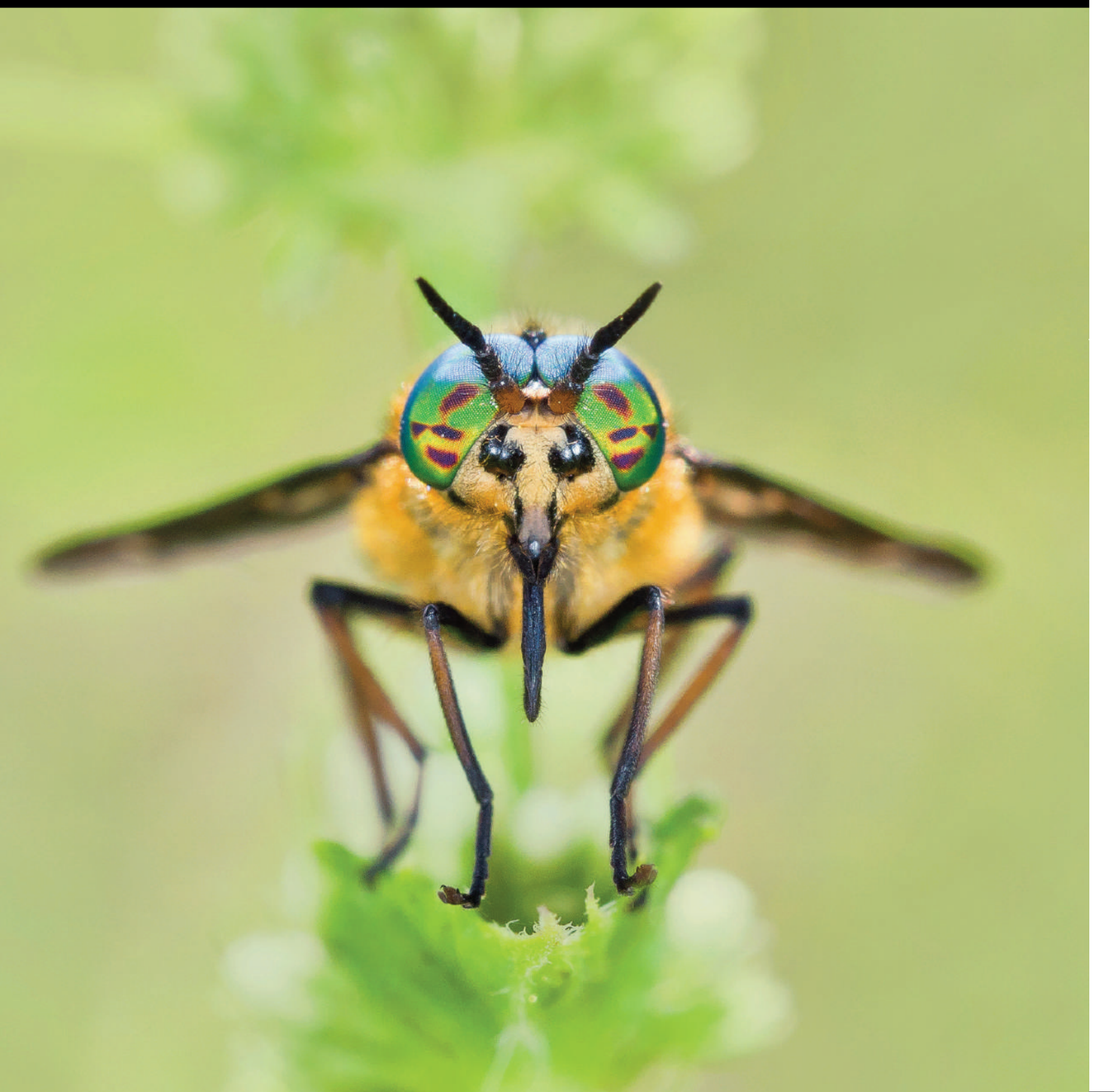
Royal Entomological Society

Volume 49(3) | 2025

# Antenna



# CONTENTS

Volume 49(3) | 2025




**Magnetic Attraction: the geomagnetic direction-finding systems of insects**




**The Darwin Tree of Life Project: sequencing everything!**




**Insects and Fire**


**113** Editorial
**114** Letter from the President
**115** Article: Magnetic Attraction: the geomagnetic direction-finding systems of insects
**123** Article: The Darwin Tree of Life Project: sequencing everything!
**128** Article: Insects and Fire
**136** Featured Insect: Meadow Spittlebug: the foam-lover (*Philaenus spumarius*)
**137** Insects in the News
**139** Society News
**153** Library and Publications
**159** Meetings
**165** Obituaries
**168** Reviews
Events


https://bsky.app/profile/royentsoc.bsky.social
https://bsky.app/profile/respublications.bsky.social

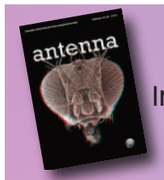
www.facebook.com/Royentsoc

www.Instagram.com/royentsoc

www.linkedin.com/company/royentsoc

www.twitter.com/RoyEntSoc

www.youtube.com/RoyalEntomologicalSociety




## Antenna

Index and online copies




**Index**

All articles, correspondence, obituaries and meeting reports published in *Antenna* from 1977-1988 and from 2002 onwards are indexed and can be searched within the Library Catalogue, Heritage Cirqa. Issues from 1989-2002 are currently being indexed. You do not need to log-in to view the catalogue. To search the indexed articles, visit https://royale.cirqahosting.com/cirqa-web-app/, click "Build a Search" option and select "Antenna" from the "Media type" box. To expand your search to other sources, change the media box to "All Media". Please contact the librarian (library@royensoc.co.uk) if you have any queries.

**Online issues**

*Antenna* issues can be found at www.royensoc.co.uk/publications/antenna/. Issues over a year old can be accessed by anybody. Newer issues can only be accessed by Fellows and Members. Logging in at www.royensoc.co.uk/my-account/ with your email address and password will allow you to access all available issues – and a host of other services.

**Cover Picture:** Twin-lobed Deerfly (*Chrysops relictus*).
Photo: Marc Brouwer; Specially Commended, 2022 Photography Competition (over-18s category).

**All RES Members and Fellows can access RES journal content free of charge online. You can also sign up for article alerts to keep up to date with the latest content. Visit our website for details. www.royensoc.co.uk/publications/journals/**

# Editorial



People may be attracted to entomology in any number of ways. For me, it was catching a Large White butterfly in a crab net, aged 8, on the very day that a card bearing that species appeared in the packet of Brooke Bond Tea delivered by the grocer. For some, it may be finding an interesting-looking insect and chasing down its identification, these days probably using an app. Yet others may have joined our ranks through an inspirational teacher or lecturer. A key plank in our new strategic plan is to increase public understanding of insect science and hence draw more people in. Insect Week is one of many channels through which we can achieve this, and some of this year's initiatives are reported herein, together with an article from Michael Samways demonstrating how the conservation of large mammals in South Africa can help with the conservation of insects, and *vice versa*: standing tall for the small in practice! Sadly, we have an obituary to the founder of Insect Week, former RES President Chris Haines, who has clearly left a magnificent legacy.

July's Council meeting was held in Liverpool, and it was a delight to visit the RES Photography Exhibition at the Liverpool World Museum. It was easy to see how that could spark people's interest, as would the exhibits at the Insects and Culture meeting held at the Natural History Museum in May. It is important to attract the attention of policymakers to the vital importance of insects. Our role in a new All-Party Parliamentary Group on 'Bees, Pollinators and Invertebrates' has the potential to be particularly impactful.

Talking of attraction, in this issue, Stuart Reynolds delves into the geomagnetic direction-finding systems of insects and likens them to systems found in smart phones that assist us in geolocation. Liam Crowley describes the incredible goals and achievements so far of the Darwin Tree of Life Project and how it will revolutionise biodiversity science. Michael Samways summarises the impacts of fire on insects, and management options for insect conservation in fire-prone environments.

Our journals are our main contribution to immortalising entomological research. In this issue, the results of the annual competition to determine the very best amongst all the excellent papers in our seven journals by early-career entomologists are revealed.

Add in our regular columns, and I'm sure you will enjoy this issue. As ever, we welcome comments and contributions and thank all those who have provided them.

Richard Harrington

## Author Guidelines



*Antenna's* Author Guidelines are published in full online at www.royensoc.co.uk/antenna-author-guidelines

Submissions are made by email to antenna@royensoc.co.uk and reviewed by *Antenna's* editorial team. There are no page charges for publication in *Antenna*, where we encourage use of full colour figures and photographs to accompany text. Standard articles are normally 1,000–3,000 words in length and submitted with four to eight images (file should be original size of image taken and not reduced in size nor cropped heavily).


# Antenna

**Bulletin of the Royal Entomological Society**

**The Royal Entomological Society**
The Mansion House, Chiswell Green Lane,
St Albans, AL2 3NS, United Kingdom
antenna@royensoc.co.uk

**General enquiries:**
Tel: +44(0)1727 899387
info@royensoc.co.uk

*Editors*
Dr Richard Harrington Hon.FRES (UK)
Dafydd Lewis FRES (UK)

*Editoral Assistants*
Dr Jennifer Banfield-Zanin FRES (UK)

*Associate Editors*
Dr Jesamine Bartlett Mem.RES (Norway)
Benjamin Chanda Mem.RES (Zambia)
Prof. Jim Hardie Hon.FRES (RES)
Dr Louise McNamara Mem.RES (Teagasc, Ireland)
Sajidha Mohammed Mem.RES (University of Calicut, India)
Moses Musonda Mem.RES
(Broadway Secondary School, Zambia)
Claire Price Mem.RES (Harper Adams University, UK)
Prof. Stuart Reynolds Hon.FRES (University of Bath, UK)
Yanet Sepúlveda De La Rosa Mem.RES
(University of Sussex, UK)

**COPY DATES**
For *Antenna* **49**(4) – 1st October 2025
For *Antenna* **50**(1) – 1st January 2026


Any facts or opinions expressed in this bulletin are the sole responsibility of the contributors. The Royal Entomological Society and the Editors cannot be held responsible for any injury or loss sustained in reliance thereon.
© Royal Entomological Society and the authors 2025

*Council 2024/2025*
President: Prof. Jane Stout FRES
Vice President: Prof. Seirian Sumner FRES
Past President: Prof. Jane Hill Hon.FRES
Treasurer: Dr Gia Aradottir FRES
Chair of Education & Training Committee / Early Career Trustee: Dr Joe Roberts FRES
Chair of Events Committee: Dr Richard Harrington Hon.FRES
Chair of Membership Committee: Prof. Walter Leal Hon.FRES
Chair of Outreach Committee: Dr Hayley Jones Mem.RES
Chair of Publications Committee: Dr Shaun Winterton FRES
Chair of Science, Policy and Society Committee: Prof. Mike Bonsall FRES
Trustee: Moses Musonda Mem.RES
Trustee: Dr Rebecca Farley-Brown FRES
Trustee: Dr Allan Watt Hon.FRES

*Chief Executive Officer*
Simon Ward Mem.RES, simon@royensoc.co.uk
*Director of Communications & Engagement*
Dr Luke Tilley FRES, luke@royensoc.co.uk
*Director of Finance & Operations*
Steven Lee Mem.RES, finance@royensoc.co.uk
*Director of Publishing*
Emilie Aimé Mem.RES, emilie@royensoc.co.uk
*Resident Entomologist*
Prof. Jim Hardie Hon.FRES, jim@royensoc.co.uk
*Special Interest Groups*
www.royensoc.co.uk/membership-and-community/special-interest-groups/

Library: Rose Pearson Mem.RES, Librarian & Archivist (library@royensoc.co.uk)
The Library is open to Members and Fellows by advance appointment.
Please contact the librarian to arrange this.

***Subscription Rates 2025***
For the latest rates please visit
www.royensoc.co.uk/membership

Printed by Andrew Smith Print Ltd
Chelmsford, Essex
andrew@asmithprint.co.uk

***Antenna* and the wrap are fully recyclable and use FSC-sourced paper.**

# Letter from the President



As entomologists, we know how vital insects are to people, to food systems, and to the healthy functioning of life on Earth. Yet insect conservation remains low on political agendas, often overshadowed by more charismatic creatures or seemingly more immediate economic and social concerns. That's why I'm delighted to share how the Royal Entomological Society is helping bring insects into the spotlight—politically, publicly, and practically.

One of our most exciting developments this year is our role as secretariat for the new All-Party Parliamentary Group (APPG) on Bees, Pollinators and Invertebrates in the UK. The name strategically includes "bees" to spark parliamentary interest, but the scope is much broader. In June, on a hot day in a small room in the Houses of Parliament, I was fortunate enough to be part of the RES team that hosted a roundtable dinner that included four MPs, a Lord, RES CEO Simon Ward, and three other RES Fellows. The conversation was refreshingly dynamic. We explored how RES can support decision-makers by sharing cutting-edge insect science, from conservation and biodiversity net gain to pest management and monitoring technologies. It was clear: there's appetite in Westminster for evidence-based, expert-informed policy on insects.

Raising political awareness is vital, but so too is engaging the public. Insect Week 2025 offered many inspiring examples of how our members are doing just that. At the Chelsea Flower Show, Sparsholt College's 'Ugly Bug Ball' garden, celebrating invertebrates, earned a well-deserved silver-gilt medal. In Ireland, I was involved in developing a new insect-themed comic that connects insect biodiversity with the Irish language, culture and bioeconomy, an innovative and inclusive way to reach new audiences, young and old. And I was fortunate to view the stunning Insect Week photo exhibition at Liverpool's World Museum – each image a reminder of how incredible and beautiful insects can be.

This summer I also had the opportunity to take my own research team, and some insect-curious colleagues, to an invertebrate conservation site in County Wicklow. There, a shift in land management from intensive sheep grazing to meadow habitat has allowed insect populations to rebound. The site is managed to encourage native wildflowers to grow and flower, and has specifically constructed microhabitats for insects and other wildlife, including a pond. It was abuzz with life: moths, butterflies, dragonflies, bees, shield bugs, beetles and more. It was a powerful, living example of how quickly nature can recover with the right interventions.

I also gave a talk at a local 'Bee Festival' in County Dublin, near to the site of a former quarry, now buzzing with more than 70 of Ireland's 100 bee species. But it's not just about bees – we talked about hoverflies, wasps, beetles - all unsung heroes of our ecosystems. We discussed the essential roles insects play, not just as pollinators of crops and wild plants, but as nutrient cyclers, pest controllers and food sources for birds, bats and amphibians.

What's clear to me after this summer is that there's still a need to boost awareness and education about insects at every level. Their diversity, importance and sheer wonder should be better known. We, as a community, are uniquely placed to share those stories with policymakers, the public and each other. So, let's get out there. Tell the stories. Share the science. Be the voice for the six-legged, winged wonders that we are fortunate enough to work with every day.



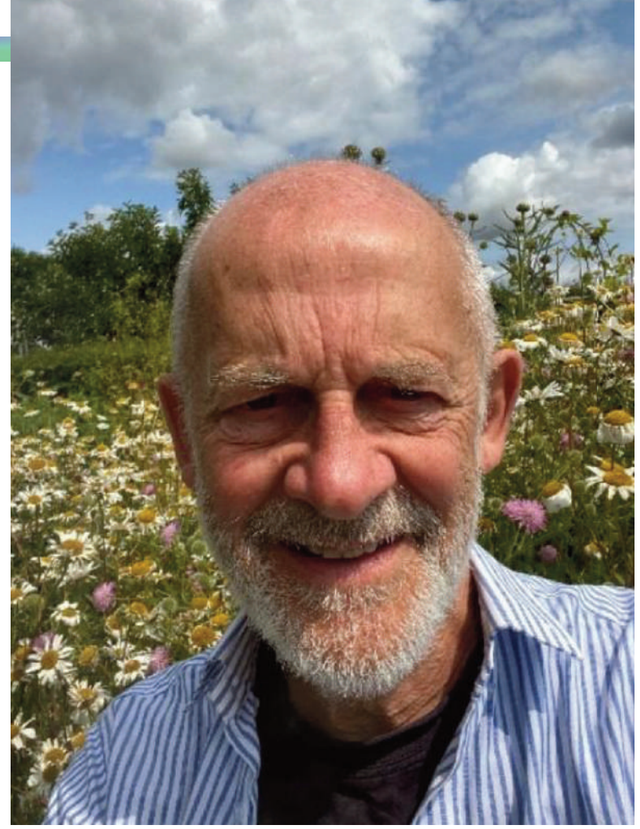
The President examining drawers of beetles and other insects at the Liverpool World Museum.

**Jane Stout**
President
Royal Entomological Society





# RESEARCH SPOTLIGHT



# Magnetic Attraction: the geomagnetic direction-finding systems of insects

**Many, perhaps even all, animals possess navigational tools of the same kinds as those found in smartphones**

**Stuart Reynolds**
Department of Life Sciences and Milner Centre for Evolution, University of Bath
s.e.reynolds@bath.ac.uk

**Migration: compass and map**

The two most important requirements when undertaking a journey from *here* to *there* are to specify the direction in which to move, and to determine how far to go. This is what we mean by *navigation.* Just as with human journeys, insects rely on navigational tools to help them avoid getting lost (Wiltschko *et al.*, 2023). This article is about one particular kind of direction-finding tool used by insects. Many insects undertake intentionally directional movements towards remote destinations whose location is specified in advance. Some of these movements are quite local, as when a Honey Bee repeatedly seeks out a particular patch of flowers that is already known to the colony as a rewarding source of pollen or nectar and then returns to the hive. But some insects undertake much longer journeys than this, migrating over hundreds or even thousands of miles in a cycle of movement that takes several generations to complete. How do they do it?

I will propose an analogy (Fig. 1). Today, it's quite usual for we humans to find our way using a smartphone satnav app (*e.g., Google Maps*). The phone acts as both map and compass, incorporating a direction-finding tool in the form of a magnetometer sensor that can find the North-South axis, and uses a satellite-based Global Positioning Signal (GPS) to locate current position on a fine scale map of the world (British Geological Survey, 2025). The magnetic compass is a physical component of the phone (hardware), while the maps are downloaded from the internet (software). The output of the app is a sequence of directions to move by the easiest path from one landmark to the next; this enables navigation from the starting place to a previously determined destination in a sequence of stages. There's no requirement for the phone to have been to the planned destination on a previous occasion, but the maps do need to have been prepared in advance by the operator (in this case, Google Maps).

There's abundant evidence that many, perhaps even all, animals possess navigational tools of

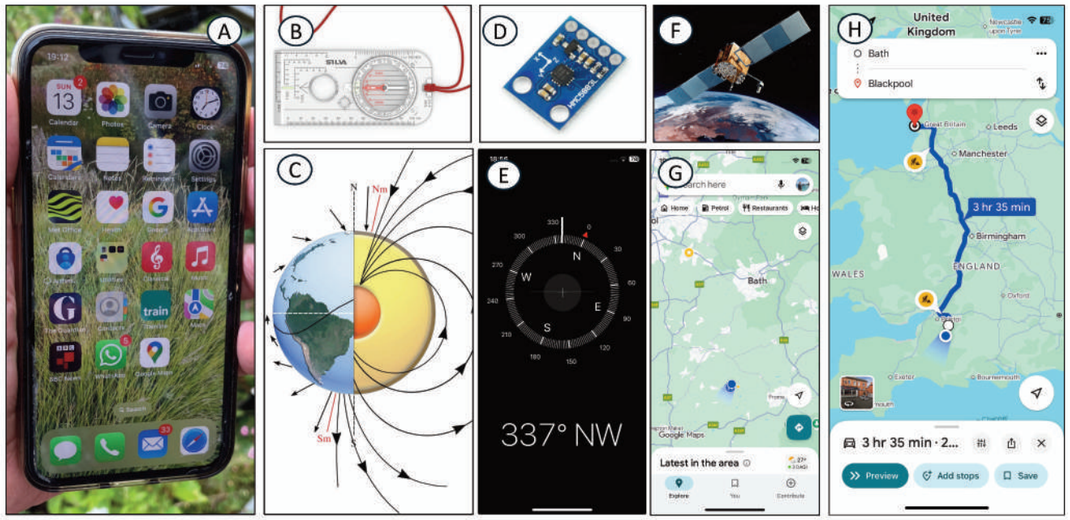



**Figure 1**. Human navigation technology. **A.** My smartphone; **B.** A Traditional magnetic compass; **C.** The Earth's magnetic field (image from Shaw *et al.,* 2015); **D.** Smartphone magnetometer; **E.** Screenshot from smartphone magnetic compass; **F.** GPS Block IIF, Navstar 2F satellite (image: USAF, public domain); **G.** Screenshot from Google Maps app; **H.** Navigational output from Google maps – screenshot of route with landmarks, distance *etc.*

essentially the same kinds as those found in smartphones. The output of an animal's navigation system is a staged series of instructions to direct its movement in the general direction of target landmarks, just as in the output from the satnav app. The analogy is not only a functional one; the direction-finding adaptations of an animal are provided by specialised sense organs and their supporting on-board neural hardware, while the animal's internal map is in most cases software, learned from a combination of personal experience and socially provided instruction. As we will see, there's rather little evidence that migrating animals use inherited detailed maps that specify where to go except in general terms.

