Biodiversity and ecosystem services: Birds, bats, bees, and cocoa trees (Ref IAP2-18-49)

Durham University, Department of Biosciences
In partnership with Newcastle University

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Key Words
1. Agriculture
2. Food webs
3. Metagenomics
4. Ornithology
5. Mammalogy

Overview

Human populations are increasing rapidly and resource consumption is intensifying. To meet these demands, industrialized agriculture has scaled up sharply: Land is being cleared at a dramatic rate such that half of tropical forests are already gone. Simultaneously, biodiversity, which provides critical ecosystem services, is being lost at an alarming and unprecedented rate. Realisation of this crisis has created an urgent need to balance agricultural production with protection of biodiversity. These two objectives are not disjoint, and indeed, biodiversity can play an integral role in increasing agricultural yields—sustainably. To achieve this balance, we must manage ecosystems for species that provide support for crops (“ecosystem service species”, e.g. species that provide pest control) as well as those that encourage biodiversity (“keystone species”), and especially those that provide both functions (“cross-over species”).

To truly work towards this balance, one must first understand the food web, because species vary greatly in their value for both agriculture and biodiversity services. For example, in North America, oaks support more than ten-fold higher richness of butterfly and moth species than most other tree genera, demonstrating their high keystone functionality. Bird and bat consumption of insects in Indonesian cacao plantations exemplify ecosystem service functionality, increasing crop yield by 31% and saving poor farmers an astonishing £550 per ha annually. A follow-up experiment found that just one bird species, the endemic white-eye, *Zosterops chloris*, was responsible for the majority of predation on pest arthropods. It further showed that the landscape context of agricultural plots affected both bird community dynamics and ecosystem services, through spill-over of individuals from primary forest. Despite such encouraging evidence, and recent advances in

Fig 1. Food webs, like the example above, are characterised by species abundance (icon size) and the strength of interspecific interactions (link thickness). Ecosystem service species increase crop yield, whereas keystone species support higher biodiversity. Cross-over species provide both functions.
technological methods, most published studies have relied on time-consuming microscopic analysis of regurgitation or faeces to document the food web, an approach that provides limited resolution and has potential biases. **This project will use a combination of (optional) field work, state-of-the-art next-generation sequencing methods, and sophisticated bioinformatic/statistical analyses to deduce the diet of hundreds of animals, map the food web, and quantify the trade-offs or synergies between biodiversity and agricultural production, thus providing great insight into species interactions.**

This project will address:

1) **Which member species are most influential in encouraging crop yields and/or increasing biodiversity?**
2) **Do the above insights change depending on the context of the landscape, e.g. at sites near or far from forest?**
3) **How can we use the above insights to manage ecosystems that are both diverse and high-yielding?**

**Methodology**

The student will investigate these questions in the food web of plants, birds, bats, and arthropods in African plantations of cacao, the main ingredient of chocolate. This agricultural system is ideal for attempting to balance ecological and agricultural imperatives. Cocoa is grown under a shade tree community, which, when managed appropriately, has the potential to support high biodiversity that in turn could provide ecosystem services in the form of biocontrol of cocoa pests. **The student will have the option to join an international team, composed of academics, postdocs, and PhD students, in Cameroon for two field seasons of 3 – 5 weeks, to mistnet birds and bats, trap arthropods, and collect representative plant samples. He or she will then conduct metabarcoding of bird and bat samples (i.e. simultaneous sequencing of all diet items using advanced DNA sequencing technology).** These sequences will then be compared to a local reference sequence database created by applying traditional sequencing methods to the collected arthropods and plants. **The student will then use sophisticated bioinformatics and statistical techniques, in collaboration with co-supervisor Evans at Newcastle and our colleagues at Glasgow University, to map the food web, examine species interactions, and link these to data collected on pest abundance and crop damage.**

**Impact:** Cocoa is typically farmed by rural Africans with few resources for purchasing pesticides or fertilizers to improve crop outputs. Encouraging natural biocontrol of pests has the potential to provide life-changing savings for farmers. At the same time, more and more land is being cleared for cocoa farming to support a growing population and satisfy the demands for chocolate in western countries like the UK. Thus, increasing crop yield may significantly slow habitat destruction or encourage alternative strategies to selectively log the land instead, thus preserving biodiversity before it is lost. Beyond this, the methods developed to rapidly assess food web dynamics can be applied to a wide range of ecological problems (e.g., characterising bacterial communities related to animal and human health, understanding dietary adaptations, etc.). **Therefore, this project will provide the student with interdisciplinary training, a broad international network of contacts, and will produce advances of both theoretical and practical importance.**

**Timeline**

**Year 1** – optional field work (3 – 5 weeks), metabarcoding labwork on birds and bats, traditional barcoding on plants and arthropods, preliminary bioinformatics and data analysis;
**Year 2** – optional field work (3 – 5 weeks), metabarcoding labwork, bioinformatics and data analysis, manuscript preparation, national scientific meeting or workshop attendance;
**Year 3** – data analysis, manuscript preparation, international scientific meeting attendance;
**Year 3.5** – finalize manuscripts and submit/defend thesis.

**Training & Skills**

![Paradise Flycatcher](Fig 2. Paradise Flycatcher (Terpsiphone sp.) captured while mist-netting in a cacao farm in Cameroon. Photo by Dr. Luke Powell.)
The student will be based in the lab of Dr. Welch at Durham University. She or he has the option to be trained and conduct fieldwork with collaborator Dr. Luke Powell (Glasgow University, Institute of Biodiversity Animal Health and Comparative Medicine) and an international team including other PhD students, as well as local entomologists and botanists. Lab work and bioinformatics will be conducted in consultation with Dr. Evans at Newcastle University, and training in statistical analysis and modelling will involve collaboration with Prof. Jason Matthiopoulos (University of Glasgow, Institute of Biodiversity Animal Health and Comparative Medicine).

Through this project the student will develop many highly desired and transferrable skills. The general lab and advanced DNA sequencing skills that will be acquired are important for a research career in ecological and evolutionary genetics, but provide a strong foundation for careers in environmental testing, molecular biology, agricultural biotechnology, and medical testing/research, etc. Numeracy, a widely desired trait, will be well developed through use of sophisticated bioinformatics approaches and implementation of rigorous statistical analyses. International collaboration with researchers, as well as our local partner non-profit organisations and charities, will expand the student’s network of contacts and open potential future employment options. Scientific writing and attendance at professional meetings will aid in development of key communication skills. Additionally, organisation and time management skills necessary for this project are widely applicable in all industries. Beyond this the project will contribute towards development of novel methodologies and ecological theory, in addition to having practical consequences for local farmers.

References & Further Reading


Further Information

This project is in competition with others for funding, and success will depend on the quality of applicants, relative to those for competing projects.

Funding includes tuition fee waiver for Durham University, a competitive stipend, and research support.

To express interest in applying, or for further information, you should contact Dr. Andreanna Welch by early January 2019.

In your email include: 1) a few sentences detailing your reasons for applying and how your experiences fit with the project, 2) your CV with marks earned for previous degrees and 3) contact information for at least two references. Only the best applicants will be asked to submit a full application, including two reference letters, by 16:00 on the 18th of January, 2019.