Brain evolution and comparative anatomy across bumblebee species

IAP-24-044

MOTIVATION

Bumblebees are agriculturally important pollinators, but are currently declining in abundance in the UK and around the world. Understanding these declines requires research on bee biology and physiology. So far the bumblebee nervous system has been extensively studied only in the species that may be purchased commercially and kept in a laboratory: Bombus terrestris and Bombus impatiens. The aim of this project is to investigate brain anatomy of 7 closely-related bumblebees from the North-East of England, together with the degree of plasticity and factors that may affect it: nutrition, climate, flower diversity and availability, bee tasks in the nest, etc.

AIMS

This project will investigate and compare brain anatomy of 7 species of bumblebees. We will specifically focus on antennal and optic lobes – the olfactory and visual processing centres of an insect brain. We hypothesise the existence of strong sexual and inter- and intra-specific dimorphisms, related to the quality of the bee's nutrition during development, bee age or to the tasks that an adult bee performs within the colony or when foraging outside.

Aim 1) Characterise brain anatomy in 7 species of field-collected bumblebees

Aim 2) Establish how larval nutrition, age and task experiences of adult bees affect their brain anatomy

Aim 3) Establish how floral diversity and climatic conditions affect brain anatomy

NOVELTY AND IMPACT

This project will focus on native UK bee species that are agriculturally important pollinators, are in decline and are poorly studied.

Image Captions

The 7 focal species of bumblebees and a bumblebee brain

Methodology

A1) Bumblebees will be collected in Durham, Newcastle and Brighton, and their brains will be investigated by: 1) dissection, immunostaining and confocal microscopy, and 2) synchrotron radiation tomography of whole bee heads.

A2) To precisely control the amount and content of food given to the larvae, we will rear larvae of Bombus terrestris in vitro in the laboratory. Adult brains will be examined as in A1. We will examine brains of queen, worker and male bees of known ages, using laboratory colonies of Bombus terrestris. We will also compare the brains of in-hive bees, pollen-foragers and nectar-foragers, as well as bees trained to a cognitively complex task and those that were not.

A3) We will barcode pollen samples from the field-collected specimen, to establish the plant species the bee foraged on, to establish whether floral diversity correlates with the anatomy of sensory structures (antennal and optic lobes) used to detect flowers. We will compare bees of the same species from the North (Durham, Newcastle) and South (Brighton) of the UK, to investigate how different climates affect brain anatomy.

Project Timeline

Year 1

Aim1 and Aim 3 in Durham/Newcastle/Brighton;
ASAB conference in the UK

Year 2

Aim1 and Aim 3 in Durham/Newcastle/Brighton;
Aim2 in Durham/Newcastle/Sussex;
Neuroethology Congress; Sensory Ecology course, Sweden

Year 3

Aim2 in Durham/Newcastle/Sussex;
International Society of Behavioural Ecology congress

Year 3.5

Finishing up experiments and writing up.

Training & Skills

THE STUDENT WILL RECEIVE TRAINING:
1) by supervisors with complementary skills and expertise (led by Sup1 and directly supported by Sups2-3)
2) by collaborators and postdocs/research fellows in the three participating labs;
3) by attending summer courses and IAPETUS-specific training events;
6) by participating in regular public outreach activities;
7) by helping Sup1 to supervise UG students;
8) by presenting their work at lab meetings and conferences.

THE STUDENT WILL ACQUIRE KNOWLEDGE AND SKILLS IN:
1) insect neuroethology, ecology and evolution;
2) comparative neuroanatomy
3) brain dissection and immunostaining;
4) confocal and tomography imaging;
5) field collections of bumblebees;
6) bumblebee colony maintenance and in vitro larval rearing;
7) bumblebee training in various behavioural tasks;
8) image processing and analysis;
9) use of 3D modelling software, such as Amira or Dragonfly;
10) statistical analysis;
11) presentation and scientific writing;
12) research supervision;
13) impact and public outreach.

This project is highly interdisciplinary, and includes e.g. field collections, behavioural assays, in vitro bee rearing and advanced bioimaging. In addition, establishing a professional network is essential for a scientist, and the student will have numerous opportunities to develop their network via attending Summer courses, conferences, IAPETUS2 events and collaborators of the supervisory team (e.g. Sup1 collaborates with colleagues in Germany, Belgium, Italy, Portugal, Australia, India, Ethiopia and USA).

The student will also benefit from developing their presentation and public outreach skills and supervision of junior students. These skills will be invaluable for career paths both in academia and beyond.

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Key Words

- Bumblebees
- olfaction
- vision
- evolution
- stressors