PROJECT TITLE: Rewiring ant communication 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 deposited into the environment (i.e. stigmergy). Reprogramed 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 as a means 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 new, 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 (Escherichia coli) such that they are able to synthesise the candidate signalling molecules. Biochemical and structural (e.g. HPLC and NMR) analyses will be performed to verify the concentrations and composition of chemicals produced and the synthetic genetic pathways optimised for maximum production. The purified compounds and the engineered bacteria will be tested for their direct ability...
to cause behavioural shifts in a range of ant species. The precise ant species used will depend on the signalling chemicals chosen but is likely to include the black garden ant *Lasius niger* which relies on chemical signals for trail formation when foraging for food. Behavioural studies will involve the use of 2D mazes with decision points where we will test the ability for a route containing bacteria to bias individual and collective choices. 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. This will include choosing the signalling molecules to investigate and deciding on whether to use the engineered bacteria as a means to dissect the native collective behaviours of ants, or to explore possible alternative ways to disrupt their ability to function towards applications in pest control, or both if time permits.

**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, 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. Experience working with ants, enzyme/pathway databases or synthetic biology would be beneficial, although not required.

**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**

- Smanski et al. (2016) Synthetic biology to access and expand nature’s chemical diversity. *Nature Reviews Microbiology* 14, 135–149. [Link]

**Useful links**

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

**NERC GW4+ DTP Website:**

For more information about the NERC GW4+ Doctoral Training Partnership please visit

https://www.nercgw4plus.ac.uk.

**Bristol NERC GW4+ DTP Prospectus:**

http://www.bristol.ac.uk/study/postgraduate/2022/doctoral/phd-great-western-four-dtp/

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

The application deadline is Monday 10 January at 23:59 GMT.

Interviews will take place during the period 23 February – 9 March 2022.

**General Enquiries:**

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