In this article, I'm going to concentrate on one particular kind of navigational tool, geomagnetic direction-finding, a topic that is of considerable current research interest. The ability to perceive low level magnetic fields and thus to orient relative to the Earth's magnetic axis is known to be widespread throughout organisms, from bacteria to humans (Mouritsen, 2018; Zadeh-Haghighi *et al.*, 2022). This includes many insects, and I will discuss what use they make of their magnetic sense in both long-range and more local directed movements, but I will defer consideration of how geomagnetic fields are actually detected until a future *Research Spotlight* article.

## Migrating insects

'Migration' is a term that can be applied to several distinct kinds of animal movement (Taylor, 1986), but what I will talk about here is a regularly recurring, large scale, *directed* movement of an animal species (Fudickar *et al.*, 2021). Actively directed migration has evolved because it brings adaptive benefits, allowing the exploitation of transient but predictable resources like food and nest sites, and the avoidance of seasonally adverse weather.

Probably the best-studied example of a migratory insect is the Monarch butterfly, *Danaus plexippus* (Fig. 2). In North America, East of the Rockies, large populations of Monarchs migrate in a single generation from North Central USA and Southern Canada to a relatively restricted region of central México, with subsequent generations making the return journey in the next year. The entire round trip takes 3-5 generations (Brower, 1996). Western populations of Monarchs

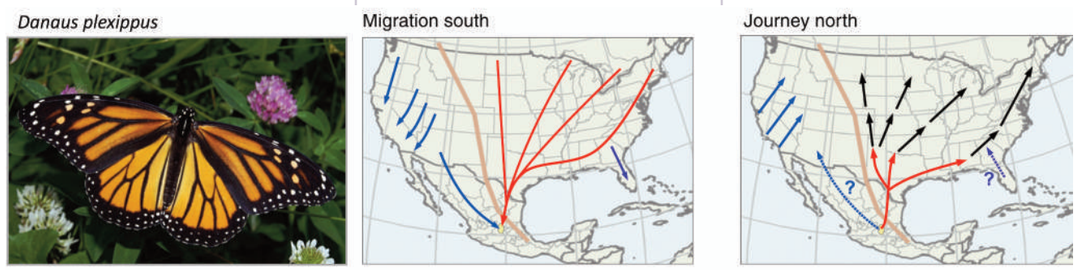



**Figure 2. Centre and Right:** Monarch migration maps. Migration south: red arrows show migration in a single generation by butterflies from sites East of the Rockies to their overwintering site in Mexico; blue arrows show migration of Monarchs from sites West of the Rockies to the coast. Migration North: red arrows show the next spring's migration of overwintered Eastern butterflies back to the southern states of the USA; black arrows show migration of two subsequent generations of adult insects back to their original sites in North-Central USA; blue arrows show return migration of California Monarch populations; the exact route followed by that part of the Western population overwintering in Mexico remains uncertain. Maps reproduced with permission from Reppert *et al.* (2018).





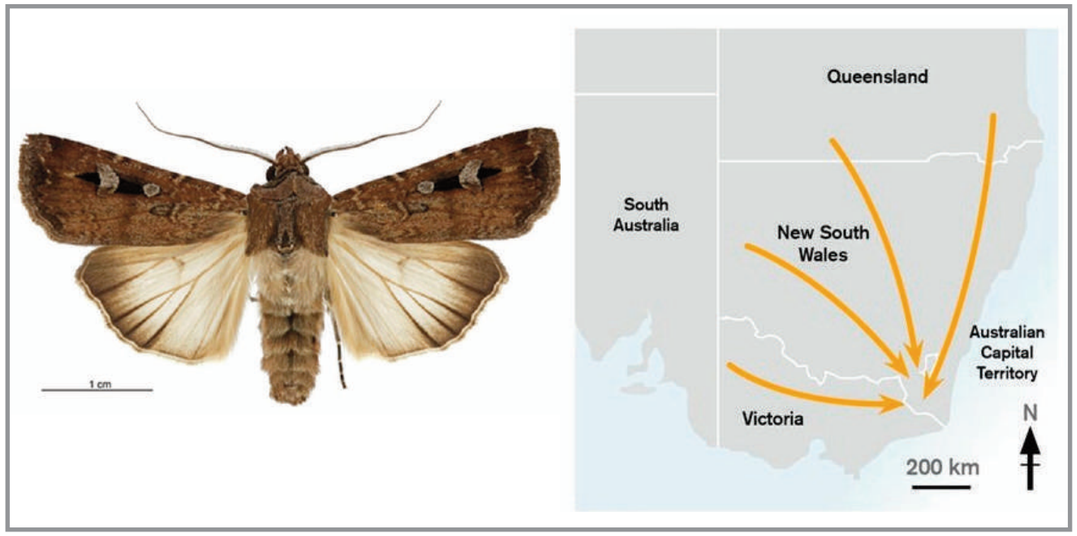



**Figure 3**. **Left:** Bogong Moth, *Agrotis infusa* (Noctuidae). Image: Landcare Research New Zealand Ltd; CC BY. **Right:** Migration map of SE Australia, reproduced with permission from https://butterfly-conservation.org/news-and-blog/nocturnal-navigators.

behave differently. Importantly, since the return route is not simply the reverse of the outward trip, no butterfly is experiencing a journey that it has undertaken before.

The noctuid Bogong Moth, *Agrotis infusa* (Fig. 3) is another well studied example, regularly migrating from breeding sites in lowland South-Eastern Australia to spend the summer in cooler mountainous zones (Warrant *et al.,* 2016). As you'd expect, the butterfly migrates only during the day, while the moth flies mainly at night. Both insects take advantage of tailwinds to reduce the cost of migration, but the direction of flight has to be continually corrected for crosswind drift to allow them to achieve their preferred destinations (Chapman *et al.,* 2008).

Long-range migration isn't limited to the Lepidoptera (Satterfield *et al.*, 2020); for example, massive migrations of the Green Darner dragonfly, *Anax junius*, occur on the East coast of the USA (Russell *et al.,* 1998), while many species of hoverfly (Syrphidae) have been shown to migrate in vast numbers over long distances in Europe as well as other continents (Reynolds *et al.,* 2024).

But so many insects are known to undertake long range directional movements of this kind that by now almost every reader of this article will have thought of a favourite entomological example that I haven't mentioned (sorry about that – there are just too many of them!).

While at least some of the observed directionality of such insect migrations may be due to passive transport in predictably oriented air currents (Wu *et al.*, 2021; Suchan *et al.*, 2024), it is now clear that in many cases the insects in question override such considerations, instead choosing where they want to go by entering airstreams travelling in the preferred direction and avoiding those moving in the 'wrong' direction (Menz *et al.*, 2022). I would contend that this represents deliberate navigation, using essentially the same techniques as those used by the pilots of hot air balloons (Cameron, 1981).

Long-distance migration brings many adaptive challenges, but the most obvious one is that the travellers should know at least approximately where they are going. This is a particular problem for migrating insects since in almost all cases the migrating individual has not undertaken the journey before. Although they are not exactly 'flying blind', the map they are following will show no previously encountered landmarks. The best that can be expected is that their on-board navigational systems will tell them with reasonable accuracy in which direction to begin. The major challenges are then to know when they have deviated from the correct route, and when to stop flying.

## How do they do it? Direction finding using sun and stars

The first requirement for directional movement is for a direction-finding sense. For insects that travel during the day, monitoring the position of the sun and comparing this with the time of day offers the most obvious way to obtain positional information (Guilford *et al.,* 2014). It has been shown that Monarchs orient their movements (*i.e.*, set a bearing) using visual cues from the sun (Perez *et al.*, 1997); and other migrating insects do so too (*e.g.*, Oliveira *et al.*, 1998; Massy *et al.*, 2021). Basically, if you know your own orientation to the sun, and you also know what time it is, then you know in which direction South lies. Such a time-compensated sun-compass has been rigorously shown to be used by migrating Monarch butterflies (Mouritsen *et al.,* 2002). It isn't necessary to perform a sextant-like sighting to derive the sun's azimuth because this can be determined with reasonable accuracy simply by measuring the sunlight intensity over the whole visual field (Shlizerman *et al.,* 2016). Even if the sun is not itself visible, the plane of polarisation of unclouded sky will allow this kind of orientation (Krapp, 2007; Heinze, 2017).

ARTICLE

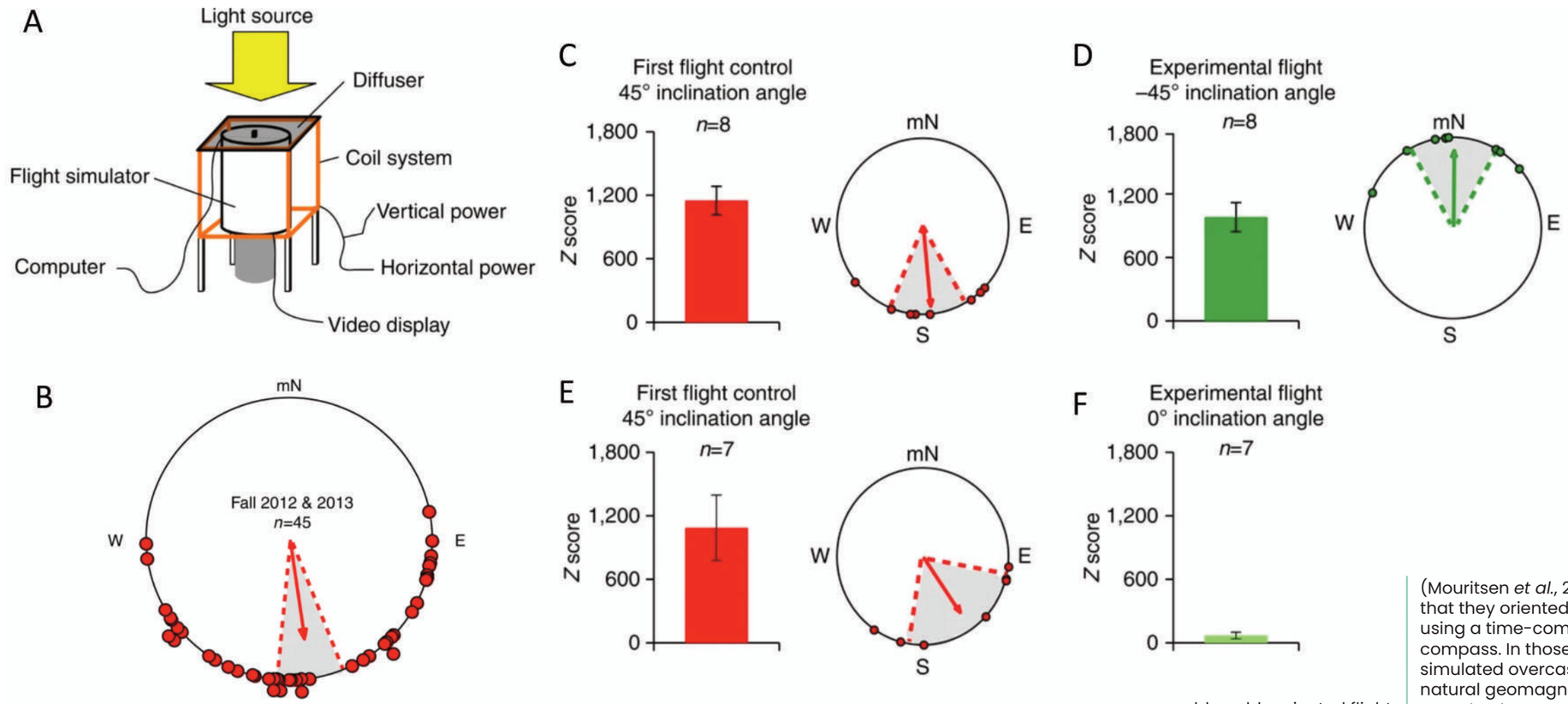



**Figure 4. A–B.** Monarch migration flight orientation is set by geomagnetic field under full spectrum light source. *A*. flight simulator with magnetic field-generating coil system; *B*. Orientation of individual directional fall-migrating Monarchs towards equator (*i.e.*, S) in generated field with a +45° inclination angle, at 141 μT field intensity. For circle diagram, arrow indicates mean orientation, shaded area is 95% confidence interval, mN is magnetic North. **C-F.** Showing the inclination magnetic compass of fall migratory Monarch butterflies (Z-score indicates increasing directionality). *C*. Fall-migrating Monarchs oriented toward equator during initial flight at 45° inclination angle; *D*. they shifted orientation to magnetic N when tested a second time under similar generated field conditions but with inclination angle reversed (-45°). *E*. Fall-migrant Monarchs oriented toward equator during initial flight; *F*. displayed flight with significantly reduced directionality when tested a second time under a horizontal field (0° inclination angle) with same field intensity. Slightly modified from Guerra *et al.* (2014).
CC BY-NC-SA 4.0

But to determine a fully accurate bearing requires compensation for the regular dawn-to-dusk movement of the sun in the sky, which requires an internal biological clock (Gkanias *et al.,* 2025). Although it's known that insects possess such clocks (Saunders *et al.*, 2002), these are well known to be only roughly accurate timekeepers (that's why they are called 'circadian' - meaning 'approximately daily'). The anatomical locations of insect clocks are closely connected with the locations of the related celestial and geomagnetic directional sensing apparatus. They require re-setting every day or they quickly drift out of sync with real time. This is good enough to determine the approximate bearing, and most migrating insects do not need to know the time more precisely than this (Massy *et al.,* 2023).

What about latitudinal position? If the sun is relatively higher in the sky for the time of day, then the traveller's position must be closer to the Earth's equator. Human mariners traditionally determine the sun's altitude at noon (*i.e.*, when the sun is at its maximum height) because this can be measured independently of local clock time (just measure the longest shadow), but latitude can actually be computed from the sun's position at any time of day – it just requires more complicated mathematics. A roughly accurate circadian clock that can indicate the middle of the day is capable of making the calculation easy.

To determine the traveller's longitude (*i.e.*, angular position relative to a N –S meridian) is much trickier, requiring exact measurement of local time at which the sun reaches the same point (usually at noon) in relation to the current time at the location of the original fix. This is a big challenge, and during the history of human navigation, famously required the development of highly accurate chronometers that could be relied upon to keep exact time over the course of long journeys (Sobell, 2007). It's hard to see how an insect could determine its own longitudinal position with any accuracy from celestial cues. Presumably those migrating insects that need to measure their latitude substitute an estimate of distance travelled.

## Magnetic navigation by migrating insects

Unfortunately, however, the sun does not always shine. Without a backup navigational system, migrants using only solar clues would be grounded under overcast skies. An additional geomagnetic direction-finding sense would enable oriented flight to be maintained, even under full cloud cover. Moreover, orientation relative to the Earth's magnetic field would not require clock correction because (unlike the sun, which appears to move in the sky because the Earth continuously revolves relative to it) the geomagnetic field turns with the Earth itself.

It is now known that migrating insects do indeed use both sky-based and magnetic field-based kinds of direction finding. Once again, the best investigated case is that of the Monarch butterfly. Both navigational systems operate simultaneously in this insect, but in the event of a mismatch between them, orientation is primarily determined relative to the position of the sun (Guerra *et al.*, 2014). This casts the geomagnetic system as being primarily a 'backup' system, but one that is regularly used. Such redundancy in navigational systems is considered essential in aerospace applications (Wang *et al.*, 2022).

Experiments in which Monarch butterflies flew for several hours in a flight simulator (Fig. 4) (Mouritsen *et al.*, 2002) showed that they oriented their flightpath using a time-compensated sun-compass. In those experiments, simulated overcast conditions in natural geomagnetic fields completely prevented normal orientation behaviour, which led the authors to conclude first that solar orientation was essential, and second that there was no evidence for magnetic orientation. This was puzzling, since previous experimental work had indicated that artificial magnetic fields could interfere with Monarch orientation (Perez *et al.*, 1997). Satisfyingly, the reason for this mismatch between experiments was later revealed to be the omission of ultraviolet light (UV) from the flight simulator apparatus (Guerra *et al.*, 2014; Wan *et al.,* 2021). We now know that UV is required for the functioning of the geomagnetic sense but is not needed for entrainment of the clock (Froy *et al.*, 2003). This discovery has implications for the way in which insect magnetic sense organs detect the Earth's magnetic field, and also for the evolutionary origin of the genetic and biochemical apparatus used to do it, but I will defer discussing this until another article in this series.

Surprisingly, the dominating geomagnetic and light sensors that underlie the Monarch's magnetic sense appear to be located in the insect's antennae, in addition to the originally expected locations in the eyes and brain. Painting over the antennae with black paint (but not clear paint) did not stop the insects orienting properly to the sun but did prevent them from orienting to an external magnetic field (Guerra *et al.*, 2014), indicating that the geomagnetic sense is quite separate from the visual navigation system. Intriguingly, the circadian clock that is used to correct sun-compass orientational responses according to time of day is also located in the antennae (Merlin *et al.*, 2009). While peripheral circadian clocks are not at all unusual in insects (Tomioka *et al.,* 2012), the physical separation of the navigational clock from the brain where visual processing occurs is surprising and remains unexplained.

## Navigating at night

Many insects migrate at night, and in this case, the night sky provides an alternative or additional source of directional information of a similar type; it has been shown that migrating Bogong Moths, which are nocturnal, use starlight to orient their direction of travel, particularly using the position in the sky of the Milky Way galaxy (Dreyer *et al.,* 2025). It seems likely that other nocturnal insects use similar directional cues for short-range directed movements; for example, the oriented dung ball-rolling behaviour of dung beetles (Scarabaeidae) doesn't involve flight but uses the same galactic cues to allow the beetles to maintain their initial straight-line bearing when pushing their dung-ball away from its original site (Foster *et al.,* 2017).

Since the galaxy occupies a much larger area fraction of the sky than does the sun, such astral direction finding must be significantly less accurate than solar navigation.

Just as with daytime navigating systems, it's all very well using the stars if you can see them, but what happens on cloudy nights? As we would predict, it turns out that Bogong Moths have a backup magnetic directional sense that allows them to maintain their bearing under

**The magnetic direction-finding sense may be used only in a subordinate capacity because it suffers from a greater degree of intrinsic 'noise' than the sun and star-compass senses**

overcast skies (Dreyer *et al*., 2018). When migrating moths were tethered in an outdoor flight simulator, they adjusted their flight direction appropriately when visual landmarks and an imposed magnetic field similar in strength to that of the Earth were rotated together, but they rapidly became disoriented when these directional cues were separately adjusted.

Given that sun and stars are only visible either in the day or the night, are frequently obscured by cloud, and require correction for the time of day, whereas the geomagnetic navigation system is available 24/7 and doesn't require a clock, one may wonder why it is that these insect direction-finding systems have not evolved to use the geomagnetic system as their main or even sole direction finding tool. Johnsen *et al.* (2020) have speculated that the magnetic direction-finding sense may be used only in a subordinate capacity because it suffers from a greater degree of intrinsic 'noise' than the sun and star-compass senses. This is inevitable because the Earth's magnetic field is weak and supplies little energy to the detection apparatus. It is likely that magnetic sense organs operate close to the limit of detection. While the noise limitation of the magnetic sense can be overcome by averaging its signals over long periods, this means that unlike visually based solar and astral navigational systems, magnetic direction-finding can respond only slowly to a change in the local geomagnetic field. This is likely to be particularly problematic when attempting to correct for crosswind course deflections, for example.

