 'covert' microbial infections in field-collected samples using molecular methods (quantitative PCR);
- 2) The propensity for migration will be quantified using Rothamsted's electronic flight mills that will automatically record the flight patterns of tethered moths;
- 3) The student will quantify the effects of migration on the susceptibility to microbial infections using pathogen bioassays;
- 4) The student may also develop simulation or mathematical models to analyse the effects of microbial infection on meta-population dynamics.

Training for Student:

The student will receive training in:

- 1) Migration biology and the use of electronic flight recorders;
- 2) Molecular ecology and the diagnosis of sub-lethal infections using qPCR;
- 3) Microbial biology and pathogen bioassays;
- 4) Insect culturing methods;
- 5) Experimental design and statistical analysis using the R package.

The student will benefit from, and add value to, an existing BBSRC grant (Wilson) exploring the interaction between *Spodoptera* caterpillars and bacterial infections, as well as DFID funding (Wilson) into the development of SpexNPV biopesticide in Tanzania. There *may* be opportunities for fieldwork in the UK and/or Tanzania (depending on funding)

Further information:*Insect and Parasite Ecology Group (iPEG)*

The student will be based within iPEG, part of the Biodiversity and Global Change Research Theme within the Lancaster Environment Centres. iPEG students conduct research on a range of projects related to insect and parasite evolutionary, population and community ecology, covering a diverse range of systems:- <http://www.lancs.ac.uk/staff/wilsonk4/>

Movement and Spatial Ecology Group

The student will also spend time in the Movement and Spatial Ecology Group at Rothamsted Research in Harpenden, Hertfordshire. This group has expertise in the migration ecology and movement strategies of insects, with a particular focus on Lepidoptera. The group uses a range of innovative tools, including vertical-looking entomological radars, computerised tethered-flight mills and flight-simulators, and the Rothamsted Insect Survey national network of light-traps. <http://www.rothamsted.ac.uk/PersonDetails.php?Who=137015>