PROJECT TITLE: Rewiring ant communications to control behaviour using engineered bacteria

DTP Research Theme(s): Living World

Lead Institution: University of Bristol

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Project keywords: synthetic biology; metabolic engineering; bioinformatics; ants; stigmergy; collective behaviours; pest control

Ants form extensive foraging trails allowing them to collectively exploit food sources. Communication and coordination within the trail are achieved via chemical signals. Image credit: Yanet Sepulveda

Reprogrammed bacteria will be used to produce on demand the chemical communication signals used by ants. Image credit: Liang Zong & Yan Liang

Project Background

Social insects such as ants make extensive use of chemical signals deposited into their environment to coordinate collective colony-level behaviours that go far beyond the capabilities of each individual. This indirect communication process, known as stigmergy, has been shown to underpin the ability for ants to efficiently forage for food, build and repair complex nests, and assess the suitability of new nest sites. Over the past few decades our understanding of the biochemical composition of these signals has substantially increased. However, difficulties in producing these molecules using standard approaches with chemistry has hindered the ability to effectively study their role and function.

Project Aims and Methods

The aim of this project is to give researchers the ability to “talk” to ants using their own chemical signals using novel synthetic biology approaches for bio-compound production. This will allow for a better understanding of the rules ants use to generate emergent collective behaviours by allowing the communications within these systems to be perturbed in precise and controllable ways. Such knowledge would not only offer new insight into how our own societies might be better organised (e.g., to reduce the spread of disease), but also offers a means to develop interventions that can disrupt the functioning of a colony as an avenue towards novel, non-destructive pest control methods.

To achieve this goal the project will be made up of three major parts that bring together bioinformatics, synthetic biology, and behavioural studies with ants. The first part will focus on the “mining” of genomic databases to search for enzymes that would enable the production of ant signalling-like molecules to explore the chemical space that is used for communication. The second part will then take these enzymes and use them to engineer the metabolism of bacteria such that they are able to synthesise the candidate signalling molecules. Finally, the third part will test the ability of the engineered bacteria to cause behavioural shifts in a range of ant species. We will also explore the possibility of creating artificial trails using bacteria directly applied the environment to control foraging trail direction and potentially divert them away from areas of interest.

Although, some candidate chemicals and enzymes have already been identified by the supervisors, thereby increasing the project's viability and chance of success (Morgan, 2009; Silva-Junior, 2018), the student will have the freedom to shape the overall direction of the project. For example, deciding whether to use the engineered bacteria to dissect the native collective behaviours of ants, or explore the possible application of this technology pest control.

Project partners

This project brings together the vibrant and growing synthetic biology and insect behaviour communities at the Universities of Bristol and Exeter. In Bristol, the student will become connected to the Bristol BioDesign Institute that aims to push the boundaries of engineering biology and the advanced ant tracking technologies of the Ant Epidemiology Lab, while in Exeter, the student will join a community of researchers focused on translating our deeper understanding of the biosciences into solutions for globally important challenges.

Candidate requirements

Applicants must have an excellent undergraduate or Masters degree (2:1 or First) in an area related to the project (e.g. Biology, Chemistry, Physics, Biochemistry, Bioengineering, Bioinformatics). They must also be willing to work as part of a highly dynamic and inter-disciplinary team and have a passion for learning the diverse experimental and computational skills needed to make this project a success. We welcome and encourage student applications from under-represented groups. We value a diverse research environment.

Training

The student will be given training in cutting-edge molecular and synthetic biology methods, bioinformatics techniques for mining sequence and metabolic pathway databases, as well as the handling and development of behavioural experiments using ants. More broadly, there will be opportunities to gain public engagement experience as part of the "Become a Biological Engineer" project run within the Biocompute Lab [Link], and the Bristol Doctoral College (BDC) [Link] will provide extensive opportunities for training in transferable skills and personal development, including productivity, teaching and communication.

Background reading and references

- Morgan (2009) Trail pheromones of ants. *Physiological Entomology* **34**, 1–17. [Link]
- Howard & Blomquist (2005) Ecological, behavioral, and biochemical aspects of insect hydrocarbons. *Annual Reviews in Entomology* **50**, 371–393. [Link]
- Blomquist (2010) Biosynthesis of cuticular hydrocarbons. *Insect Hydrocarbons, Biology, Biochemistry, and Chemical Ecology*, Cambridge University Press. [Link]
- Silva-Junior et al. (2018) Pyrazines from bacteria and ants: convergent chemistry within an ecological niche. *Scientific Reports* **8**, 2595. [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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