**Recognising the destination**

How do migrating insects like Monarchs know to stop flying when they have arrived in the right place? In my smartphone analogy, recognising the desired end of the journey requires the existence of a satellite-based GPS supplying information about

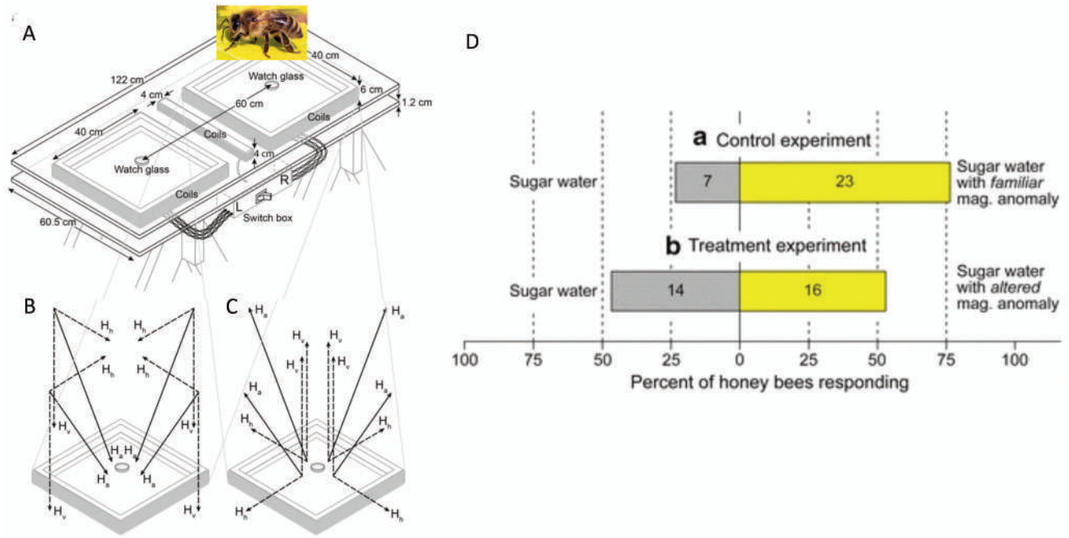



**Figure 5. A.** Two-choice bioassay table used to test Honey Bee magnetic sensing. A reward is presented at one of the two watch glasses which differ in the accompanying magnetic field, as generated by one lateral coil or the other (the central coil, in conjunction with the opposite lateral coil, minimises perturbations to the magnetic field on the other side of the table).
**B** and **C**. Schematic representations of the magnetic field in the vicinity of each watch glass, showing decomposition of the 'anomaly' fields ($H_a$) into vertical ($H_v$) and horizontal ($H_h$) components of opposite (N-S) polarity.
**D.** Responses of Honey Bees that were first trained to associate a magnetic field anomaly of type B with a sugar reward. Each trained bee was then subjected to two different experiments, conducted in pseudo-random order. In the control experiment (a) the polarity of the magnetic anomaly was the same ('familiar mag. anomaly') as during the training session. In (b) the polarity was reversed ('altered mag. anomaly'). Bees continued to respond to the magnetic anomaly in the control experiment ($\chi^2$ test, $p = 0.0035$) but did not respond in the treatment experiment ($\chi^2$ test, $p = 0.72$). Slightly modified from Lambinet *et al.* (2017b); CC BY 4.0.





exact map coordinates of the desired destination; such information is obviously not available to migrating insects.

Just as experienced human mariners do, an insect using the sun or the stars to navigate could in theory measure the sun's azimuth to determine its position relative to the Earth's North-South axis (*i.e.*, its latitude). Although foraging Honey Bees can perform such computations when locating local food sources (Gould, 1984; 1998), the extent to which migrating insects rely on this to determine the location of their final destination is uncertain.

Is this where magnetoreception comes in? While some animals, including sea turtles, spiny lobsters, newts and birds, do use the Earth's magnetic field to determine their location (Lohmann *et al*., 2007), there's little evidence that insects do so. Such a magnetic location-detector would make use of the angle of inclination of the geomagnetic field relative to the Earth's surface, as well as its N–S orientation. It's known that at least some insects can detect this. Monarch butterflies are differentially sensitive to variation in the horizontal vector plane of the magnetic field, so that the butterflies hardly respond at all to one oriented at 0° (*i.e.*, a magnetic field with lines of force parallel with the ground) but react strongly to an imposed field oriented at 45° to the horizontal by flying in a southward direction. When the magnetic inclination is tilted to -45° the insects interpret the compass direction to be reversed from South to North (Guerra *et al*., 2014) (Fig. 4C-F).

Does such behaviour indicate that the insects are using an internal magnetic map? Possibly, but because it can't be based on the migratory experience of the individual insect, it would have to be an inherited, genetically specified map. Such a map would be unlikely to have good spatial resolution. Moreover, the angle of inclination of the Earth's magnetic field does not map on the surface of the Earth with a regular pattern. Experiments with imposed magnetic fields fail to stop the butterflies from correctly locating their final destination from visual cues, so it seems simplest to suppose that there is no such internal magnetic map (Guerra *et al.,* 2022).

**Geomagnetic navigation by foraging insects**

While it's uncertain to what extent long distance insect migrations rely on path integration, there's evidence that more local foraging expeditions do make use of direction-finding tools and computational navigational systems to reduce travel costs, especially on the way home. Many of them are social Hymenoptera (ants, bees and wasps) (Fleischmann *et al*., 2018; 2020). These insects don't migrate over long distances but are nevertheless strongly dependent on accurate positional sensing for targeted central place foraging. Importantly for this article, we now know they not only employ visual cues based on sun and stars but can also use endogenous geomagnetic sensors in their navigational decision-making systems although (just as in migrating insects) they don't always do so.

Honey Bees have been shown to locate visual memories within a framework of geomagnetic coordinates (Collett *et al*., 1994) and can learn to distinguish patterned visual targets with different geomagnetic orientations (Frier *et al.* 1996). There is convincing evidence from conditioning experiments that paired magnetic training stimuli with food rewards, that Honey Bees can not only sense imposed magnetic fields of about 150 μT (microTesla) (about three times the average strength of the Earth's magnetic field), but can also determine the North-South polarity of the field (Lambinet et al., 2017a) (Fig. 5). These conditioned responses to magnetic stimuli were abolished by pre-exposing the bees to a 5 s pulse of a strong magnetic field produced by a neodymium-iron-boron alloy (NdFeB) magnet; the strength of this imposed field was 220 mT, or about 4,400 times the strength of the natural geomagnetic field (Lambinet *et al.,* 2017b). The authors showed by measuring induced magnetism in bee tissues that exposure to the magnet rendered dysfunctional a putative magnetoreceptor most likely located in the bees' abdomen.

Other insects that have been shown to select foraging pathways according to magnetic cues include the termites *Trinervitermes geminatus* (Rickli *et al*., 1988), *Reticulitermes chinensis* and *Odontotermes formosanus* (Gao *et al*., 2021).

Such findings indicate that Honey Bees, and other insects that undertake central place foraging from a nest, clearly possess and can use a geomagnetic sense, but the data don't prove that the insects regularly use their magnetic sense in everyday direction finding or decision making. It remains possible that local geomagnetic sensing is simply a backup system like that used in migration. Foraging workers of the three termite species mentioned above all lay pheromone trails to help them get home, but the trails do not last long, and it is hypothesised that the insects learn geomagnetic cues on the way to foraging sites and can use them if necessary to find their way home.

An additional point of interest in the case of social insects is that the colony's total foraging efficiency can be boosted by communicating the location of a rewarding food source between colony members. In the case of Honey Bee worker foraging trips, we know that both the direction and the distance of travel of the computed, shortest route to the resource can be communicated symbolically by an experienced 'teacher' worker to inexperienced 'learner' nestmates by means of the 'waggle dance' (Menzel *et al*., 2011), thus reducing the travel costs of the other bees that 'learn the map'. Since this transfer of information takes place inside the hive, where it is dark even during the day, some form of non-visual orientational cue must be used as a reference for the directional content of the dance. It has long been known that at least some aspects of the dance language can be influenced by experimental interference with the local geomagnetic field (Martin *et al.,* 1977). Nevertheless, when the matter was carefully reinvestigated by Lambinet *et al.* (2014), no evidence was found

that the local ambient geomagnetic field at the dance-floor site acts as the reference for the alignment of waggle-dancing bees.

**The geomagnetic sense**

It should be clear from all the above that there is abundant evidence that, like many other animals, insects are able to detect and orient to external magnetic fields, including the relatively weak geomagnetic fields produced by the interaction between the Earth's rotation and its iron core. How this highly sensitive magnetic sense works is at present unknown, although there is a great deal of speculation, and many scientific investigations are under way. The magnetic sensors of insects are prominently involved in such work. I will return to the subject in a future *Research Spotlight* article.

## References


British Geological Survey (2025) https://geomag.bgs.ac.uk/education/smartphones.html (accessed 30 June 2025)
Brower, L. (1996) *Journal of Experimental Biology* **199**, 93–103.
Cameron, D. (1981) *Ballooning handbook*. pp171, London, Michael Joseph.
Chapman, J.W. *et al.* (2008) *Current Biology* **18**, 514–518.
Collett, T.S. *et al.* (1994) *Nature* **368**, 137–140.
Dreyer. D. *et al.* (2018) *Current Biology* **28**, 2160–2166.
Dreyer, D. *et al.* (2025) *Nature* early access: DOI: 10.1038/s41586-025-09135-3.
Fleischmann, P.N. *et al.* (2018) *Current Biology* **28**, 1440–1444.
Fleischmann, P.N. *et al.* (2020) *Animal Cognition* **23**, 1051–1061.
Foster, J.J. *et al.* (2017) *Philosophical Transactions of the Royal Society* B **372**, 20160079.
Frier, H. *et al.* (1996) *Journal of Experimental Biology* **199**, 1353–1361.
Froy, O. *et al.* (2003) *Science*, **300**, 1303–1305.
Fudickar, A.M. *et al.* (2021) *Annual Review of Ecology, Evolution and Systematics* **52**, 479–497.
Gao, Y. *et al.* (2021) *Communications Biology* **4**, 1121.
Gkanias, E. *et al.* (2025) *Nature Communications* **16**, 2832.
Gould, J.L. (1984) *Animal Behaviour* **32**, 149–152.
Gould, J.L. (1998) *Current Biology* **8**, R731–R738.
Guerra, P.A. *et al.* (2014) *Nature Communications* **24**, 4164.
Guerra, P.A. *et al.* (2022) *Ecology and Evolution.* **12**, e9498.
Guilford, T. *et al.* (2014) *Animal Behaviour* **97**, 135–143.
Heinze, S. (2017) *Current Opinion in Insect Science* **24**, 58–67.
Johnsen, S. *et al.* (2020) *Journal of Experimental Biology* **223**, jeb164921.
Krapp, H.G. (2007) *Current Biology* **17**, R557–R560.
Lambinet, V. *et al.* (2014) *PLoS ONE* **9**, e115665.
Lambinet, V. *et al.* (2017a) *Journal of Comparative Physiology A* **203**, 1029–1036.
Lambinet, V. *et al.* (2017b) *Proceedings of the Royal Society B* **284**, 20162873.
Lohmann, K.J. *et al.* (2007) *Journal of Experimental Biology* **210**, 3697–3705.
Martin H. *et al.* (1977) *Journal of Comparative Physiology A* **122**,145–187.
Massy, R. *et al.* (2021) *Proceedings of the Royal Society B* **288**, 20211805.
Massy, R. *et al.* (2023) *Biology Letters* **19**, 1–6.
Menz, M.H.M. *et al.* (2022) *Science* **377**, 764–768.
Menzel, R. *et al.* (2011) *Current Biology* **21**, 645–650.
Merlin, C. *et al.* (2009) *Science* **325**, 1700–1704.
Mouritsen, H. (2018) *Nature* **558**, 50–59.
Mouritsen, H. *et al.* (2002) *Proceedings of the National Academy of Sciences USA* **99**, 10162–10166 (2002).
Oliveira, E.G. *et al.* (1998) *Journal of Experimental Biology* **201**, 3317–3331.
Perez, S.M. *et al.* (1997) *Nature* **387**, 29.
Reppert, S.M. *et al.* (2018) *Current Biology* **28**, R1009–R1002.
Reynolds, S.K. *et al.* (2024) *Ecological Entomology* **49**, 749–767.
Rickli, M. *et al.* (1988) *Ethology* **77**, 209–216.
Russell, R.W. *et al.* (1998) *American Midland Naturalist* **140**, 325–342.
Satterfield, D.A. *et al.* (2020) *Frontiers in Ecology and the Environment* **18**, 335–344.
Saunders, D.S. *et al.* (2002) *Insect Clocks* 3rd edition, pp 560. London, Elsevier.
Shaw, J. *et al.* (2015) *Journal of the Royal Society Interface* **12**, 20150499.
Shlizerman, E.J. *et al.* (2016) *Cell Reports* **15**, 683–691.
Sobell, D. (2007) *Longitude*. London, Bloomsbury.
Suchan, T. *et al.* (2024) *Nature Communications* **15**, 5205.
Taylor, L. R. (1986) In: *Insect flight: Dispersal and migration. Ed. W. Danthanarayana. Berlin: Springer.* pp. 265-280.
Tomioka, K. *et al.* (2012) *Journal of Comparative Physiology* **182**, 729–740.
Wan, G. *et al.* (2021) *Nature Communications* **12**, 771.
Wang, S. *et al.* (2022) *Aerospace Science and Technology* **126**, 107631.
Warrant, E. *et al.* (2016) *Frontiers in Behavioral Neuroscience* **10**, 7.
Wiltschko, R. *et al.* (2023) *European Physical Journal Special Topics* **232**, 237–252.
Wu, Q.L. *et al.* (2021) *Journal of Integrative Agriculture* **20**, 694–706.
Zadeh-Haghighi H, *et al.* (2022) *Journal of the Royal Society Interface* **19**, 20220325.





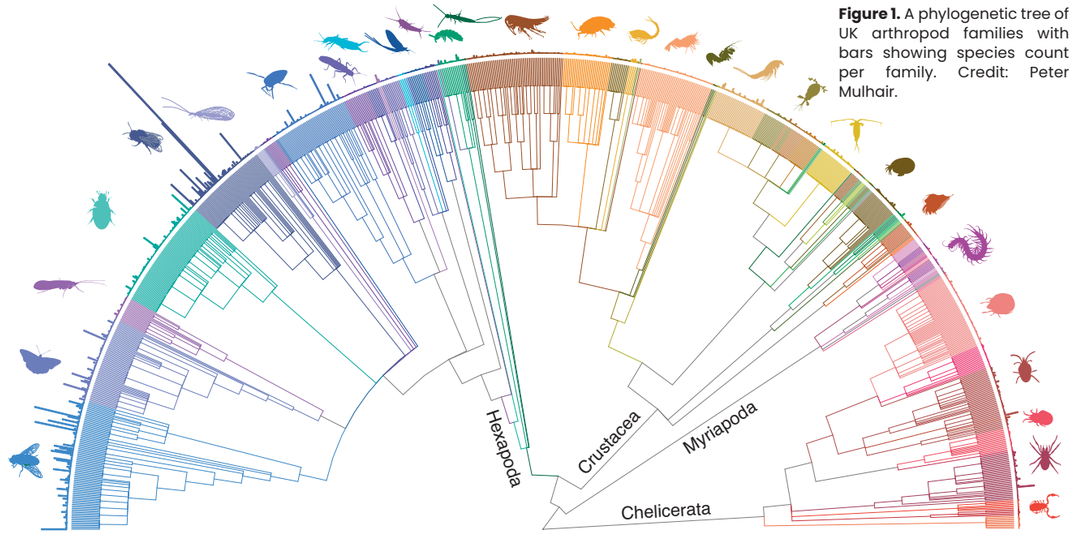




**Figure 1.** A phylogenetic tree of UK arthropod families with bars showing species count per family. Credit: Peter Mulhair.

# The Darwin Tree of Life Project: sequencing everything!


**Liam Crowley[1], Peter Mulhair[2], Owen Lewis[1] and Peter Holland[1]**
[1] University of Oxford
[2] University of Liverpool
liam.crowley@biology.ox.ac.uk


Back at the turn of the millennium, a significant milestone was reached in our understanding of biology with the announcement of a first draft of the human genome. This remarkable achievement had taken over a decade and cost somewhere in the region of $4 billion. Sequencing our genome has revolutionised biomedical science and provided the foundation for many genomics projects, such as the 100,000 Genomes Project (Turnbull *et al.*, 2018). Now it's the turn of every other species.

Commencing in 2020, the Darwin Tree of Life (DToL) Project is an ambitious, groundbreaking project with the aim of sequencing the genomes of every species of eukaryotic organism in Britain and Ireland (Darwin Tree of Life Project Consortium, 2022). It sits within the aspirational Earth BioGenome Project, aiming to sequence every eukaryote on the planet (Lewin *et al.*, 2018). DToL is the first funded effort to attempt to sequence the complete flora and fauna of an entire region. The core of the funding for the project comes from the Wellcome Trust, with additional support from a discretionary award and in-kind funds from partner institutions. One of the reasons why this project is so exciting is because it is truly trailblazing. Advances in sequencing technologies and exponential decreases in associated costs mean that this is the first time ever that a project of this scale is even feasible.

Naturally, such a gargantuan task requires a huge collaborative effort, which indeed the project has, with involvement from a multitude of organisations with expertise in biodiversity, sequencing, data management and more. The nine core partners are the Wellcome Sanger Institute, Natural History Museum, Royal Botanic Gardens Kew, Royal Botanic Garden Edinburgh, University of Oxford, University of Cambridge, University of Edinburgh, Marine Biological Association and Earlham Institute. The majority of the sequencing itself is undertaken at the Sanger Institute, with the biodiversity focussed partners taking on the role of 'Genome Acquisition Laboratories' (GALs), finding, identifying, collecting and preserving samples of all the species. Wytham Woods at the University of Oxford is one such GAL. Based in the university's famous research and education woodland, the Oxford team is aiming to sequence the full genome of every species that occurs within the site, establishing

it as the world's first 'genomic observatory'.

As well as the production of an unprecedented number of genomes, the project has a set of guiding principles that can be summarised by four 'Cs': Complete, Calibre, Comprehensive and Collaborative. 'Complete' refers to the target of all genomes produced being fully finished, with almost every nucleotide mapped, chromosomally complete and including all nucleic and extranucleic DNA. 'Calibre' describes the quality of genomes being produced. Next-generation sequencing methods, such as long-read sequencing, are being used to produce some of the most accurate genomes ever. For example, the first wave of Lepidopteran genomes produced had N50 values (a way of measuring the lengths of sequence fragments to infer the accuracy of genomes produced) that were in some cases an order of magnitude greater than any produced previously for the group. 'Comprehensive' relates to the coverage of taxa being sequenced, with an aim to eventually sequence every animal, plant and fungus in Britain and Ireland and initially prioritise a breadth of species across the eukaryote phylogeny. Finally, 'Collaborative' conveys how the project is fundamentally open to all. This includes both participation in, and benefitting from, the project. Large numbers of people and organisations have, and continue to, contribute to the scheme by suggesting species, assisting with sample acquisition and contributing specimens. All data are also open and freely accessible by anyone, anywhere, even when incomplete. This means that genomes have already begun to contribute to research and conservation efforts around the world, often in unexpected ways!

The question of exactly how many species are included in the overall aim is rather difficult to answer. The UK Species Inventory currently lists more than 70,000 species, although many of these are rare vagrants, introductions restricted to buildings/greenhouses or no longer resident. The project, therefore, applies a remit of including only those species that occur in Britain and Ireland with a self-sustaining, outdoors population (Crowley *et al.*, 2023). This still leaves tens of thousands of species, with some 40% being terrestrial arthropods, especially insects (Fig. 1). The work at the Wytham Woods GAL has focussed on terrestrial arthropods, collecting more than 2,000 species from the site during the first 5 years of the project.

Whilst the ultimate aim is to sequence everything, it is necessary to start somewhere, and we therefore employed a prioritisation process to select species that should be targeted first. It was important that the first genomes delivered were as useful as possible, so species were prioritised based on a hierarchy of criteria (Crowley *et al.*, 2023). Breadth and depth of sampling maximises the potential for comparative genomic analysis, whilst genomes of specific species are useful for investigations and applied research into those species. Breadth of sampling was achieved by aiming to sequence species from as many different taxonomic families as possible. Depth was delivered by focussing on certain groups for 'deep dives', sequencing as many species as possible from the group. The hierarchy for selecting family representatives and deep dive taxa started with those species/groups that were most important, iconic and/or interesting. For example, hoverflies were selected as a deep dive group as they are economically, ecologically and evolutionarily important and there is an existing research interest, with multiple groups already researching Syrphidae genomics. The following steps in the hierarchy are selection of taxa based on availability, representativeness and relative ease of sequencing.

