

PROJECT TITLE: Social wasps across Africa: exploring how societies evolve at a continental scale

DTP Research Theme: Living World

Lead Institution: University of Bristol

Lead Supervisor: Dr Patrick Kennedy, University of Bristol, School of Biological Sciences

Co-Supervisor: Dr Gavin Broad, Natural History Museum, Insects Division

Co-Supervisor: Dr Stephen Montgomery, University of Bristol, School of Biological Sciences

Co-Supervisor: Professor Andrew Radford, University of Bristol, School of Biological Sciences

Co-Supervisor: Dr Andrew Higginson, University of Exeter, School of Psychology

Project Enquiries: patrick.kennedy@bristol.ac.uk

Project keywords: Social evolution; cooperation; Africa; wasps; field experiments; theory.

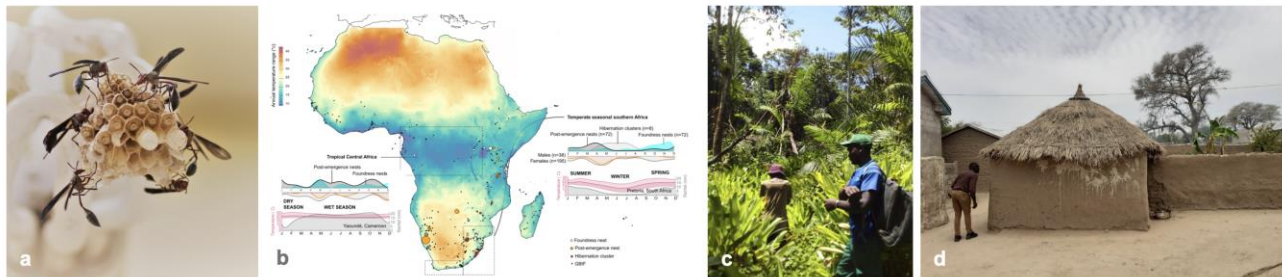


Fig. 1: (a) *Belonogaster* wasps form small social groups – perfect microcosms for testing theories about the evolution of cooperation and conflict. (b) They live across Africa’s extremes, from (c) tropical rainforest to (d) the arid margins of the Sahel and the temperate highlands of South Africa. This offers a rare opportunity to explore how social evolution is shaped by radically different climates. (c, d) This PhD will combine fieldwork behavioural experiments, museum specimens, and laboratory analyses to illuminate the evolution of animal societies in the wild. Photographs: P. Kennedy.

Project Background

Explaining the evolution of cooperation has been a challenge to biologists since Darwin. Today, a major objective is to explain the tantalising links between climate and cooperation. Across the face of the planet, do the pressures driving the evolution of animal sociality differ in systematic ways with climate? This PhD will provide a highly timely analysis. At present, there are almost no intraspecific studies of sociality across large climatic gradients, and key theoretical predictions remain untested. You will exploit the extraordinarily wide distribution of Africa’s most common wasp (*Belonogaster juncea*) – which ranges from tropical rainforest to arid deserts to temperate zones – to investigate key links between climate and sociality. How does social conflict differ across different climates? How has natural selection shaped brains and body morphology in different types of worker under different climates? Do the benefits and costs of cooperation differ systematically across the continent? Africa’s *Belonogaster* wasps represent a powerful model system for answering these questions, as well as posing as contemporary models for the early evolution of eusociality.

Project Aims and Methods

You will focus on pan-African social wasps, combining field behavioural experiments, computational modelling, museum specimen analyses, and laboratory work. Fieldwork on *Belonogaster* from Bristol is currently ongoing with international collaborators in Cameroon, Kenya, and South Africa, and you will be encouraged and supported to conduct fieldwork with wild populations. We will encourage you to take ownership over the research direction and approaches to study questions that most interest you. The likely core objectives include:

1. **Experiments:** You will conduct field-based manipulations of wild social wasp colonies, with each individual given a unique paint code, to measure social interactions before and after careful experimental perturbations of the social system (such as removing the queen to trigger a competitive power vacuum).
2. **Theory:** You will have the opportunity to develop models of cooperation and conflict amongst related individuals to derive predictions that you will test during experiments.
3. **Morphology:** By digitising 2,000 *Belonogaster* specimens at the Natural History Museum and your own field samples, you will use image analysis and advanced statistics to explore how morphology varies across climate zones.

4. Brain evolution: By dissecting and imaging wasp brains, you will test for neuroanatomical divergence between social castes under divergent climatic regimes.

Candidate requirements

We are looking for a highly motivated student with a passion for biology. The two most important requirements are: (1) you have a strong interest in the evolution of animal social behaviour and (2) you find appealing the prospect of conducting fieldwork over several months per year studying (occasionally stinging) insects in Africa. Prior fieldwork or mathematical modelling experience may be helpful, but is not required. A basic knowledge of French or a willingness to learn is desirable, as you may work in Cameroon, but not essential. We welcome and encourage applications from under-represented groups. We value a diverse research environment.

Project partners

University of Bristol: You will work at the state-of-the-art laboratories in the Life Sciences Building, actively participate in lab group meetings, and present your work to students and staff. You will also be encouraged to form strong links with our international research collaborators at universities and research centres in Africa. **Natural History Museum:** You will access and work on the extensive *Belonogaster* collection in London, and interact with the museum's world-leading scientists and digitisation work. **University of Exeter:** You will work with Dr Andrew Higginson at Exeter to develop evolutionary models tailored to the experimental system.

Training

Training opportunities will include fieldwork in target climate zones in Africa, running creative behavioural experiments, how to make models of social behaviour, working with museum collections, and neuroanatomical skills (brain dissection and imaging).

Background reading and references

For an introduction to altruism and kin selection: Sigmund, K. & Hauert, C. (2002). Primer: altruism. *Current Biology* **12**, R270-R272

For an introduction to social life in similar wasps: Jandt, J.M., Tibbetts, E.A. & Toth, A.L. (2014). *Polistes* paper wasps: a model genus for the study of social dominance hierarchies. *Insect. Soc.* **61**, 11–27

To see the sort of approaches we use in the field: Kennedy, P., Sumner, S., Botha, P. et al. (2021). Diminishing returns drive altruists to help extended family. *Nature Ecology and Evolution* **5**, 468–479

For inspiration to do a PhD in social evolution: Dawkins, R. (1979). *The Selfish Gene*. Oxford University Press, Oxford
Please feel free to email for PDFs of papers if needed (patrick.kennedy@bristol.ac.uk).

Useful links

School of Biological Sciences, Bristol: <https://www.bristol.ac.uk/biology/courses/postgraduate/>

Natural History Museum: <https://www.nhm.ac.uk/our-science/collections/entomology-collections.html>

Wasps work at Bristol: <https://www.patrickckennedy.com/>

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>.

General Enquiries: Bristol NERC GW4+ DTP Administrator

Email: bristol-nercgw4plusdtp-admin@bristol.ac.uk