Imperial College London

NERC SCIENCE OF THE ENVIRONMENT

Centre for Doctoral Training in Quantitative & Modelling Skills in Ecology & Evolution (www.imperial.ac.uk/qmee-cdt/)

What's the buzz about acoustic biomonitoring?

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Little did Rimsky-Korsakov know that listening to Flight of the Bumblebee may have the potential to help conserve the insects that so inspired his musical composition. For those classical music enthusiasts, I am afraid that this is not an advert for a music project or at least not in the strict sense. Instead, we propose a PhD project to study acoustic patterns produced from bumblebees in flight to ultimately autonomously detect bumblebees in the field. Focusing on the sonic vibrations of their 'buzz' during different aspects of flight the project will bring together the disciplines of ecology, maths and engineering to develop an autonomous monitoring platform. By eavesdropping on the sounds made by bumblebee communities we can monitor bumblebee behavioural patterns across different landscapes to help inform conservation and land management strategies.

Background: Developing solutions to mitigate insect pollinator declines is critical in protecting the ecosystem functions and services they provide. Bumblebees are particularly important pollinators, but range contractions and species extinctions show they are under threat. Implementing schemes to monitor bumblebees, is therefore important to understand current population status, favoured habitats, phenology (life-history timings) and movement across landscapes all of which reveals bumblebee pollination potential and indicators of stress.

Using current insect pollinator monitoring methods, however, comes with limitations. Traditional methods often suffer from lethal capture, high expense of employing taxonomically skilled people over long time periods, observer bias and species capture biases. Molecular methods have been an important advance but remain expensive for the scale of monitoring that is required, typically require invasive capture or focused eDNA approaches. Data is therefore temporally and spatially limited, and often tell us the presence of an individual but little insight into behaviour.

Learning from recent developments in bird and mammal studies, this project will look to develop an inexpensive and automated method of insect acoustic monitoring. The project will develop a novel taxonomically tuned autonomous system through studying the sound frequencies of wingbeat induced vibrations during bumblebee foraging flight.

The project will:

1. Use bumblebee flight mill setups to record the pitch of wingbeat frequencies under different controlled environment conditions. This data will be used to help design microphone and sensor setups along with required embedded electronics.
2. Use flight arenas to provide different foraging challenges to understand acoustic signatures of different foraging behaviours within and between species.
3. Carry out machine learning techniques by applying state-of-the-art software tools. Student will collect representative sets of acoustic recordings from replicable flight behavioural trials to train models.
4. Test if specific acoustic signatures from the machine learning outcomes can be identified in semi-field and field scenarios (such as flower patches) and quantitatively analyse data on foraging rates and behaviours.
5. Look to test this technology in different landscape scenarios.

To apply please email Richard Gill directly with your CV and a Cover Letter (max 1-page A4) that describes your suitability for the position. **Application deadline is 1st July 2019 23:59, and interviews will be carried out before 13th July**. Eligibility: you must be a UK citizen or have lived in the UK for the past 3 years.

Key quantitative skills:
Ecoinformatic tools to process big data
High performance computing, machine learning & statistical approaches.
Coupling flight behaviour with acoustic recordings from representative sets of behaviours, computer models will be trained to identify consistent signatures.
Threshold based comparative analyses will identify signatures of body size, species & foraging behaviours.

Multidisciplinarity statement:
Experimental biology & ecology: lab & field setups, bee foraging behaviour, bumblebee landscape ecology
Engineering: designing microphone setup, sensor development & embedded electronics
Bioinformatics (computing & maths): managing big data, advanced statistics, developing algorithms, model testing & training
Audio analyses: computer linguistic & phonetic approaches

Innovation:
Develop novel technology to affordably measure an aspect of ecosystem dynamics across long time-frames by acoustically eavesdropping.
Taking bottom-up taxonomic driven approach, we can autonomously record species of interest in the environment using prior knowledge rather than naïve approach.
Quantitative data on different behaviours from flight acoustic signatures, not just presence/absence.

Ecological/Evolutionary Theory Elements:
Investigating allometric and isometric relationships with wing beat frequency under different temperatures.
Contribution of body size vs species in explaining acoustic variation. Does phylogeny play a role?
How do wing beat patterns change with different flight behaviours?
How does landscape context affect bumblebee communities?
Testing how mass flowering crops dilute bumblebee abundance & behaviour.

Real world applications:
Developing insect pollinator monitoring tools helps us understand current population status, favoured habitats, phenology and movement across landscapes revealing pollination potential, areas of pollination deficits & indicators of stress. Gaining these insights informs when and where we can help support and conserve insect pollinators, such as bumblebees.

Potential impact:
The data will provide a novel understanding of bumblebee behaviour in the wild. Automated monitoring devices could be deployed widely to understand local, regional, national & global trends.
Using these insights can provide economic and ecological benefits, incl. managing pollinators for increased farming yields & improvement of floral resources to support pollinators.

Training:
Supervisors & current PhD students Sarab Sethi & Elise Damstra will provide training & support on experimental design, bee ecology, engineering skills in building acoustic recording setups & reading audio files, bioinformatic skills; computational analyses & machine learning techniques.
Student will look to collaborate with sound machine learning lab at ICL & attend machine learning summer school.