But what is genome sequencing and how does it work? When we say "genome sequencing", we are talking about creating a reference genome. A reference genome is a complete record of the DNA sequence of a representative

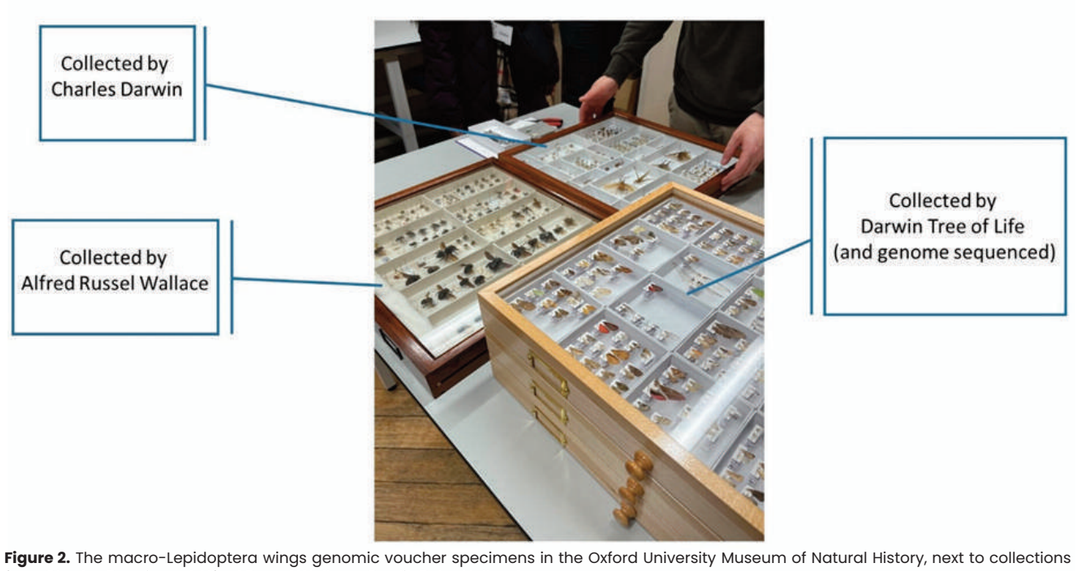



**Figure 2.** The macro-Lepidoptera wings genomic voucher specimens in the Oxford University Museum of Natural History, next to collections from Charles Darwin and Alfred Russel Wallace. Credit: Peter Holland.







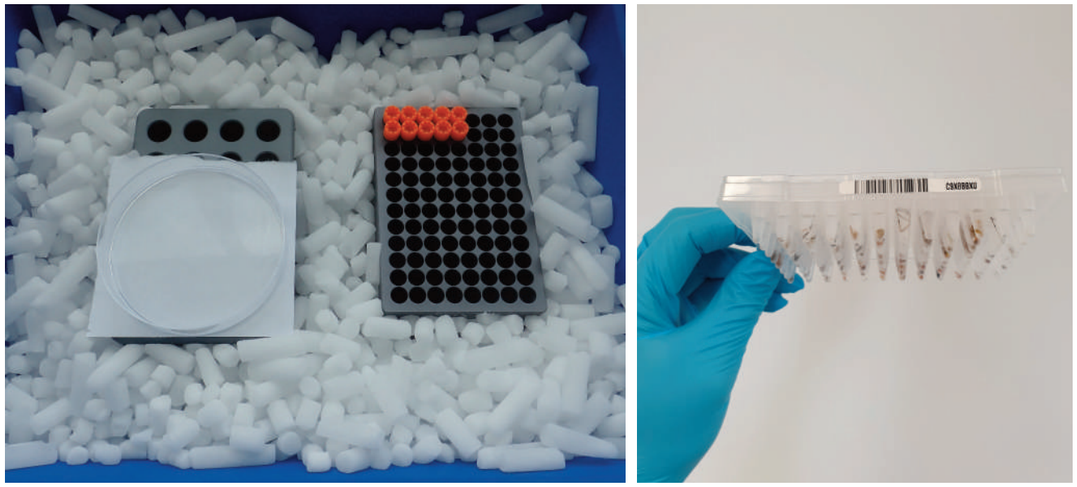


**Figure 3. Left:** The cryogenic preservation system used by several GALs, bathing specimens in pellets of dry ice to flash-freeze them at -80ºC. **Right:** A 96-well plate with legs dissected from specimens for DNA barcoding. Credit: Liam Crowley.

individual of a species. Therefore, where possible it is useful to keep some form of voucher specimen from the individual sequenced to act as a 'genomic type' specimen. For example, a set of wings (usually the right-hand set) has been kept from all the macro-Lepidoptera sequenced from the Wytham Woods GAL, which are now kept in the Oxford University Museum of Natural History (Fig. 2).

DToL is using long-read sequencing technology to produce high-quality genomes. Much like how a jigsaw with a few large pieces is much easier to assemble correctly than one with many small pieces, the same is true for assembling sequences of DNA into a genome. This is especially true given the highly repetitive nature of genomes, whereby repeats of sequences can be missed by sequencing smaller reads.

One of the implications of long-read sequencing is the requirement it has on how samples are collected and preserved. DNA is a remarkably unstable molecule, constantly breaking from the wear and tear of everyday life in a cellular environment. Normally, this is not an issue as cells contain repair machinery that continuously repairs DNA (remarkably accurately almost all of the time!). However, once an organism dies this machinery ceases to work, meaning than within minutes DNA begins to break down into shorter segments that are not usable in long-read sequencing. The result of this is that in order to collect high molecular weight DNA for genome sequencing, we need to instantaneously preserve it in long fragments. This is achieved by flash-freezing live or recently live samples at -80 ºC (or colder) using dry ice (or liquid Nitrogen) (Fig. 3). The consequence of this is that once frozen, samples must be maintained at this temperature in a continuous 'cold-chain' until DNA can be extracted and sequenced.

Perhaps a more significant constraint resulting from the requirement of flash freezing live specimens is that this makes species identification by traditional morphological methods challenging. Ideally, identifications need to be made on live specimens that can then be flash-frozen, which for the majority of the British list is extremely difficult. Fortunately, we have developed a few ways to deal with this issue. Firstly, we began with species that could reliably be identified in the field, *e.g.*, many macro-moths. For many taxa where this is not possible, temporary knockdowns using either $CO_2$ or low temperatures to incapacitate specimens for a short period of time to allow ID using a stereomicroscope have been very successful. Other groups have been identified by removing key pieces of morphology as the specimen freezes and identifying this later. This is typically male genitalia but can include various diagnostic features that can be easily dissected.

Every specimen that is submitted for genome sequencing also undergoes DNA barcoding (Twyford *et al.*, 2024) (Fig. 3). This is undertaken for two reasons: 1) as an insurance against error – the DNA barcode region of the resulting genome can be checked against the original barcode to ensure that no mix-ups have occurred; 2) as a confirmation of ID – the barcode can be checked against barcode reference libraries to determine if the specimen matches against the putative taxon.

Once a genome is completed for a species, a 'genome note' micro publication is written and released in the journal Wellcome Open Research (*e.g.*, Crowley *et al.*, 2022; Hawkes *et al.*, 2023). This serves as an announcement of the successful completion and release of the genome as well as containing information on the natural history of the species and details of the sequencing process and features of the genome.

To date, the project has collected over 9,000 species, started sequencing over 6,000 and finished over 2,000 genomes (Fig. 4). Globally, 50% of all high-quality genomes sequenced come from this project. Furthermore, a 'genome engine' of methods and processes has been developed, that is now being used by various genome sequencing initiatives around the world such as the Aquatic Symbiosis Project, European Reference Genome Atlas, Project Psyche and AEGIS that are collectively sequencing







**Figure 4.** Fieldwork collecting specimens of insects for genome sequencing at Wytham Woods. Credit: Liam Crowley and Luke Lythgoe.









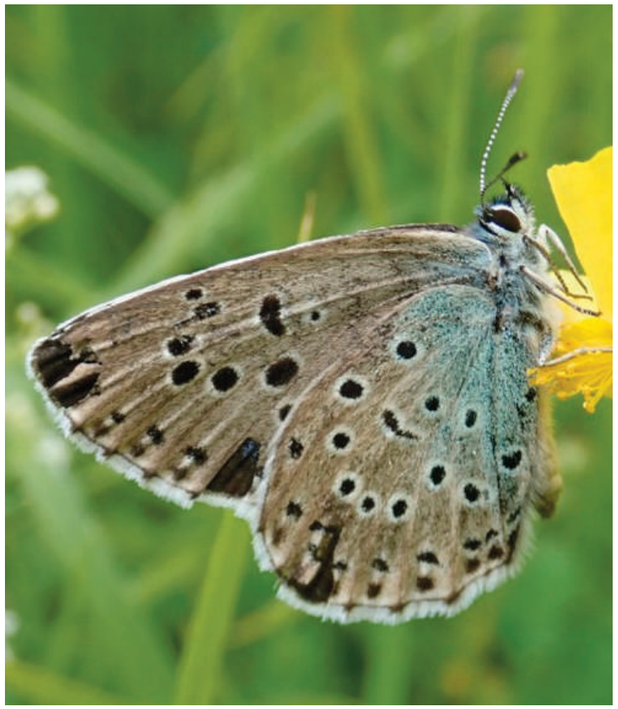



**Figure 5. Left:** One of the two adult female Large Blue butterflies (*Phengaris arion*) collected and preserved for genome sequencing. **Right:** An adult Large Blue butterfly in situ at Daneway Banks nature reserve. Credit: Liam Crowley.

around 12,000 species.

The arrival of the quantity and quality of genomes produced by DToL is revolutionising bioscience, both in terms of discovery science and enabling science. Reference genomes are quickly becoming an essential component of the 21st century biology toolkit, facilitating myriad methods of investigation from evolution to physiology, from ecology to behaviour. Examples include resolving difficult phylogenies where existing markers are insufficient, examining genome structure such as karyotypes and studying the evolution of genes and gene families (*e.g.*, Mulhair *et al.*, 2023a, b).

One of the most powerful applications of whole genomes is in the field of comparative genomics. High-quality genomes from different species can be compared and differences examined. For example, recent work by the University of Oxford DToL team looked at rates of evolution and gene duplication across Lepidoptera. One intriguing case of gene duplication involved the Lipocalin gene superfamily. A subgroup, the bilin-binding proteins (BBP), are present in all Lepidoptera and are involved in binding the pigments responsible for blue colouration. Interestingly, this subgroup underwent extensive duplication within the Lycaenidae family, which contains 'the blues', with as many as 24 copies in some species! The large and consistent duplication of BBP in Lycaenidae may be linked to the blue colouration of many species, providing a potential answer to the question 'how did the blues become blue?'.

Another area where full genomes are incredibly useful is in conservation population genetics. The Large Blue butterfly (*Phengaris arion*) is the current focus of conservation efforts in Britain following the successful reintroduction in Somerset and Gloucestershire. As populations of this species grow and spread, it is important that we understand their genetic make-up, for example to determine if interventions are required to safeguard genetic diversity. A reference genome is a vital pre-requisite for identifying suitable marker regions to enable targeted sequencing of multiple individuals. Two adult females were collected from Daneway Banks in 2022 (under licence), and the resulting genome released in 2024 (Meredith *et al.*, 2024) to facilitate this important work (Fig. 5).

Whilst the first phase of the DToL project has come to a close, sequencing continues, with thousands of additional genomes expected to be produced over the coming years. This data avalanche will unlock many different opportunities for genome-enabled research as well as practical applications, revolutionising biodiversity science.

## References

Crowley, L.M. *et al.* (2022) *Wellcome Open Research* **7**, 27.
Crowley, L. *et al.* (2023) *Wellcome Open Research* **8**, 123.
Darwin Tree of Life Project Consortium (2022) *Proceedings of the National Academy of Sciences*, **119**, e2115642118.
Hawkes, W.L. *et al.* (2023) *Wellcome Open Research* **8**, 106.
Lewin, H.A. *et al.* (2018) *Proceedings of the National Academy of Sciences* **115**, 4325–4333.
Meredith, S.A. *et al.* (2024) *Wellcome Open Research* **9**, 506.
Mulhair, P.O. *et al.* (2023a) *Genome Research* **33**, 32–44.
Mulhair, P.O. *et al.* (2023b) *Molecular Biology and Evolution* **40**, msad241.
Turnbull, C. *et al.* (2018) *BMJ*, **361**.
Twyford, A.D. *et al.* (2024) *Wellcome Open Research* **9**, 339.

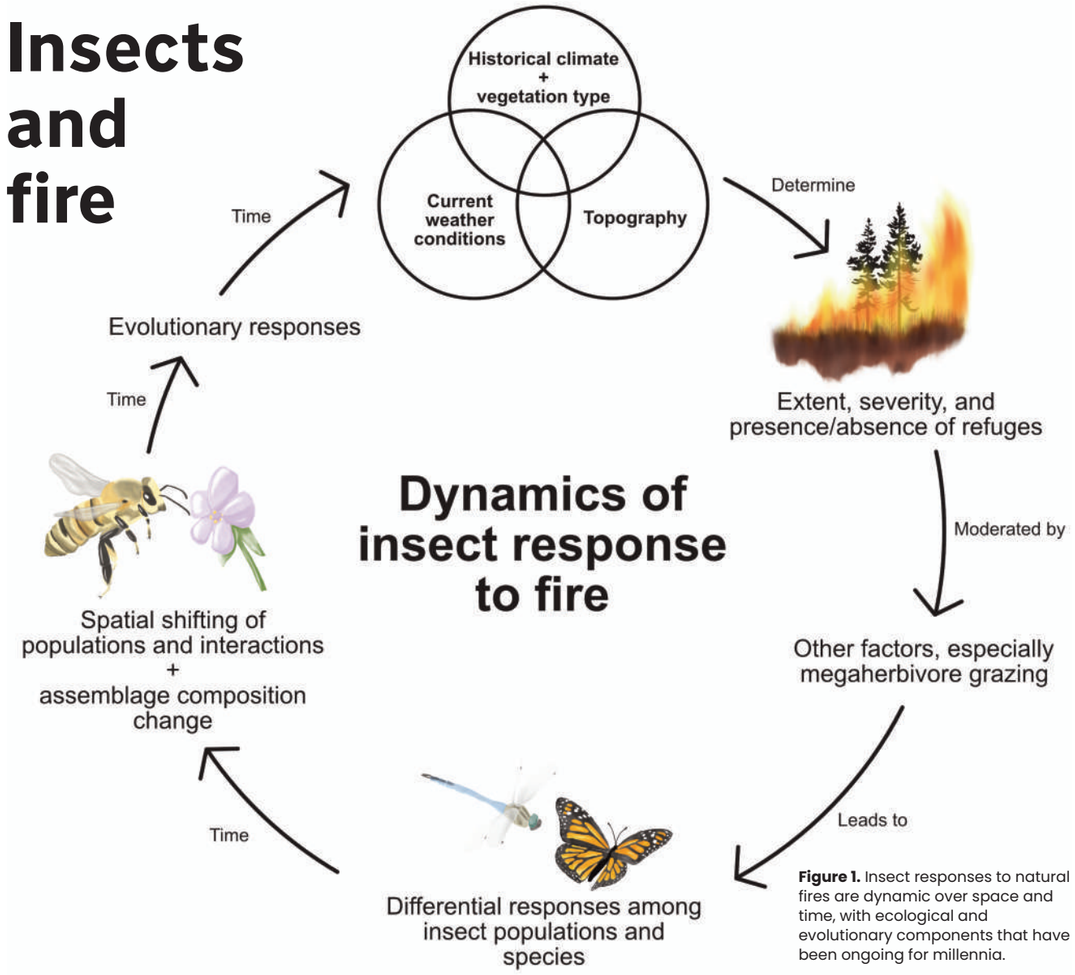



**Figure 1.** Insect responses to natural fires are dynamic over space and time, with ecological and evolutionary components that have been ongoing for millennia.

**Michael Samways, James Pryke, René Gaigher and Charl Deacon**
Department of Conservation Ecology & Entomology, Stellenbosch University, South Africa
samways@sun.ac.za

## Introduction

Insects, like all terrestrial life, have faced fire events in their >400 million years of evolution. Landscapes burn naturally through rock fall, spontaneous combustion, volcanic activity, meteorite strikes and lightning. Today, rapid climate change is increasing fire frequency and intensity, which is likely to escalate in the coming years (Dole *et al*., 2023).

Fires are especially prevalent in areas with extreme wet-dry cycles, and high plant productivity allowing periods of dry vegetation biomass to be susceptible to burning. Dry spells in nearly all biomes trigger fires, especially in tropical dry forests, savannas, scrublands, heathlands and grasslands (Robinne *et al*., 2018). In short, fires are widespread in many of the warmer parts of the world.

Fires also interact with other human pressures, such as livestock grazing. Together, fires and grazing change plant communities (Furquim *et al*., 2024). Fire is also used by humans to clear land and for field stubble burning to create suitable agricultural land. This means that fires are more prevalent where there is landscape transformation, even in tropical rainforests (Juárez-Orozco *et al*., 2017).

Both fire intensity and degree of spread are significant factors for insects. Fuel load, in terms of accumulated ignitable organic matter, normally in the form of dry plant biomass, is another important factor. The greater the load, the more intense the fire. In turn, fire intensity is moderated by prevailing weather conditions. Dry and windy conditions encourage fire, while rainfall dampens it, both greatly affecting insect







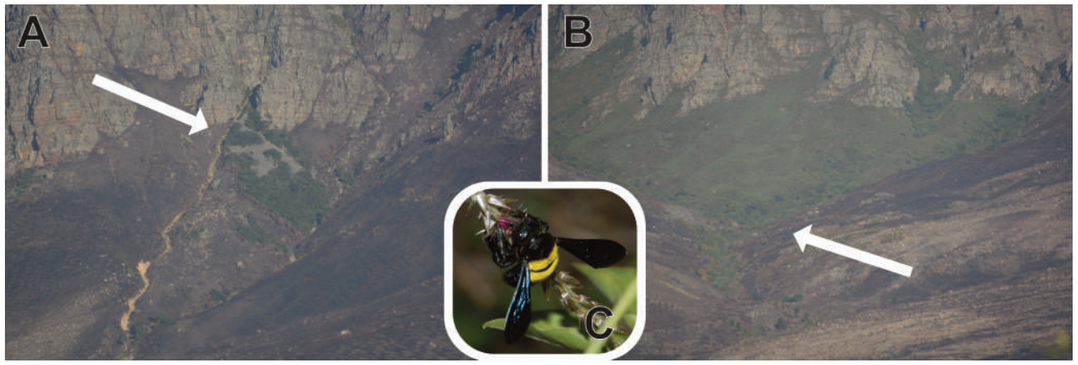



**Figure 2.** Through the haze of the smoky aftermath of a megafire in the Cape Floristic Region, South Africa, can be seen green refuges on a scree (A) and between stream beds (B). These refuges are critical for the survival of insects like the local carpenter bee *Xylocopa caffra* (C).

population dynamics and interactions (Fig. 1).

The composition and structure of plant species matter too. Some plants are more flammable than others, although many plant species are adapted to recover well after fire. Some even have volatiles that promote fire, such as the eucalypts of Australia and the turpentine grasses of Africa. Standing vegetation may have some type of fire protection, such as fire-resistant bark. Other species have fire-tolerant root systems, while others require fire to propagate and resprout (Pausas, 2019).

The aim here is to comment on the various insect responses to fire, with special reference to their conservation.

## Insect adaptations to fire

Fire can be a minor or major rapid disturbance event, depending on its extent and intensity. Fire is of great consequence for insect conservation at various spatial and temporal scales and can have an extensive impact on many insect species (New, 2014). Insects are variously adapted to fire (Davies *et al*., 2014) according to species, their evolutionary history, dispersal ability and lifestyle, in association with location, ecosystem and geomorphology (Koltz *et al*., 2018). Different insect groups, as well as individual species, are variously adapted to fire events, having different recovery times (Pryke & Samways, 2012a) and abilities to cope with fire (Yekwayo *et al*., 2018).

Some insect groups are highly vulnerable to fire events. In the case of the plant-rich but fire-prone Cape Floristic Region, South Africa, this area is species rich in most insect groups, but poor in bush cricket species. Bush crickets in the region are mostly large and flightless, and seemingly susceptible to fire events through being unable to rapidly respond to fire and recolonise from fire refuges (Thompson *et al*., 2020).

Fire impacts different insect taxa according to fire intensity, extent and season. Furthermore, fire can affect insects and other invertebrates living in the soil, affecting their densities both directly through mortality and, indirectly, through the effects of fire on food resources (Sileshi & Mafongoya, 2006). For example, the Mediterranean *Cicada orni* undergoes a population crash after fire, due to damage to the host tree and its roots declining leading to the death of eggs (Pons, 2015).

In contrast, in the Cape Floristic Region, ants and springtails are highly resilient to fire events, particularly springtail species that can retreat below ground (Janion-Scheepers *et al*., 2016). Yet, in the same region, pollinators are not as instantly resilient to fire events (Pryke & Samways, 2012b). Due to insects and other arthropods in the region being variously adapted to fire, there is a distinct succession of insect assemblages over time since last fire (Yekwayo *et al*., 2018). In Spain also, different insect taxa show various levels of recovery over time in the burned areas. Over a 15-year period, sphecid wasps increased in diversity, partly related to recovery of the plant structural diversity, and increases in availability of prey (Cruz-Sánchez *et al*., 2014).

Fire can reverse ecological succession from grassland to forest. However, where variations in topography result in fire-protected areas, a sharp ecotone (transition area) can develop between the burned/unburned areas, with distinct vegetation composition and structure on each side of the boundary, along with their own characteristic insect assemblages (Kotze & Samways, 1999). Some insect groups, such as ants, grasshoppers, springtails and flies, are most abundant in young regrowth after fire (Driessen & Kirkpatrick, 2017).

