PROJECT TITLE: Viral spillover: the conditions influencing the success of viral host shifts from bees to ants

DTP Research Theme(s): Living World

Lead Institution: University of Bristol

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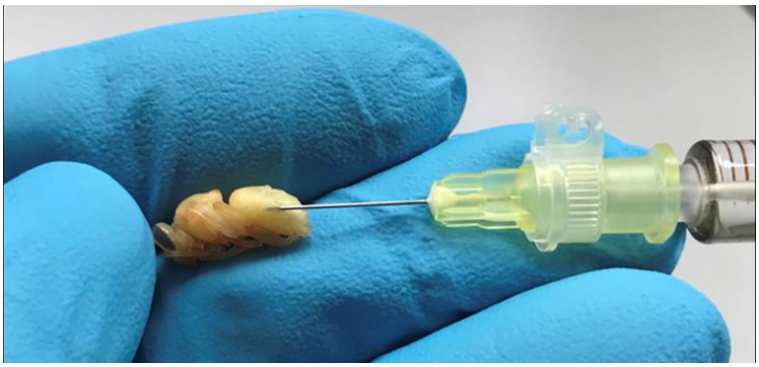
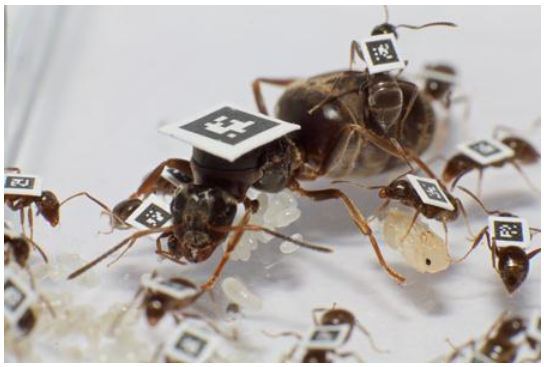
Project keywords: virus, host shift, ants, honeybees, transmission, epidemics, behavioural tracking



Injecting honeybee pupa with ABPV virus prior to conducting virus spillover experiments. Image by Daniel Schläppi.



Individually-marked black garden ant queen and workers for automated tracking experiments. Image by Timothée Brütsch.

Project Background

Emerging infectious diseases often originate from a host shift, where a pathogen is transferred from its original host to a new host species. Successful host shifts leading to new epidemic outbreaks depend on the survival, replication and secondary transmission of the pathogen within the new host. These processes are influenced by an array of factors ranging from the phylogenetic distance between the two hosts species to the ecology of the new host[1,2]. Being able to accurately predict and prevent successful host shifts could be key to designing effective disease control strategies, but this has been hindered by the relative dearth of experimental studies of the transmission of pathogens within a new host shortly after a spillover event.

Project Aims and Methods

The overall goal of this project will be to experimentally study the recently described spillover of the Acute bee paralysis virus (ABPV) from its original host, the European honeybee *Apis mellifera*, to a new host, the black garden ant *Lasius niger*[3], via foodborne transmission. We aim to achieve better understanding of the conditions under which an initial spillover might result in a successful host shift and subsequent epidemic outbreaks, and shed new light on the ecology of host-pathogen interactions after cross-species transmission.

To achieve this goal, the project will consist of two main parts combining field work, molecular analyses and behavioural experiments involving automated ant tracking.

The first part will consist in investigating the conditions favouring the initial transmission of the virus from the honeybee reservoir to the novel ant host. This will be achieved using (i) comprehensive field surveys and viral genome sequencing to establish the presence or absence of ABPV in natural populations of *L. niger* as a function of ecological factors (e.g. distance to apiaries), (ii) follow-up laboratory experiments to experimentally test hypotheses arising from the field survey and (iii) a combination of behavioural experiments and chemical analyses of ABPV-infected pupae via GC-MS (gas chromatography with mass spectrometry) to uncover the mechanisms underlying the apparent preference of *L. niger* for ABPV-infected over healthy pupae (unpublished data).

The second part will consist in empirically testing whether successful secondary transmission of infection among ants occur following the initial host switch. This will be achieved using a combination of (i) controlled natural (foodborne) and artificial (injections) primary infections of the ant host, (ii) molecular analyses to test for successful replication of the virus following secondary transmission of the virus via social contact between infected ants and their healthy nestmates, and (iii) automated behavioural tracking experiments[4] to uncover the dynamics of appearance of clinical symptoms (altered mobility and paralysis) within exposed colonies, and highlight the pathways of transmission of the virus through the colony.

The project detailed above should be considered as a general guidance, but the supervisors would be happy to adapt or change the project to better match the interests of the student.

Candidate requirements

Applicants must have an excellent undergraduate or Masters degree (2:1 or 1st) in a relevant area (e.g. Biology, Biomedicine). They must be happy to work as part of highly dynamic, inter-disciplinary teams and willing to learn the diverse experimental and computational skills involved in the project. Experience with social insects, insect immunity, viruses, coding or analysing large datasets would be a plus. We welcome and encourage student applications from under-represented groups. We value a diverse research environment.

Project partners

This project will involve the collaboration between two world-leading research-intensive Universities, the University of Bristol and the University of Exeter. The student will be part of Dr Stroeymeyt's Ant Epidemiology Lab (LINK) at the University of Bristol, whose research focuses on the strategies used by ant colonies to minimise the likelihood and impact of infectious epidemics, and of Dr Longdon's Virus Ecology and Evolution team (LINK) at the University of Exeter, whose research focuses on pathogen switches between host species, with a particular focus on insects and their natural viruses.

Training

The student will become proficient in cutting-edge automated individual tracking methods and quantitative behavioural analysis of large datasets through writing their own code. They will also gain training in state-of-the-art molecular and microbiology methods related to the culture, infection and monitoring the replication of viruses in live hosts, and sequencing viral genomes. The student will also gain expertise in experimental design, field work, and chemical fingerprint identification through GC-MS analysis. Finally, they will learn how to communicate their results effectively to both scientific and general audiences, both in writing and orally. They will also have access to a variety of training opportunities provided by the NERC GW4+ partnership as described here (LINK).

Background reading and references

1 Longdon, B. *et al.* The causes and consequences of changes in virulence following pathogen host shifts. *PLoS Pathogens* **11**, e1004728 (2015). [LINK]

2 Imrie, R. M., Roberts, K. E. & Longdon, B. Between virus correlations in the outcome of infection across host species: Evidence of virus by host species interactions. *Evolution Letters* **5**, 472-483 (2021). [LINK]

3 Schläppi, D., Chejanovsky, N., Yañez, O. & Neumann, P. Foodborne transmission and clinical symptoms of honey bee viruses in ants Lasius spp. *Viruses* **12**, 321 (2020). [LINK]

4 Stroeymeyt, N. et al. Social network plasticity decreases disease transmission in a eusocial insect. *Science* **362**, 941-945 (2018). [LINK]

Useful links

http://www.bristol.ac.uk/biology/courses/postgraduate/

Bristol NERC GW4+ DTP Prospectus:
https://www.bristol.ac.uk/study/postgraduate/research/great-western-four-doctoral-training-partnership-nerc/

How to apply to the University of Bristol:
http://www.bristol.ac.uk/study/postgraduate/apply/

Please note: If you wish to apply for more than one project please contact the Bristol NERC GW4+ DTP Administrator to find out the process for doing this.

The application deadline is Tuesday 9 January 2024 at 2359 GMT. Interviews will take place from 26 February to 8 March 2024.

For more information about the NERC GW4+ Doctoral Training Partnership please visit https://www.nercgw4plus.ac.uk.

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