An insect species' response to fire interval and extent is not necessarily related to its rarity. Indeed, some threatened insect species even require fire, such as the American Fender's Blue butterfly (*Plebejus icarioides*) larvae. Fire improves larval-tending behaviour by ants and so supports larval survival to emergence (Warchola *et al*., 2015).

Evolution of insect survival strategies occurs in many species in highly fire-prone areas. Insect populations survive fire by retreating to unburned refuges such as ravines, screes, stream margins, spaces between and under boulders, and rocky outcrops, or even in patches that remain unburned because of the fire changing course (Fig. 2).

The Cape Floristic Region is rich in plants and pollinators, with bees, beetles, wasps and flies being the most frequent pollinators of flowering plants. Highest interaction activity occurs in fire refuges following a fire event. Interactions also track flower abundance, highest in fire refuges and lowest in burned areas. Interactions are mostly of specialised flower visitors,




**Figure 3.** At the small spatial scale, some plants survive and others do not, with the ground cover here reduced to ashes (A). Just six months after the fire, the ground cover recovered, and flowers re-appeared (B).

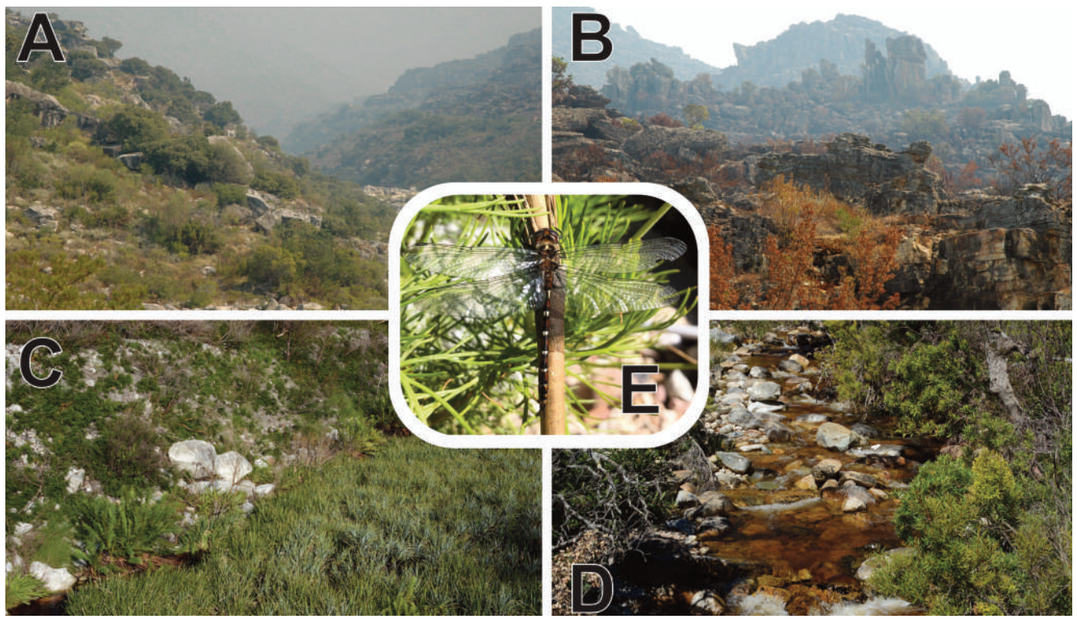



**Figure 4.** Many dragonflies in the Cape Floristic regions are powerful fliers and often forage away from water in the mountains. But when they detect the smoke of an approaching fire (A) they leave the area to seek refuges. The rocky terrain leads to patchy burning of the vegetation and, where smaller and less mobile, insects retreat (B). However, along rivers, often the vegetation escapes the fire (C), and sometimes leaves important woody refuges (D). It is refuges such as these that enable rare endemic species like the Mahogany Presba (*Syncordulia venator*) (E) to survive the fire.





especially in refuge areas. These findings emphasise the importance of flower-rich fire refuges to sustain plant–pollinator interactions, especially those involving specialised species, in a fire-prone landscape (Adedoja *et al*., 2019a). Furthermore, the burned Cape landscape goes through regrowth and succession as part of the ecosystem recovery process after a major fire event, with pollinators responding accordingly (Adedoja *et al*., 2019b) (Fig. 3).

Also in the Cape Floristic Region, the hot and dry mid-summers are a time of great fire risk, aggravated by highly inflammable invasive alien trees (*Eucalyptus*, *Pinus*, *Acacia*), fanned by high winds. It is also a time of year when prey for adult dragonflies is scarce. The adults, such as those of the endemic Cape Skimmer (*Orthetrum julia capicola*), Yellow Presba (*Syncordulia gracilis*), Gilded Presba (*S. legator*) and Mahogany Presba (*S. venator*), have a strategy for avoiding fire. Firstly, they detect the onset of fire by its billowing smoke in the mountain foraging area, and then they immediately retreat to the safety of refuges. These retreats are in the valley bottoms and are in the form of unburned vegetation along the river's edge and protected microhabitats between huge boulders (Samways & Deacon, 2022) (Fig. 4).

Conversely, in the Drakensberg Mountains of South Africa, many grasshopper species are behaviourally adapted to fire, finding refuge among rocks on craggy hilltops that escape the direct impacts of fire (Samways, 1990).

In Australia, the diversity of soil litter macroinvertebrates enhances functional resilience of litter decomposition following fire. Fire can change these dynamics according to refuges, with litter breakdown still occurring within three years following an intense fire but only where there is the possibility of recolonisation from refuges. This indicates that there can be fire tolerance depending on where and when in the landscape the fire has an impact or not (Buckingham *et al*., 2015).

Highly extensive and catastrophic fire can also increase levels of threat among certain insect species. The massive 2019–2020 Australian Black Summer wildfires caused a sudden and marked reduction in population sizes of many species. Endemic wild bees were hard hit, with fires causing several species to be placed in the IUCN threatened species categories (Dorey *et al*., 2021).

Smoke is an ever-increasing problem emanating from megafires in particular. Insect species react differently to smoke exposure, with some species attracted to the smoke (*e.g*., some beetles such as the buprestid *Melanophila acuminata*) while others are repelled (*e.g*., some bees such as the widespread pollinator *Apis mellifera*) (Liu *et al*., 2022) (Fig. 5).

**Interaction between fire and grazing in low-canopy systems**

In grasslands and savannas, fire is necessary for maintaining the open habitat required by grassland insects despite the potential for negative effects on individual arthropod species populations. Furthermore, there is an interaction between fire and grazing by large herbivores, which

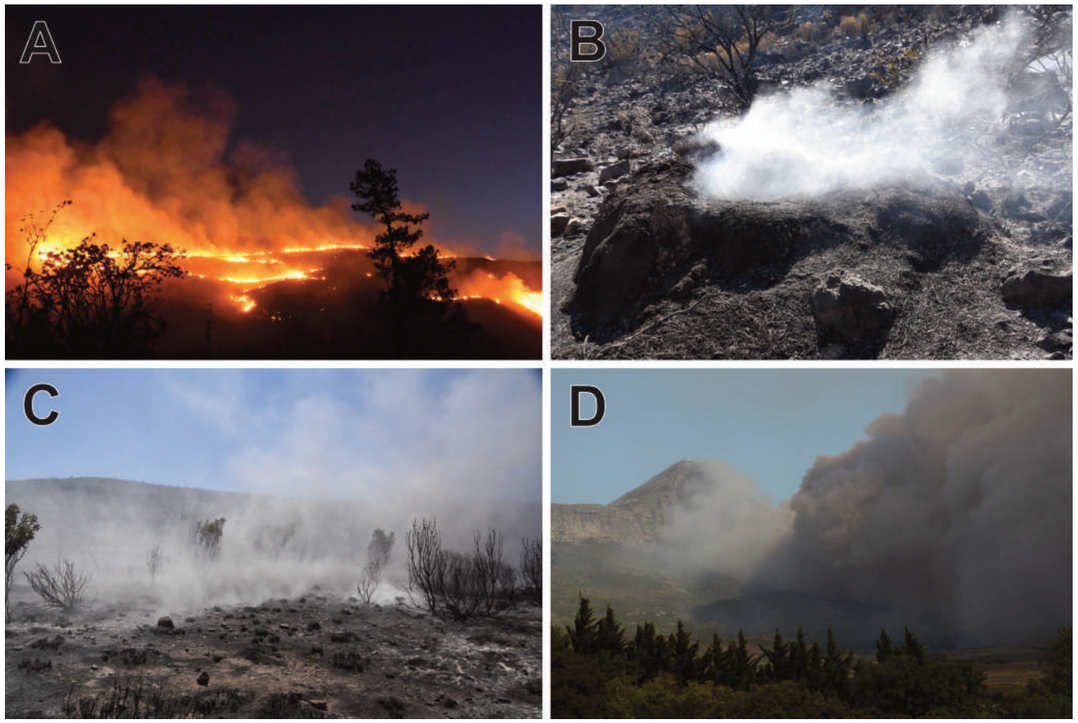



**Figure 5.** The burning of natural vegetation (A) can produce considerable smoke, attracting some insects but causing many to seek refuge. Depending on the intensity of fire and the time after fire, smoke intensity can vary from low (B) to high (C), and even intense under certain circumstances (D).

ARTICLE

together act as co-dominant ecosystem drivers in most grasslands worldwide. These two drivers together produce shifting mosaics of vegetation, which shape the landscape, influencing consumer distribution, abundance and diversity, and so maintain grassland structure and function (Joern & Laws, 2013; Foster *et al*., 2015).

In effect, fire and grazing can create high landscape and habitat heterogeneity through differential effects at large spatial scales. However, fire and grazing can equally simplify the habitat at small spatial scales. In Namibian savanna grasslands, grazing overrides the impacts of fire and its effects on tenebrionid beetles. But where the effects of these two drivers are similar, it is because there has been previous niche and assemblage simplification of the beetles' habitats (Reinhard *et al*., 2019).

Moderate livestock grazing can maintain insect diversity in the absence of natural drivers such as indigenous grazing mammals and fire, with fire having a greater effect than grazing for insects in an African grassland (Little *et al*., 2013). However, fire- and grazing-induced effects on savanna lead to alternate ecosystem states (Hempson *et al*., 2019). The change in these states then leads to different local insect assemblages which shift back and forth according to the time period between these two states.

**Fire and forests**

Forests present a different situation compared with that in grasslands. In Belize, selective logging has little effect on tropical fruit-feeding butterfly assemblages, seemingly because this activity simulates natural disturbance from fire and hurricanes (Lewis, 2001). However, extensive tropical forest wildfires can greatly affect some insects, especially relative to El Niño Southern Oscillation events, as in Borneo. During these events, vegetation structure changes, with concurrent great changes in butterfly assemblages, dropping five-fold in comparison with intact natural forest (Cleary & Mooers, 2006). Amazonian dung beetle assemblages change considerably in response to dry season fires, with loss of larger-sized species in favour of smaller ones, affecting nutrient cycling and seed dispersal (de Andrade *et al*. 2014).

Fire over long time periods can change landscape structure. The naturally small (many of <450 m diameter) forests in the Afromontane grassland matrix are forest islands across the grassland landscape. Their origin is due to the fire front stopping at their edges over many millennia. These islands are rich in insect species, with each island differing in its arthropod fauna following a long history of differentiation (Pryke *et al*., 2013). The size of these forest islands, as well as their position across the landscape, determine the arthropod composition of each one (Yekwayo *et al*., 2016) (Fig. 6).

With increasing forest fire occurrence in response to rapidly changing climate, there is a drop by half in insect herbivore damage on understorey Wax Current bushes in the Rocky Mountains. There are also changes in plant–insect interaction dynamics in response to changes in plant quality in relation to fire (Murphy *et al*., 2018). Similar findings come from a bushland reserve in Australia, where there was a change in the relationship between the Western Jewel butterfly (*Hypochrysops halyaetus*) and its host plant in response to different fire intervals (Dover *et al*., 2009).

**Management and insect conservation in fire-prone environments**

Today, habitat fragmentation is a further major synergistic driver of insect diversity in fire-prone systems. Higher trophic levels are especially sensitive to these combined drivers. Fire is also more frequent than in the past, particularly close to cities. This increased frequency is mostly harmful to insect diversity with, for example, repeated human burning of forest in Amazonia resulting in a grassland savanna, which has a major effect on ant assemblages (Paolucci *et al*., 2017). Furthermore, both too little and too much fire can be a threat to tropical forest biodiversity (Román-Cuesta *et al*., 2007). Suppression of natural forest fires to protect natural resources can have a harmful effect on some forest insects. However, certain rare insect species require fire, which can be carefully managed but only in extensive forests (Warren & Key, 1991).

Too little fire in grassland or savanna often leads to increased vegetation complexity, due to increased woody growth and accumulation from ecological succession. This shift results in changes in ant (Andersen *et al*., 2006), and overall arthropod assemblages (Driessen & Kirkpatrick, 2017).

Sampling of African grasshopper assemblages in 40-year experimental plots that variously received burning and mowing (to simulate natural megaherbivore grazing) treatment, revealed great changes in the assemblages, despite the plots being close enough for the grasshoppers to have a choice of plots to occupy. Grasshopper abundance and species richness were highest in both the spring/early summer mowed and the annually burned plots. Recommendations are that to conserve grasshoppers in this African grassland system, annual burning on a rotational basis is preferred and is logistically feasible (Chambers & Samways, 1998).

Humans have changed the way fires interact with landscapes. Prehuman fires were large, infrequent events likely during the driest and windiest times of the year. This would mean that fires would burn quickly and extensively. Humans allow biomass to build up by protecting areas that need to burn from fires, meaning that modern fires are often much more intensive than historical fires. The optimal situation for conserving insect diversity is to mimic natural fire disturbance as closely as possible, while also considering important issues like landscape heterogeneity, connectivity and configuration (Samways, 2007).

For example, after decades of fire suppression, the coniferous forests today in western North America are different in structure and composition from their natural state. High densities of older trees, heavy fuel loads and extensive wildfires have changed insect and tree disease statuses, with populations of forest insects and diseases now greater than historical levels. This undesirable outcome necessitates gradual introduction of smaller and cooler fires to reduce potential unacceptable insect and disease responses (Parker *et al*., 2006). However, this is a dynamic situation under ongoing climate change, requiring much attention to risk management strategies (Anderegg *et al*., 2022). But these strategies are complex in the case of insects. Fire can benefit pollinators by opening up forest canopies, which enhances floral resource availability. Yet, bark beetle and defoliator outbreaks can greatly affect fuel loads. Differences in the severity, extent and timing of outbreaks, fire regimes, weather and topography, among other factors, all confound our understanding of the effects of bark beetle and defoliator outbreaks resulting from wildfires (Fettig *et al*., 2022).

Increasing extensive fire prevalence and extreme fire events are great threats to insect populations. The extent and impact of these megafires make it difficult for insects to evade fires and find refuges, with postfire recolonisation slowed following temporary extirpation of populations. Land managers can potentially mitigate megafire impacts by pre-emptively establishing refuges and promote habitat heterogeneity across the landscape, as well as controlled burns to reduce biomass and reduce burn severity. These post-fire landscapes potentially provide opportunities to restore historical fire patterns and ecosystem health to the benefit of insects (Dole *et al*., 2023).

Fire, together with grazing by livestock or indigenous megaherbivores, can shape the ecology of grasslands. When both fire and livestock grazing are at moderate levels, they benefit local grasshopper diversity in Africa (Joubert *et al*., 2016), especially as grazing by indigenous megaherbivores is a major driver of natural ecosystem processes (Pryke *et al*., 2016), and livestock partially mimic this process (Fig. 7). However, without fire and grazing, African savanna develops into a woody environment. Grazing by large indigenous mammals reduces the fuel load, decreasing fire frequency and intensity (Case & Staver, 2017).

Fire management decisions can be difficult in human-modified landscapes. Large networks of conservation corridors play a major role in insect conservation, and where fire is needed to maintain indigenous butterfly diversity while also protecting the commercial plantation matrix by reducing fuel loads. Fire prevents the corridors going through ecological succession from open grassland to indigenous forest via




**Figure 6.** Millennia of natural fires, mostly ignited by lightning, in the Drakensberg summer rainfall area of South Africa, create a mosaic of grassland and small forest patches because of fire burning the grass cover but not the tree canopies (A). This long-term effect of fires is an evolutionary generator of insect species, especially though isolation of the forest patches (B). Some large forest patches may contain old growth (C).

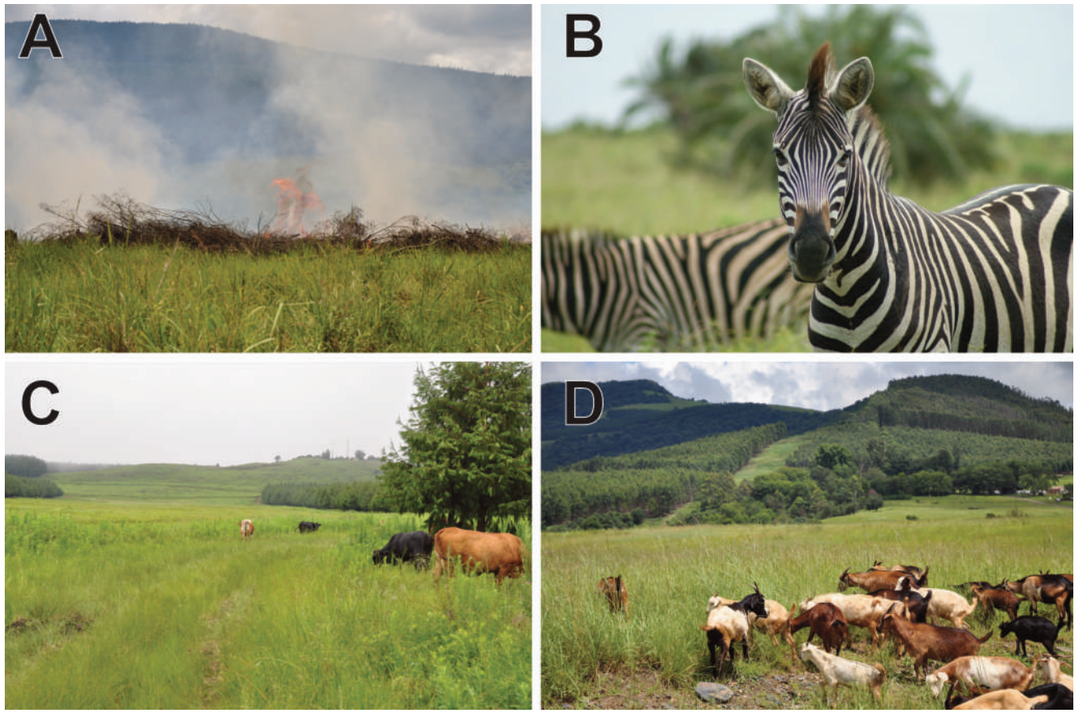



**Figure 7.** Large networks of conservation corridors of remnant near-natural grassland separate timber stands. The corridors are retained for the conservation of biodiversity. There must be a balance between conservation and timber production. Brushwood from pruned trees is burned, which has only a short-term effect on the soil fauna (A). Fire in the grassland is complementary with grazing by megaherbivores, which together maintain a healthy grass sward (B). However, limited and highly mobile livestock like cows (C) and goats (D) also contribute to grassland health, and are important for local livelihoods, so long as grazing is not too intense. Fire events must also be managed, mostly though managed firebreaks around timber stands.

**Table 1.** Fire management options for insect conservation.

| Management action | Feasibility | Comments |
|---|---|---|
| Assess, monitor, and prioritise | Feasible when carefully planned | Tough choices have to be made as to what is the subject: certain populations, species, ecosystems, fire refuges, effectiveness of management plans, *etc*. |
| Control highly inflammable invasive alien trees | Feasible | Alien trees are generally harmful to insect diversity and often can also intensify fire events. |
| Do not let fuel load increase to dangerous levels | Feasible in certain areas | Prescribed burns and rotational burns are already used by skilled practitioners. |
| Maintain grassland with megaherbivores | Varies in feasibility according to region and human historical events | Ideally, the grazers should be indigenous megaherbivores. These may be introduced through rewilding projects. Domestic livestock can also be used at moderate densities. However, they are limited in their plant preferences, usually less so than a variety of natural megaherbivores. Benefit local communities. While mowing is a substitute for herbivore grazing, it is only possible in small high-value areas, such as cities or for certain valuable crops. |
| Introduce firebreaks | Feasible | Already a common practice to protect urban areas and timber stands. Requires training and permission. |
| Create fire refuges | Only occasionally feasible | Fire refuges are such a crucial factor in insect conservation that they must be considered at all times. Many types of natural refuges are present, but their effectiveness depends on fire intensity. Burning firebreaks is one way forward to create them. |
| Maintain veteran trees | Feasible | Veteran trees are vitally important for so many insects as well as mycorrhizal fungi. Veteran trees should be protected by firebreaks. |









an intermediate thicket stage. The issue is that the thicket is unsuitable for both the grassland and the forest butterflies, but thicket is prevalent in corridors where optimal fire management for grassland is logistically difficult. There are two management choices: remove the thicket through burning, or let succession follow its course to forest. Maintaining the intermediate stage of thicket is not viable, as it supports low butterfly diversity, is a fire risk to plantations, and once established it is difficult and expensive to remove (Gaigher *et al*., 2019).

For those insect species that require fire, it may not always be possible to manage fire optimally in high-risk urban areas. This is the case for certain highly sensitive species, such as the Altona Skipper butterfly (*Hesperilla flavescens*) in Australia (Relf & New, 2009).

Carefully prescribed fire can increase insect population growth rates and maintain effective population sizes (Warchola *et al*., 2018). However, prescribed fires that are too frequent can cause a decline in insect species. In the USA, grass-skipper butterflies are affected by too much fire both through direct mortality and from thick tall grass regrowth, unsuitable for the larvae (Swengel & Swengel, 2015). Sometimes, alternative approaches to prescribed fire are preferred. In Germany, while fire has been used as a general landscape management approach, the larval habitat of the rare Woodland Grayling butterfly (*Hipparchia fagi*) is damaged. The best alternative for this butterfly is light grazing by goats (Möllenbeck *et al*., 2009).

Another management approach concerns the highly fire-resilient ant populations in the African savanna. The ant assemblages respond more to whether a particular patch burns or not, rather than to any particular applied burn treatment. This means that burn management decisions should be based rather on more sensitive-to-fire insects (Parr *et al*., 2004).

Climate change is likely to bring about extreme weather events, with very wet periods creating large amounts of biomass and very dry periods allowing this biomass to burn, which in turn causes more intense fires in natural ecosystems. We are likely to see a considerable change in insect responses to fire in ecosystems globally due to the effect of increased fire frequency from changing climate. This is concerning for the forest species that require old-growth habitats and specific features such as dead wood (Buddle *et al*., 2006), but also to fire prone ecosystems. High fire intensity means that more refuges burn and leave fewer places for insects to escape fire, as well as less vegetation on the landscape for insect forage and shelter.

Overall, the findings to date indicate that fire applications must be done with great care. There must be consideration for the possible and widely differing responses of the different insect species in the target area relative to the degree to which they are threatened, along with consideration of how fire-prone landscapes are managed to ensure resilience (Hessburg *et al*., 2015). Overall, it is critical that multiple insect taxa are used to assess the effect of fire, whether natural or prescribed, so to best inform practical fire management (Pryke & Samways, 2012a) (Table 1).

## References

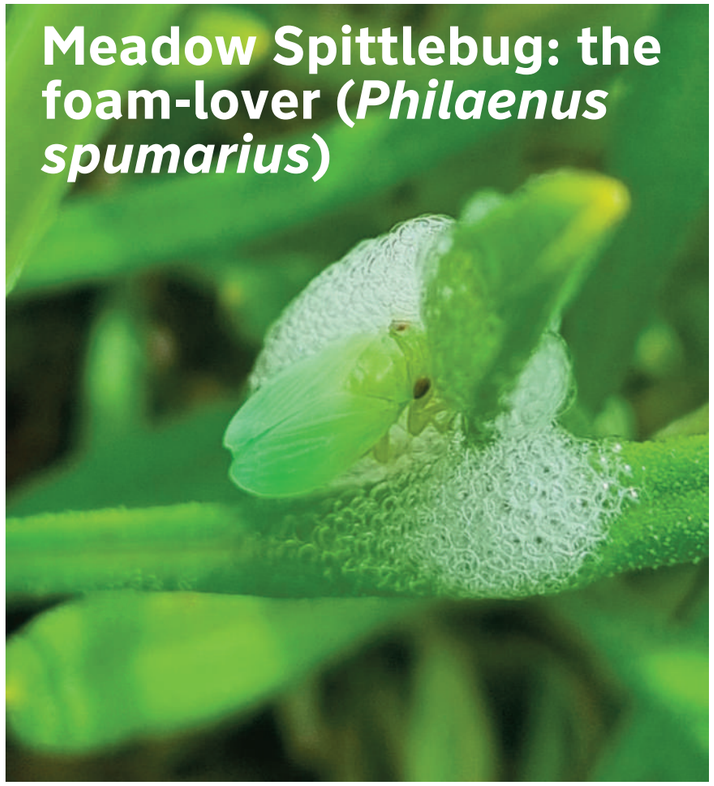

Adedoja, O.A. *et al.* (2019a) *Ecology and Evolution* **9**, 5777–5786.
Adedoja, O. *et al.* (2019b) *Ecosphere* **10**, e02849.
Anderegg, W.R.L. *et al.* (2022) *Ecology Letters* **25**, 1510–1520.
Andersen, A.N. *et al.* (2006) *Journal of Biogeography* **33**, 823–832.
Buckingham, S. *et al.* (2015) *PLoS ONE* **10**, e0124556.
Buddle, C.M. *et al.* (2006) *Biological Conservation* **128**, 346-357.
Case, M.F. & Staver, A.C. (2017) *Journal of Applied Ecology* **54**, 955–962.
Chambers, B.Q. & Samways, M.J. (1998) *Biodiversity and Conservation* **7**, 985–1012.
Cleary, D.F. & Mooers, A.Ø. (2006) *Diversity and Distributions* **12**, 409–416.
Cruz-Sánchez, M.A. *et al.* (2014) *Journal of Insect Conservation* **18**, 903–908.
Davies, K.W. *et al.* (2014) *International Journal of Wildland Fire* **23**, 417–424.
de Andrade, R.B. *et al.* (2014). *Journal of Insect Conservation* **18**, 1097–1104.
Dole, H.E. *et al.* (2023) *Current Opinion in Insect Science* **60**, e101129.
Dorey, J.B. *et al.* (2021) *Global Change Biology* **27**, 6551–6567.
Dover, J.W. *et al.* (2009) *Journal of Insect Conservation* **13**, 487–503.
Driessen, M.M. & Kirkpatrick, J.B. (2017) *Journal of Insect Conservation* **21**, 15–37.
Fettig, C.J. *et al.* (2022) *Current Forestry Reports* **8**, 301–316.
Foster, C.N. *et al.* (2015) *Journal of Vegetation Science* **26**, 1112–1123.
Furquim, F.F. *et al.* (2024) *Applied Vegetation Science* **27**, e12800.
Gaigher, R. *et al.* (2019) *Journal of Applied Ecology* **56**, 1322–1332.
Hempson, G.P. *et al.* (2019) *Trends in Ecology & Evolution* **34**, 286–290.
Hessburg, P.F. *et al.* (2015) *Landscape Ecology* **30**, 1805–1835.
Janion-Scheepers, C. *et al.* (2016) *Applied Soil Ecology* **108**, 165–175.
Joern, A. & Laws, A.N. (2013) *Annual Review of Entomology* **58**, 19–36.
Joubert, L. *et al.* (2016) *Insect Conservation and Diversity* **9**, 290–301.
Juárez-Orozco, S.M. *et al.* (2017) *Tropical Conservation Science* **10**, e1940082917737207.
Kotze, D.J. & Samways, M.J. (1999) *Biodiversity & Conservation* **8**, 1339–1363.
Koltz, A.M. *et al.* (2018) *Current Opinion in Insect Science* **29**, 110–116.
Lewis, O.T. (2001) *Conservation Biology* **15**, 389–400.
Little, I.T. *et al.* (2013) *Biological Conservation* **158**, 258–270.
Liu, Y. *et al.* (2022) *Environmental Entomology* **51**, 871–884.
Möllenbeck, V. *et al.* (2009) *Journal of Insect Conservation* **13**, 77–87.
Murphy, S.M. *et al.* (2018) *Frontiers in Ecology and Evolution* **6**, e135.
New, T.R. (2014) *Insects, Fire and Conservation*. Springer.
Paolucci, L.N. *et al.* (2017) *Biological Conservation* **214**, 295–302.
Parker, T.J. *et al.* (2006) *Agricultural and Forest Entomology* **8**, 167–189.
Parr, C.L. *et al.* (2004) *Journal of Applied Ecology* **41**, 630-642.
Pausas, J.G. (2019) *Oikos* **128**, 147–153.
Pons, P. (2015) *Journal of Insect Conservation* **19**, 601–606.
Pryke, J.S. & Samways, M.J. (2012a) *Journal of Insect Conservation* **16**, 177–185.
Pryke, J.S. & Samways, M.J. (2012b) *Austral Ecology* **37**, 460–469.
Pryke, J.S. *et al.* (2013) *Biodiversity & Conservation* **22**, 2857–2873.
Pryke, J.S. *et al.* (2016) *PLoS ONE* **11**, e0164198.
Reinhard, J.E. *et al.* (2019) *Insect Conservation and Diversity* **12**, 39–48.
Relf, M.C. & New, T.R. (2009) *Journal of Insect Conservation* **13**, 143–149.
Robinne, F.N. *et al.* (2018) *Global Fire Challenges in a Warming World*. IUFRO.
Roman-Cuesta, R.M. *et al.* (2007) Fire challenges to conserving tropical ecosystems: the case study of Chiapas. In: Newton, A.C. (Ed.) *Biodiversity Loss and Conservation in Fragmented Forest Landscapes: The Forests of Montane Mexico and Temperate South America*. CABI, Wallingford, UK, 291–313.
Samways, M.J. (1990) *Conservation Biology* **4**, 375–382.
Samways, M.J. (2007) *Annual Review of Entomology* **52**, 465–487.
Samways, M.J. & Deacon, C. (2022) Extinction reprieve for the ancient and imperiled dragonflies at the southern tip of Africa. In: DellaSala, D.A. & Goldstein, M.I. (Eds.) *Imperiled: The Encyclopedia of Conservation*, vol. 1. Elsevier, 471–484.
Sileshi, G. & Mafongoya, P.L. (2006) *Biodiversity & Conservation* **15**, 3153–3160.
Swengel, A.B. & Swengel, S.R. (2015) *Journal of Insect Conservation* **19**, 279–292.
Thompson, A.C. *et al.* (2020) *Bioacoustics* **29**, 249–265.
Warchola, N. *et al.* (2015) *Journal of Insect Conservation* **19**, 1063–1073.
Warchola, N. *et al.* (2018) *Journal of Applied Ecology* **55**, 800–809.
Warren, M.S. & Key, R.S. (1991) Woodlands: past, present and potential for insects. In: *Conservation of Insects and their Habitats Collins*, N.M. & Thomas, J.A., Eds) Academic Press, London. Pp. 155–211.
Yekwayo, I. *et al.* (2016) *Insect Conservation and Diversity* **9**, 224–235.
Yekwayo, I. *et al.* (2018) *PLoS ONE* **13**, e0195414.






# Featured Insect

## Meadow Spittlebug: the foam-lover (*Philaenus spumarius*)



Scientific name: *Philaenus spumarius* (Linnaeus, 1758)

Common name: Meadow Spittlebug

Order: Hemiptera

Family: Aphrophoridae

**Susmita Aown**
Department of Ecology and Evolution
University of Sussex
Falmer, Brighton BN1 9RH
UK
s.aown@sussex.ac.uk

Have you ever looked at 'cuckoo spit' and wondered what it is, and what produces it? It's *Philaenus spumarius* (Meadow Spittlebug), nymphs of which feed on the xylem of herbaceous plants and produce this spittle as waste material. The spittle serves as dual protection for the nymphs, providing a cool, moist environment that shields them from desiccation while concealing them from predators. The adults do not produce any spittle; instead, they flick away their watery excretions as droplets. *Philaenus spumarius* has three stages in its life cycle: eggs, nymphs and adults. They have one generation per year and overwinter as eggs. Adult females oviposit from late September to November in the UK, either in leaf litter near suitable host plants or on the host plant's leaf nodes (Bernat-Ponce *et al.*, 2025). The eggs (~ 1 mm long and 0.35 mm wide) are transparent, laid in clusters, and held together by a hardened, frothy cement. The nymphs emerge in spring. There are five nymphal instars. The first and second instars are small and do not produce much spittle, but the later instars can produce substantial quantities of spittle, which is what we call 'cuckoo spit'. The last instars make chambers in the spittle and emerge as winged adults in summer. The nymphs live a primarily sedentary lifestyle, as they are wingless, whereas the adults are more mobile.

Adult *P. spumarius* are called 'froghoppers', as they are known to jump up to 70 cm above ground. Adults are also known to fly up to 4–6 m above ground. Despite this ability to jump and fly, adults travel infrequently, mainly to find suitable host plants for feeding and mating (Lago *et al.*, 2021).

*Philaenus spumarius* is a generalist insect herbivore feeding on around 1,340 known host plants worldwide (Thompson *et al.*, 2023). They are obligatory xylem feeders, drinking about 1,000 times their body mass in xylem per day. They do not cause noticeable damage to plant health or impede plant growth. However, *P. spumarius* has been a significant topic of research in the last decade due to its role as the primary insect vector of *Xylella fastidiosa*, a bacterial plant pathogen in Europe.

*Xylella fastidiosa* causes disease in economically important crops such as olives, resulting in huge economic losses. Once the bacterium is introduced into an area via infected plants, it can only infect healthy plants via the insect (Saponari *et al.*, 2014). *Xylella fastidiosa* has not yet been detected in the UK, but there is a high likelihood of its introduction in the near future. Therefore, understanding the feeding behaviour of *P. spumarius* is critical to attempts to reduce the spread of the bacterium if it is ever detected. This is where my PhD research comes in, as I am investigating the host plant preferences of *P. spumarius* on lavender and grapevines.

### References

Bernat-Ponce, S., *et al.* (2025) *Insects* **16**, 1–14.
Lago, C., *et al.* (2021). *Scientific Reports* **11,** 1–14.
Saponari, M., *et al.* (2014) *Journal of Economic Entomology* **107,** 1316–1319.
Thompson, V., *et al.* (2023) *PLoS ONE* **18,** e0291734.









# Insects in the News

## April to June 2025

**Richard Harrington with the help of material from Hugh Loxdale, Stuart Reynolds and Dafydd Lewis**




I've just been half-watching *Summer in the Scilly Isles* on Channel 5, whilst doing *The Daily Telegraph* crossword. My full attention was grabbed, though, when the Scilly's beekeepers were shown engaged in their mark/recapture project, named 'Game of Drones', designed to show whether Honey Bee males can travel between islands. This had never been proven and hence, to ensure genetic diversity, bees have been imported from the mainland. The joy on the apiculturists' faces when a blue-blobbed bee painted on Tresco turned up on St Martin's was a true delight; no need for further imports and the risk of disease that brings. Mass transport of bees risks more than disease spread. Many outlets reported that a lorry carrying 250 million bees (estimates vary) overturned in Washington State near the Canadian border, the whole cargo buzzing off into the countryside. Beekeepers reckoned that they could re-hive most of the fugitives within 48 hours. If they were wrong, there should be bumper crops and wildflower displays in the area. The generally favourable press given to bees has been dented somewhat this time. *The Daily Telegraph* reported that an Indian billionaire friend of Prince William died after being stung in the mouth during a Windsor polo tournament. Meanwhile, residents of the Warndon Villages of Worcester have been plagued for two years by a million bees (who's counting?) from 'unmanaged hives' in a back garden. "It's impossible to get a window cleaner" complained one resident.

Flies have also been on the rampage, this time in Leamington Spa. *The Daily Telegraph* described a "nightmarish invasion that has become absolute hell and is ruining peoples' lives". A local recycling plant is thought to be to blame. Buglife, however, is urging people not to kill flies that come into your house in an effort to slow the reduction in insect numbers. Really? Try "urging" my wife!

Bees are under threat from the Asian Hornet (*Vespa velutina*). *The Daily Telegraph* reported work from Nottingham Trent University to identify its flight sounds using inexpensive microphones, the idea being that these microphones could be deployed at hives to alert beekeepers, via their smartphones, to the intruders. And not before time; The *Observer* reported queens occurring on Jersey two weeks earlier than usual, 262 of them being recorded by 11th April, and it is feared that the dry, sunny start to spring will lead to a surge in the UK. The European Hornet (*Vespa crabro*), on the other hand, should be welcomed in gardens, says *The Independent*. They are pollinators, predators of lepidopteran larvae (that's good news and bad news, I'd say) and are harmless to bees (don't believe everything you read in the papers). In Japan, larvae of the wasp *Vespula shidai*, are considered a delicacy, but little has been known about what the larvae themselves eat. *Earth.com* reported a study from Kobe University which used DNA metabarcoding to identify 324 different prey species in wild wasp larvae, including not only insects and arachnids, but also birds, mammals, reptiles, amphibians and even fish. Captive-reared populations have a reduced reliance on vertebrate carrion and, according to a survey of consumers, taste less good. Bon appétit!

You can't win. Most readers would celebrate funding going into biodiversity research. But, according to *The Daily Telegraph*, the Welsh Government has come under fire for spending £250,000 from the National Lottery Heritage Fund on a project to count moths. The two-year scheme, called 'Cryptic Creatures of the Creuddyn' involves working with schools to protect rare invertebrates. A Conservative councillor told *Wales Online*: "In its own little world, I can see some benefits … but I find it incredible that they can fund projects like this but can't find money for basic amenities such as toilets …". Clearly, the importance of biodiversity hasn't got through to everybody – and maybe the Heritage Fund doesn't do toilets? I checked, and it does! The Church of St James the Great, Cradley, received £30,065 for the installation of disabled toilets and an extra fire escape. Loos or moths – now there's a dilemma!

*The Independent* reminded us that genetic technology has the potential to "wipe disease-carrying mosquitoes off the face of the Earth" but that bioethicists are "not in favour of remaking the world to suit human desires". I remember such discussion from Charles Godfray's Verrall Lecture a few years back. *The Guardian* repeated the mantra that climate change could bring insect-borne tropical diseases to the UK and Europe, adding that West Nile Virus (WNV) has recently been detected in UK mosquitoes for the first time, although there is no evidence of transmission to humans. In 2024, though, there were 1,400 cases of locally acquired WNV in France and Italy. Back in the day, my Rothamsted Insect Survey colleagues despatched thousands of suction-trapped mozzies (*Culex* spp.) to colleagues at The Pirbright Institute, where they were assayed for WNV as part of the government's surveillance project. No WNV was found. Cuts to international aid, says *The Guardian*, will lead to a collapse in crucial surveillance, control and





treatment programmes in endemic countries, leading to more deaths. A scientist said that the "absolute number one priority" for the UK government if it wants to protect UK citizens long-term is to invest in measures to control these diseases in the tropical countries where they cause the overwhelming burden of illness and death". Meanwhile, *The Daily Telegraph* reported the finding of a mosquito in Shetland, the northernmost record for the UK. The BBC reported the discovery by Harvard University of drugs which can rid mosquitoes of malaria when absorbed through their legs. The hope is that such drugs can eventually be used on bed nets. Finally on mosquitoes, an Afghan accused of smuggling thousands of migrants into the UK should not be extradited to Belgium because there are mosquitoes in prison there, a court heard. According to *The Daily Telegraph*, he is fighting extradition on the grounds that the conditions he would face would violate Article Three of the European Convention on Human Rights, which protects people from "inhuman or degrading treatment or punishment". Presumably, then, whilst in the UK he would decline medical treatment on account of the cockroaches, rats and sewage leaks plaguing NHS hospitals (*The Daily Telegraph*).

The public continues to be kept informed about insect declines, especially by *The Guardian*. There was a twelve-page interview on its website with renowned entomologist Dan Janzen, who laments the massive reduction in moth abundance since his childhood and warns of the impact up the food chain. There have been several articles on the dreaded 'splatometers', results from which draw the same conclusions. On the other hand, the warm spring has brought "plagues of aphids", and led to butterflies flying earlier and longer, and laying more eggs. Both reports are from *The Guardian*, which has also provided a list of "25 easy and effective ways you can help protect insects". You'd guess most of them, but I don't think I'd have got "choose polyester-free clothing". Apparently, a single load of polyester-containing laundry can shed 700,000 microplastic fibres, which can reduce pollinator health and lifespan. Cotton, too, is taboo,



*Culex pipiens* adult. Credit: The Pirbright Institute.

as it is responsible for about 4% to 10% of the world's pesticide use. You could opt for organic cotton, though.

It's always interesting to see obituaries of entomologists in the nationals. In *The Daily Telegraph*, I spotted one to: "Charles Dewhurst, entomologist whose work on the armyworm helped to save crops in Africa". He was instrumental in establishing the Swallowtail and Birdwing Butterfly Trust. So, I got in touch with the President of the SBBT, and he has kindly provided an obituary for this issue.

Other headlines: "A stonefly in the sun – this is a sign of clean water" (*The Guardian*); "Why three-toed sloths risk their lives to help moths" (*National Geographic*); "Dangerous bug that is 'game over' if it arrives in your garden (*Liverpool Echo* reporting on the Vine Weevil, *Otiorhynchus sulcatus*); "Prague Zoo joins the effort to ensure the survival of a rare insect" (*The Independent*, reporting on efforts to save the Lord Howe Island Stick Insect, *Dryococelus australis*); " 'Musical insect' extinct in the UK for over 30 years to be brought back" (*The Independent* reporting on the New Forest Cicada, *Cicadetta montana*).

*The Daily Telegraph* reported a population crash involving the larvae of an iconic lepidopteran, *Colinus marksandspenceri*. The cause was an entomopathogenic virus that infected the caterpillar's circulatory system. It is important in entomophagy, being the only insect species regularly featuring in the human diet in the UK. Guests at weddings and children's birthday parties have had to sponge off other species, *Cuthbertus aldii* being the most easily accessible. Stored product entomologists are working to restore online supplies of Colin the Caterpillar.

And finally, a quizzical headline from *The Guardian*'s Country Diary. "What has the head of an ant, eyes of a housefly and legs of a spider?" (It only has six of the latter, though). It dropped on to diarist Claire Stares' arm whilst she was standing under an oak tree. You can find the answer by working through the highlighted letters in this article.



*Colinus marksandspenceri.* Photo: Jen Banfield-Zanin.





# Society News

Marbled white butterfly in meadow at Daneway Banks Credit Tim Cockerill

# News from Council

**Council Meeting**
Council met online on 14th May and in-person/online on 16th July at the Liverpool Exhibition Centre. The latter meeting included workshops on EDI and publishing strategies, a visit to the Liverpool World Museum to see the RES photography exhibition, which was on display as part of Insect Week, a tour of the Museum's Entomology Department, and a tour of the proposed venue for the RES bid to host the 2033 International Congress of Entomology.

**CEO's Report**
The Society has completed its first three-year strategy, and an impact report has been produced. Many projects in the new strategy have started strongly. Policy and public affairs work is developing apace, and the RES has been invited to be the secretariat for a new All Party Parliamentary Group on Bees, Pollinators and Invertebrates, the inaugural meeting of which took place during Insect Week, along with a round-table discussion event in the Houses of Parliament in Westminster. There has also been an introductory meeting with Chi Onwurah, who chairs the Science, Innovation and



Trustees and staff at the RES Photography Exhibition.



The President presents a copy of the RES book *Insects* to Tony Hunter, Assistant Curator of Entomology, National Museums Liverpool, for their library.

Technology Committee. She has asked the RES to produce some questions that she can table to parliament to keep up the momentum on discussing insect declines following the report in 2024. There have also been meetings with several MPs and Peers from a range of political parties to engage them with the work of the Royal Entomological Society and its members.

Over £33,000 has been raised through the Chapman Charitable Trust for Insect Week, the Big Green Match campaign for work of the conservation science team, and in sponsorship for the RHS Chelsea Flower Show Garden in partnership with Sparsholt College. Sponsorship for Ento25 is at a record level. Funding is being sought for the cataloguing and restoration of library materials including correspondence from Project Wallace (see Issue **49** (2)). The Insect Welfare and Research Society has agreed to fund the first part of a programme to develop codes of practice for insects as livestock. A range of commercial partnerships is being built, including with Yeo Valley and Aardman.

The development of a new methods-focused journal, *Approaches in Entomology*, is in the process of being approved. The third book in the *How to be a…* series is being written on dung beetles. The first handbook to be published with CABI will be out in late 2025 – UK Dolichopodidae by Martin Drake. Other book-publishing opportunities are being considered.

Insect Week (see pages 141-144) was very successful and started with the launch of the latest report on UKCEH's Pollinator Monitoring Scheme. Three hundred people took part in a family event at the RES garden in Stratford Cross.

**Matters for Discussion**

A statement originally drafted by the Entomological Society of America (ESA) on the importance of global collaboration in entomology was developed and shared for review and signing by other national entomological societies.

The management accounts were presented at each meeting.

An update was provided on the Head Office relocation. The purchasers of The Mansion House have pulled out and the property will be advertised on the open market through a nationwide estate agent. The purchase of Wenlock Road is proceeding apace. A security-backed lending facility has been arranged in case needed to bridge any gap between sale and purchase.

The Chair of the Science, Society and Policy Committee, Mike Bonsall, presented impressive developments in this area, some of which are described in the CEO's report (above).

An update was provided on the workforce restructure.

**Matters for Decision**

Following recommendation from our solicitors, it was agreed to propose to the membership an addition to the byelaws regarding signatures and use of the Society's seal on legal documents.

The Society's investment policy was approved.

Following an open call for nominations, four members were put forward as President Elect. After a vote by trustees, Allan Watt was selected to be put forward to the membership for election.

The Events Strategy was approved subject to minor changes.

**Matters for Information**

Papers on the reserves policy and the annual accounts for RES Charity, RES Trading Ltd and Audit were tabled. Minutes of the Finance Committee, Outreach Committee, Science, Policy & Society Committee, Library Committee and Events Committee were tabled.





# 2025 Insect week

**Standing up for insects #StandTallForTheSmall**

***Fran Sconce,*** Senior Outreach and Learning Officer
fran@royensoc.co.uk

Insect Week is our annual celebration of insects, aiming to engage the public by showing how remarkable and valuable insects are. As ever, events took place around the UK and abroad, supported by collaborators and partners and ranging from exhibitions such as 'The World of Wasps' at the Grant Museum of Zoology, UCL; insect themed 'Hilltop Live' talks at the RHS Garden Wisley; and workshops on bumblebee identification and surveying with the Bumblebee Conservation Trust in the Cairngorms.

This year, we invited the public to #StandTallForTheSmall and take the **Insect Week pledge** to discover, observe and protect insects. 180 people signed the pledge during the week. Do join them at royensoc.co.uk/pledge and download the Insect Week poster, which highlights common UK insect species and the plants that support them.

Here we highlight some of the fantastic events that took place over the course of a packed week.

**Bees, Pollinators and Invertebrates APPG launched**

***Simon Ward,*** CEO
simon@royensoc.co.uk and
**Emilie Aimé**, Director of Publishing
emilie@royensoc.co.uk

As part of the RES vision to enrich the world with insect science, the Society set an objective of being an independent voice to decision makers. To help achieve this, the Science, Policy and Society Committee was established in 2023, and a new Policy and Public Affairs Strategy was developed in 2024. Following on from this, an engagement programme with parliamentarians has been taking place since the start of this year. As a result, the RES was asked to be the secretariat for an All-Party Parliamentary Group (APPG). The inaugural meeting of the Bees, Pollinators and Invertebrates APPG was held on Tuesday 24th June in the UK Houses of Parliament. Its remit is to raise awareness in Parliament of insect science and the impacts of insect biodiversity change. It will also raise awareness of the issues surrounding invertebrates and pollinators, promote their importance for the national economy and natural environment, and highlight pathways to both conservation and growth of insect and pollinator populations.

The APPG will be chaired by Barry Gardiner, MP (Labour). MPs and peers joined a launch reception in Parliament to pledge their support, and nearly 50 parliamentarians have signed up as members so far. All devolved nations are represented, and we had cross party support from Labour, Conservatives, Liberal Democrats, Plaid Cymru, DUP and UUP.

As secretariat, the RES has an important route to ensuring research influences policy and that decision makers are informed by insect science. The Science, Policy and Society Committee will oversee this work.

Following the APPG launch, the RES had a round table event with some great discussions between insect scientists and parliamentarians. The event focused on insect biodiversity change and how this can inform policy. This will hopefully be the first of many such events that will sit alongside an active APPG programme.

Huge thanks go to Jane Stout, Michael Bonsall, Claire Carvell and Erica McAlister for being such great advocates at this first event.




From left to right: Matt Turmaine MP (Labour, Watford), Julia Buckley MP (Labour, Shrewsbury), Katie White MP (Labour, Leeds North West), Barry Gardiner MP (Labour, Brent West), Lord Randall (Conservative), Daisy Cooper MP (Liberal Democrat, St Albans), John Slinger MP (Labour, Rugby). Credit: Warren Page / RES.



Simon Ward (RES CEO), Jane Stout (RES President), Barry Gardiner MP (Labour, Brent West). Credit: Warren Page / RES.




The RES Garden with branded flag. Credit: RES.



Joshua Sammy talks to visitors. Credit: RES.



Visitors at the RES Garden. Credit: RES.

**Public event at the RES Garden**
***Fran Sconce***

On 28th June, the Society hosted a free, family-friendly day at the RES Insect Garden in Stratford Cross, near the Queen Elizabeth Olympic Park in East London. Families enjoyed insect-focused activities set up throughout the garden, led by members of the RES Outreach Committee and volunteers.
Joshua Sammy (PhD graduate, University of York) focussed on pollination, with an activity on bees and bee-mimicking insects, which insects pollinate which food plants, and a display about flower shapes and insect mouthparts.
Victoria Burton (Postdoctoral Researcher, Natural History Museum, London) led 'minibeast' hunts in leaf litter within the garden and examined different invertebrates under the microscope. Jasper Hubert (Technical Manager, Koppert Biological Systems) displayed predatory insects such as ladybirds, parasitoid wasps and lacewings under the microscope, and highlighted how natural predators support both sustainable agriculture and horticulture.

Hayley Jones (Principal Entomologist, RHS and chair of the RES Outreach Committee) focussed on gardening for insects, with a 'hoverfly nectar feast' display and an activity to design your own green space, big or small, for insects.

250 visitors attended the event (including some Iron Maiden fans ahead of a concert at the London Stadium that evening!). The RES worked with Kevin Burchell from Resources for Change, who carried out a structured evaluation of attendees' engagement during and after the event. Data from this work will inform and improve future outreach activities at the garden and elsewhere, and provide evidence needed to access possible future funding for our outreach.

Thank you to volunteers Sophia Reinisch, Ben Biddle and Josie Stuart, and to the Stratford Cross estate team for their site support.









The exhibition and photographs *in situ*. Credit: National Museums Liverpool.

**RES Photography Exhibition at Liverpool World Museum**

***Anne Weinhold***, Business Development and Fundraising Manager anne@royensoc.co.uk

Together with partner and supporter Mitie Landscapes, the Society celebrated our community of insect photographers with an exhibition at the World Museum Liverpool. Curated and set up for Insect Week 2025, the exhibition featured a selection of stand-out images from the annual photography competition.

Liverpool Museums Assistant Entomology Curator Josh Boe took the team on a walkthrough of the exhibits, picked his highlight entries and filmed the results, inviting visitors to the Museum's Bug House where the exhibition was housed. It was on display until the 20th July, allowing for more guests to enjoy the special imagery celebrating insects in all their colours, shapes and sizes.

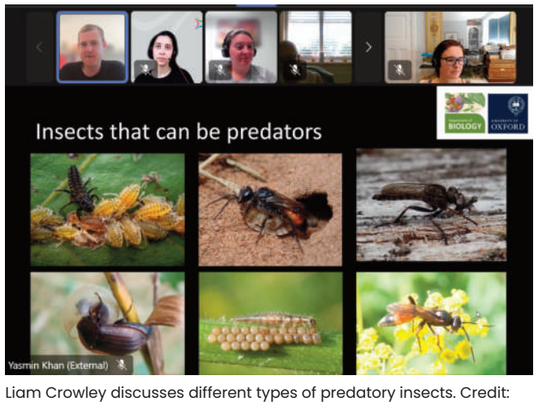
**Webinar for primary schools**
***Fran Sconce***

The Society collaborated with Yasmin Khan at the London STEM Ambassadors hub for a schools' webinar for 7- to 11-year-olds, called 'Nature's hidden heroes - the importance of insects!' on 26th June. Fifty school classes joined the webinar; an estimated audience of 1,500 students.
Fran Sconce introduced the RES and Insect Week, and highlighted opportunities for teachers to get involved with our work, as well as our recent publications *How to be a Ladybird* and *Insectarium Activity Book*.

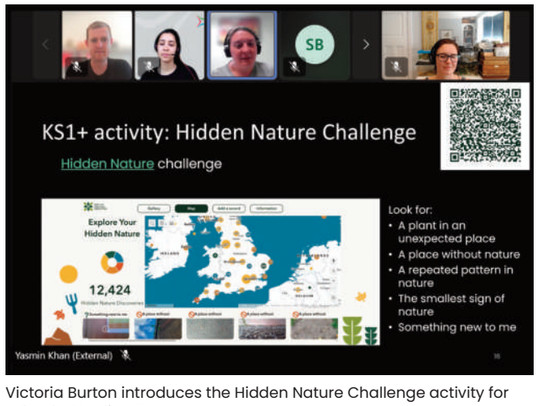
Liam Crowley (Postdoctoral Research Assistant, University of Oxford) talked about the important roles that insects play in the world, and asked questions to the audience such as "can you name three different types of insect that can pollinate" and "how far can a dung beetle roll dung".

Victoria Burton (Postdoctoral Researcher, Natural History Museum, London) introduced the National Education Nature Park project and how schools can get involved, featuring activities such as 'Hidden Nature Challenge', where children are encouraged to find the smallest sign of nature, or a plant in an unexpected place; and 'Pollinator Count', an adapted 'Flower-Insect Timed Count' from the UK Pollinator Monitoring Scheme.

To find out more about our education work, sign up for our education newsletter (https://www.royensoc.co.uk/newsletter/).




Liam Crowley discusses different types of predatory insects. Credit: RES.




Victoria Burton introduces the Hidden Nature Challenge activity for schools. Credit: RES.

### PoMS report published

***Fran Sconce***

Coinciding with Insect Week, the 2025 report from the UK Pollinator Monitoring Scheme (PoMS) was published, highlighting the importance of supporting a wide range of plants and habitats to provide essential feeding and sheltering for pollinating insects. It also revealed several insect species that have never before been recorded in PoMS surveys since the scheme began in 2017, such as Little Blue Carpenter Bee (*Ceratina cyanea*), Variable Nomad Bee (*Nomada zonata*), Golf-club Duckfly hoverfly (*Anasimyia transfuga*) and Variable Pufftail hoverfly (*Sphegina sibirica*). These findings show how valuable citizen science can be in contributing to scientific knowledge.

### Lancaster Mini Zoo and Butterfly House activities

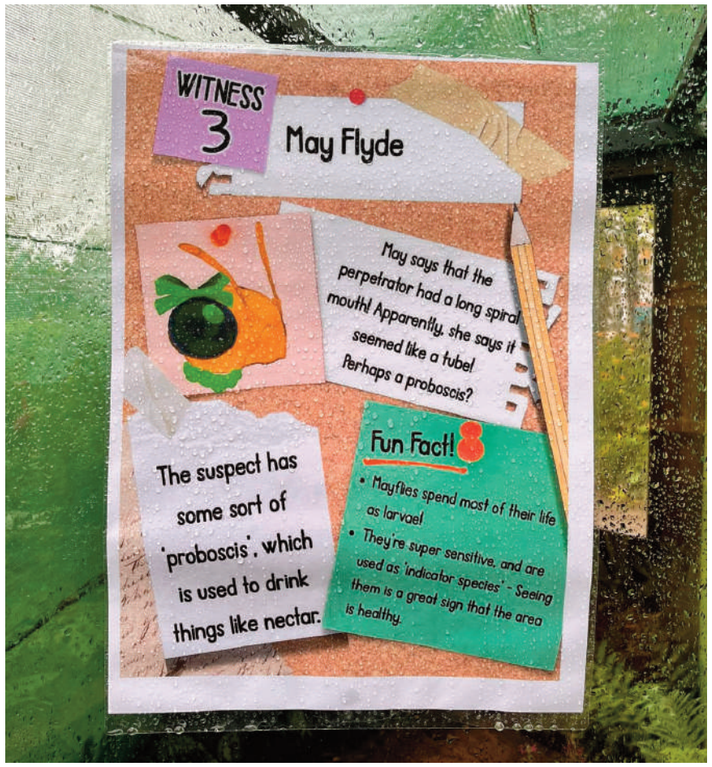
***Jessica Stokes,*** Project Officer
jessica@royensoc.co.uk

Lancaster University undergraduate students brought the world of insects to life for over 300 visitors at the Lancaster Mini Zoo and Butterfly House. Despite a very wet week, their enthusiasm never faltered, and their efforts enriched the public with fascinating insect facts and experiences.

The week-long programme included family-friendly favourites such as 'Mystery at Monarch Manor' (a clue-based trail through the zoo) as well as bug bingo, pond dipping, moth monitoring, and a show-and-tell stall featuring live and preserved specimens. Highlights included an engaging talk by Phil Donkersley on his bee research and 'BeeBox', and a student-led lecture on ants, introducing visitors to the wonders of myrmecology.

The aims were clear: to raise awareness of insect biodiversity, highlight their ecological importance, and inspire the next generation of entomologists. The students more than delivered, with creativity, energy and expert knowledge.

Special thanks to Lancaster Mini Zoo staff, Lancaster Council, Lancaster University students and Phil Donkersley for supporting this valuable outreach.




A clue on Lancaster Zoo's trail. Credit: Jessica Stokes.



Lancaster University students prepare for pond dipping. Credit: Jessica Stokes.







# Standing tall for the small using great big corridor networks

Michael J. Samways
**Department of Conservation Ecology & Entomology, Stellenbosch University, South Africa**
samways@sun.ac.za



**Figure 1.** There are so many insects, with many types of lifestyles, in any one area that we must find ways that conserve them all at their natural levels of abundance. Shown here are the dragonfly *Palpopleura lucia* (Lucia Widow) (left), *Paracilacris periclitatus* (middle), and *Amauris ochlea* (Novice Friar) (right). Photo credits (left to right): Michael Samways, Piotr Naskrecki, James Pryke.

Insects are such a major component in the functioning of terrestrial ecosystems that their conservation is vital. But there are so many insect species that we must ask how we go about conserving them all. We must also bear in mind that all these species need a myriad of microhabitats for finding food, dispersing, mating, laying eggs and growing up to become adults (Fig. 1).

A way forward is to embrace the 'Nature knows best' principle. This is the aim of nature reserves. But what do we do when people and insects compete for the land? One answer is for people who work on the land to team up with those who conserve its wildlife and find a mutually beneficial solution.

South Africa is a megadiverse country, extremely rich not only in insect species, but also in interactions with plants. Many of the insect species and plants are highly localised and often occur only in small areas. This means that the loss of a species from a locality could lead to its extinction. This risk has stimulated management that embraces the 'precautionary principle', where it is best to conserve land and water just in case there are species at risk present somewhere (Fig. 2).

But timber production is important in the country which has few natural wood resources, with plantations covering huge swaths of land. So, here at Stellenbosch University we have been working for many years to find a solution that suits both timber producers and conservationists through working with nature and not against it. The principle behind the solution is to set aside land that separates the plantation compartments, covering about half a million hectares nationally. These set-asides are in the form of networks of large corridors of natural habitat, composed of mostly natural grassland, but also naturally small patches of trees, wetlands and small rivers (Fig. 3).

It is essential, though, to ensure that the corridors are indeed functioning naturally. We have done this by equating the corridors with fully protected areas as a benchmark. We chose insects and other arthropods as indicators because they are numerous, species-rich and show a wide range of lifestyles. They live



**Figure 2.** Certain rare species like *Aethriamanta rezia* (Pygmy Basker) (left) and the highly threatened *Orachrysops ariadne* (Karkloof Blue) (right) are conserved in the conservation corridors. Photo credits: Michael Samways (left) and Shen-Shan Lu (right).



**Figure 3.** The large-scale networks of conservation corridors of mainly grassland are set-aside areas of land among plantation patches. The aim of the corridors is to maintain intact a whole range of ecosystems and their functional connectivity, while preserving landscape heterogeneity. The timber compartments (here, dark green pine trees) are kept back away from wetlands (top left), and away from small rivers (top right) to maintain hydrological processes. The corridors also retain the naturally small indigenous forest patches, with both the trees and the ecotones between the trees and grassland rich in insect species (bottom left). Maintaining landscape heterogeneity involves recognition of topographical features where the mix of vegetation types, rockiness and the highest elevations are retained intact so that insects can freely roam the landscape and engage in hilltopping behaviour to meet mates (bottom right). Photo credits: Michael Samways.

in the soil, and/or are associated with plant canopies, with many species also associated with water bodies. They interact with many other species, especially plants, and in South Africa also with many vertebrates, big and small.

An important factor all along has been that the corridors must be natural remnant ecosystems and as wide as possible. Great width avoids any adverse effects from the adjacent plantation trees, mostly alien pines and eucalypts, while allowing all the interactions and processes to take place as they would naturally. These wide corridors are over 120 m across. This does not mean that narrower corridors have no value, as many natural interactions can still take place and they continue to allow insects to ebb and flow along their length.

Most importantly the corridors are almost all connected to each other. This creates a massive network of natural habitats weaving its way over hundreds of kilometres, and across all types of terrain and elevations, and making up about a third of the overall landscapes. Crucially the networks encompass an enormous amount of landscape heterogeneity. This gives the insects ongoing choices to forever seek optimal habitat, even in the face of climate change. It is what ecologists call 'resilient landscapes'.

Another critical factor is that the natural water systems and soils are maintained intact. This means that the plantation trees are never planted close to streams, rivers or wetlands. An absolute minimum distance is 30 m, but in most cases the plantation trees and water systems are separated by much greater distances. This resilience approach reduces the risks stemming from extreme weather events, whether heavy rainfall or drought. Fire must also be considered as it is a natural phenomenon in the area, preventing the grassland from developing into a bushy landscape.

There are many nuances associated with corridor establishment. Very moist soil is left intact to help maintain natural ground water movement. The interfaces between tree clumps and grassland are also given particular attention, as they support many rare and important insect species. Additionally, big game animals are left to roam as they would naturally, because this helps keep the grass sward in a healthy state, as does fire.

We have investigated many species of insect and other arthropods but, interestingly, butterflies and grasshoppers alone can speak not only for themselves but also for many other species associated with above-ground vegetation. Documenting bush cricket song has also been valuable for making sure that management activity is optimal. In turn, ants and springtails have proved to be good indicators of soil quality. As regards the freshwater systems of









**Figure 4.** Large vertebrates, by standing tall, not only help conservation of insects but also are essential for supporting a wide range of dung beetles. Photo credits: James Pryke and Michael Samways.

all types, dragonflies have been very effective for assessment and monitoring, especially as they are easy to sample and act as umbrellas for many other aquatic insects.

Not surprisingly, there have been challenges with implementation of these large-scale networks of conservation corridors. One has been invasive alien plants. The woody aliens have been dealt with relatively easily, but it is American Bramble that presents the greatest challenge. Recent research using satellite technology and machine learning has identified its invasion path, enabling swift and effective bramble removal to take place.

Local human communities must also be considered. They graze the land with cattle and goats, but ongoing communication and discussion around the risks of overgrazing is resolving many of the issues. Firebreaks have also been implemented to help stop wildfires from entering the plantation blocks. Timber tree harvesting only uses certain transport tracks and is done as sensitively as possible. Poaching of large mammals is strictly controlled, resulting in healthy populations of zebra, elephant, rhino and many others. This is important for insects, as these large animals support a rich variety of dung beetles (Fig. 4).

So, what do the plantation owners gain from setting aside this land? Firstly, as the land and water systems are maintained intact, it makes this forestry practice highly sustainable. Secondly, the main producer of timber and pulp is Mondi, which is regarded internationally as a champion of sustainable forestry. This enables the company to get Forest Stewardship Certification and so can export products to Europe and elsewhere.

The three scientific reviews below summarise the scientific findings to date.

## Further reading

Samways, M.J. *et al.* (2010) *Biodiversity and Conservation* **19**, 2949–2962.
Samways, M.J. & Pryke, J.S. (2016) *Ambio* **45**, 161–172.
Samways, M.J. *et al.* (2025) *Biodiversity & Conservation* **34**, 357–379.













# Welcome to The Ugly Bug Ball!

**Lucy Lewis**
**Sparsholt College**
askhorticulture@sparsholt.ac.uk **(horticulture queries)**
press@sparsholt.ac.uk **(press queries)**

"Welcome to The Ugly Bug Ball!": a statement that was said hundreds, if not thousands, of times during the 2025 RHS Chelsea Flower Show as guests visited the Silver-Gilt winning Sparsholt College garden. Working in collaboration with the Royal Entomological Society, the garden encouraged and educated guests about the less attractive and often unwanted insects in their gardens and aimed to help them understand the wide range of benefits these insects can provide in horticultural settings, from pest control to soil improvement.

The concept for the design was discussed during the 2024 RHS Chelsea Flower Show where many stands seemed to focus their efforts on bees. This posed the question "What about the other bugs?" and coincided with the publication of the Royal Entomological Society's book, *Insects: Discover the Science and Secrets Behind the World of Insects,* written by a team of expert entomologists including University Centre Sparsholt lecturer, Claire Cresswell. The collaboration between Sparsholt College and RES was a natural choice!

Six insect groups were chosen to be showcased: moths, hoverflies, springtails, earwigs, beetles and ants. These insects were selected by the team as they are often misunderstood by gardeners and the students worked with experts from the RES to research facts about them and design habitats especially for them.

The design featured a modern-style building, representing a house, surrounded by a back and front garden with a meadow-style pavement and verge at the front. The back gardens were divided into zones representing different habitats and planting styles.

The hot garden, featuring plants such as *Hemerocallis* (daylilies) and *Iris*, had a bright colour pallet and had been designed for pollinating insects such as



One of Darren Allsopp's insect-friendly sculptures. Photo: Stewart Turkington.

hoverflies. Recycled aggregate between the paving and planting provided burrowing opportunities for insects and invertebrates whilst also being a great sustainable option.

Moths were encouraged in the woodland edge garden, where plants were chosen for their strong scents. A standout addition in this part of the garden was *Philadelphus* 'Petite Perfume' with beautiful scented pink flowers; it was awarded RHS Plant of the Year 2025, and it was a hit with visitors and insects alike. BBC Gardeners' World presenter, Carol Klein, was particularly enamoured with it and it was featured as part of the BBC TV coverage.

To create wildlife corridors, the different zones were linked seamlessly together, as the planting was allowed to be naturalistic and wild in places. The planting styles particularly appealed to Adam Frost, who featured them on Gardeners' World. In total the garden was filmed four times over the course of the week.

Along with TV presenters, the garden was extremely well received by visitors. The strong support each day from the wonderful entomologists from the RES meant we were able to get our message about insects across. Their knowledge and enthusiasm were fantastic and proved to be inspiring and educating for all our guests (as well as Sparsholt staff and students!). In addition to sharing their knowledge, the RES connected Sparsholt with UK Centre for Ecology & Hydrology, who were able to loan us an Automated Monitoring of Insects (AMI) system which was displayed in the garden. Showcasing cutting edge AI technology, the AMI provided a great talking point with guests. Through this, we were able to promote RES Insect Week and encourage visitors to participate in bug counts in their own gardens.

The finishing touch to the garden was the addition of six

bespoke sculptures, one for each of our showcased insects. Designed and built by Hampshire sculptor Darren Allsopp, the insects were made entirely from recycled materials such as cutlery, saucepans and foraged elements from the horticulture department. Each piece had insect habitats incorporated into their design.

As with previous years, the garden was designed and built by current Level 3 Horticulture learners and part-time adult learners at Sparsholt College. This year, 20 learners were involved in the project, providing them with an unforgettable experience. As a team, we have been inspired and fascinated by the things we have learnt along the way, and we hope the collaboration with the RES will be long-lasting.




The team receive their Silver-Gilt medal. Photo: Stewart Turkington.



The Ugly Bug Ball. Photo: Stewart Turkington.





# Spotlight on Ethics: Survey Insights and New Resources

**Jessica Stokes[1] and Bob Fischer[2]**

[1] Project Officer, RES; jessica@royensoc.co.uk
[2] Insect Welfare Research Society, USA

As part of a broader effort to foster best practices in entomological research, the Royal Entomological Society conducted a survey to understand current thinking and practice around ethics in insect research. You might be surprised to learn that around half the universities that responded to our survey expect researchers to submit ethics documentation for their work with insects. This marks a significant shift toward formalising consideration of welfare in entomological research.

But what do researchers think? The results, which will soon be published, provide some thought-provoking insights. Researchers with direct experience of submitting ethics applications, whether mandatory or voluntary, were more likely to view the process as beneficial to research quality. People's views appear to track their career stage, with researchers earlier in their careers seeing ethics as having a more positive effect on research quality. Encouragingly, many expressed interest in more guidance and support on these issues.

In response, the RES will soon be launching a dedicated webpage that will serve as a hub for resources, including links to our new 'continuing professional development' course on insect welfare and our upcoming video series designed to support ethics review panel members navigating insect-related research.

Ento25 included a lively panel discussion on insect welfare in research. For those unable to attend, key outcomes and materials from the panel will soon be available online.

As interest and discussion around this topic continue to grow, we look forward to supporting the entomological community as it pursues research of the highest quality.

Visit the online Insect Ethics hub.

# EDI Committee increases focus on entomology for all

**Anne Weinhold**
**Business Development and Fundraising Manager**

Convened last summer, with representatives from across all RES committees recruited, the EDI Committee has worked closely with colleagues across the RES staff team as well as other RES committees to embed EDI actions and processes into the organisation. Following the creation of the terms of reference, the committee has worked with Council on the development of overarching EDI objectives as well as an action plan which is now going through RES committees for review, discussion and approval. The action plan is key to proactively developing EDI initiatives for every RES committee, with a set timeline and measures of success. Each committee commits to taking action on EDI by, for example, reviewing accessibility at our major events, or showcasing the diversity of our membership in our publications.

The overarching objectives for EDI at RES have been agreed by Council as follows, with concrete actions for RES committees being approved at the moment:

1. Reflect, and encourage greater diversity of our community in the work we do;
2. Improve accessibility of entomological knowledge, and engagement in entomological activity;
3. Make space for minoritised communities to feel supported and less isolated;
4. Gather baseline data so we can ensure measurable results of our actions.

The Outreach Committee has already approved its first action to "review Insect Week activities in 2025 with recommendations for at least two activities in 2026 that ensure greater public engagement in entomology." This will be measured following an evaluation of activities during Insect Week 2025, with proposals for the 2026 event discussed in the committee through an EDI lens.

The EDI committee is also developing a baseline EDI survey to identify any training needs and support further resource development, first for RES committees and, following the results from the initial survey roll-out, the wider membership. The survey will also support the gathering of data from our membership to understand how we can have meaningful discussions around EDI priority areas and support the membership with opportunities to directly engage in further

embedding EDI processes and actions at the RES.

To support our membership with projects and ideas furthering EDI in our community, we piloted a grant in 2024 encouraging applications from our membership. After a review of the pilot, the committee updated the information on the EDI grant webpage and prepared guidelines for assessment of future applications. The 2025/2026 call for applications was launched in early June and was promoted to our membership, including Student Members. The total grant amount available for successful applications is £3,000 this year; however, we hope to recruit a suitable partner for 2026/2027 to raise this to £6,000. A grant panel of EDI Committee members will assess and judge all the eligible applications and come to a consensus view. Funded applicants will receive opportunities to promote their projects to the wider membership.

The recently closed round of applications brought in 13 eligible applications, and we are excited to see the successful projects at work.



## ENTOMOLOGICAL FRSs





It is a pleasure to report that two entomologists are amongst the 95 scientists elected to the Fellowship of the Royal Society this year. One is our former president, Professor Jane Hill OBE, Associate Dean for Research, Faculty of Sciences & Department of Biology, University of York. The other is this year's Verrall Lecturer, Professor Iain Couzin, Director, Max Planck Institute of Animal Behaviour and Professor, University of Konstanz, Germany.

Many congratulations to them both.

THE ROYAL SOCIETY







# Library and Publications

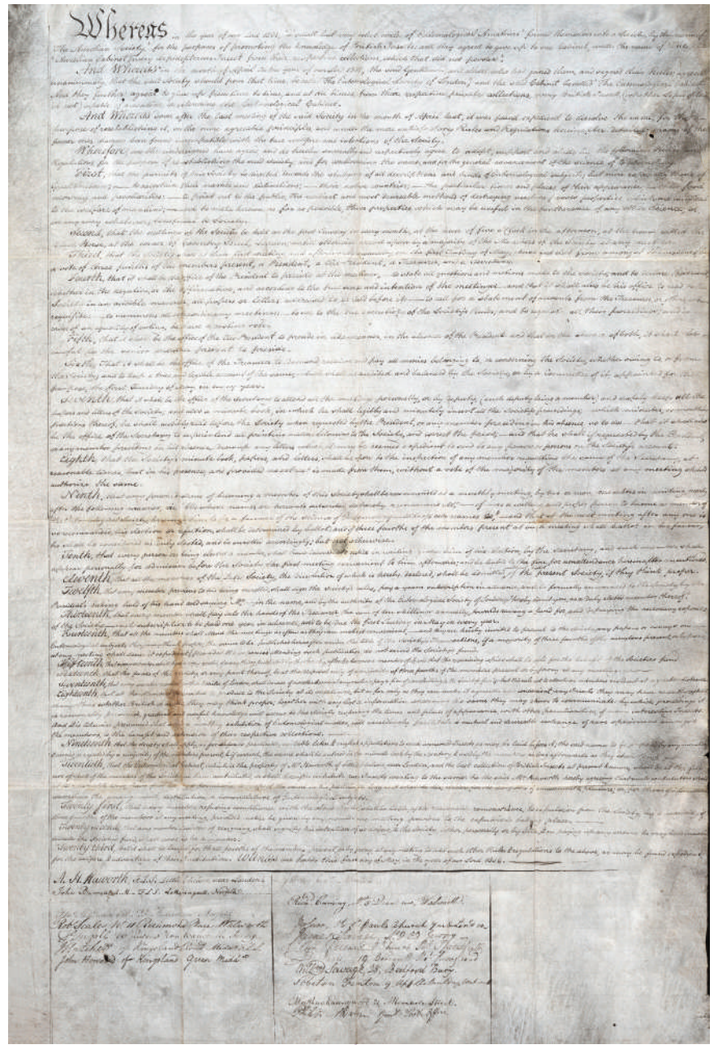
## Treasures of RES Library: The Aurelian Deed

**Rose Pearson**
**RES Librarian and Archivist**

In 1950, a Mr F. Evans discovered a very unusual item in a Clapham bookshop and presented it at an RES Meeting. The document, handwritten on a large sheet of velum, detailing the founding and byelaws of 'The Entomological Society of London' in 1806, is a fascinating insight into the activities of early entomological societies, and came to be known as 'The Aurelian Deed'.

A 'Society of Aurelians' was first recorded in the early 18th century, reflecting the increasing popularity of entomology at this time. The name 'Aurelian', meaning butterfly collector, comes from *aureoles,* Latin for golden, after the golden chrysalises of some butterflies. Notable members included the naturalist and illustrator Benjamin Wilkes, and the then 12-year-old Moses Harris, later author and illustrator of several key 18th century entomological works. The group met in the Swan Tavern, in Bank, London. The Society came to an unfortunate end in March 1748 as a fire swept through the area, destroying the Tavern and the Society's collection of books and insect specimens kept there.

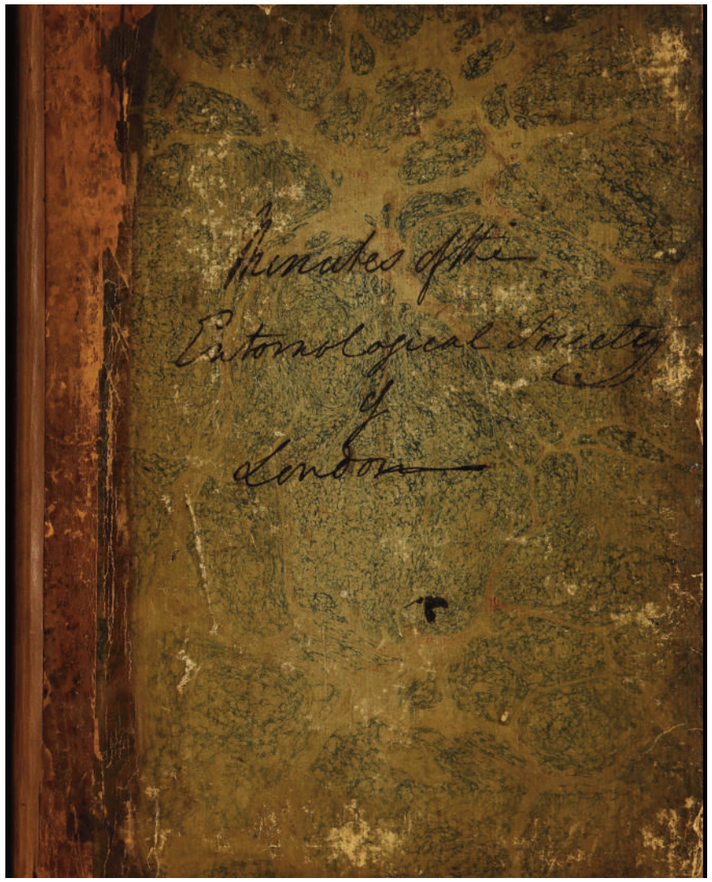
Several short-lived entomological Societies followed, including a second Aurelian Society with Moses Harris as Secretary, formed in 1762, and the 'Society of Entomologists' which lasted from 1780–1782. A third Aurelian Society was founded in 1801, with the aim 'to form a complete and standard cabinet of the entomological productions of Great Britain', known as the 'Aurelian Cabinet'. It was required for members to donate specimens from their collections that were not already held in the cabinet to the society, a somewhat controversial rule that limited membership.




The Aurelian Deed.

It is in this context that, on 1st May 1806, the deed for the foundation of a new Society was created. Seventeen initial members signed their names and gave their addresses.

The document describes how, in 1805, it was agreed to dissolve the




Minute Book of The Entomological Society of London.

third Aurelian Society and re-establish it under "more favourable conditions." The name of the Society was changed to 'The Entomological Society of London' (coincidentally a former name of the RES) and the 'Aurelian Cabinet' was to be known as the 'Entomological Cabinet'. Twenty-three byelaws were outlined. Number eighteen clarified that it was no longer compulsory for members to donate specimens from their collections to the cabinet, although the practice was still encouraged. The Society was to cover multiple areas of entomology, from taxonomy to pest control, with a focus on British insects.

With taverns a perennially popular meeting place for entomologists, the Society was to meet at the Black Horse, near Piccadilly Circus in London, on the first Thursday of each month, at 5 o'clock. To encourage attendance there was a fine of one shilling if local members missed a meeting, although those living more than five miles from London were exempt. New members had to be recommended by two current members and be voted in by three quarters of the existing membership.

The President of the Society, and the keeper of the 'Entomological Cabinet' at his home in Little Chelsea, was Adrian Hardy Haworth. Initially training as a lawyer, a large inheritance allowed him to focus on his passions for entomology and botany. He was the author of the four-volume *Lepidoptera Britannica* (1803–1828), the first work to cover British Lepidoptera in its entirety, which included insects new to science. He was made a Fellow of the recently founded Linnean Society in 1798.

Between 1807 and 1812 the Society published three volumes of the first known entomological journal, *Transactions of the Entomological Society of London.* After 1812, membership declined and only occasional meetings were held.

Following the dissolution of the organisation in 1822, many members remained enthusiastic natural historians and joined other scientific societies including *The Entomological Society of Great Britain*, *The Zoological Club of the Linnean Society* and the *Zoological Society of London*. Such organisations were not confined to the capital, and two members, John Burrell and Thomas Skrimshire, formed the *Entomological Correspondence Club* which met in Norfolk between 1823 and 1825.

The RES itself, then also known as *The Entomological Society of London,* formed in 1833, and Haworth's death from cholera in the same year was noted in the *Proceedings* 'on account of the loss which Science, especially Entomology, has sustained by his lamented decease'. His insect collection was split up and sold, with specimens now held at the Natural History Museum in London and the Hope Entomological Collections in Oxford.

As well as the deed itself, the RES holds several other items relating to the Society, including *Transactions*, a complete set of minutes, records of attendance, accounts and lists of insects desired for inclusion in the cabinet. These and other items from our archive can be viewed in our library in St Albans. Email library@royensoc.co.uk or call 01727 899387 to make an appointment.



Portrait of Adrian Hardy Haworth.





# RES Journal Awards 2024

**Report by Jayne Whiffin**

We are delighted to announce the winners of the Royal Entomological Society Journals Awards for the best articles led by early career entomologists, published during 2024. The winners were selected by the Editors-in-Chief of each journal using set criteria that assessed a wide variety of competencies, such as scientific rigour, excellent writing, and novel insights. There was stiff competition again this year, and several highly commended papers were awarded in addition to the winners. The high number of qualifying papers, plus their quality, indicates that there is excellent work being done by early career researchers: a fantastic indication of an exciting future for insect science.

Congratulations to all our winners!

Read the Virtual Special Issue celebrating our winning articles:
https://resjournals.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)9999-0021.Early-Career-Entomologist-Awards-2024

Agricultural and Forest Entomology — Royal Entomological Society

**Gwenaëlle Deconninck:** Fallen fruit: A backup resource during winter shaping fruit fly communities (**26**(2), 232–248)



Gwenaëlle and her co-authors of this field study show how temporal dynamics of communities of native and invasive fruit fly species developing on unharvested fallen fruits are structured by local and seasonal thermal conditions, habitat composition, and the quality and quantity of the fruit resources.

The judges commented that the article was "very pleasing because the authors explicitly ground their study in ecological theory, their research is hypothesis-driven with complementary statistical analyses, and they illustrate the paper with clear and informative data displays." They added that it was a high-quality paper providing important new insights on how the dynamics of invasive and native fruit fly communities are shaped by natural and anthropogenic factors and the implications for ecosystem function and pest management.

Gwenaëlle's research journey started with an Erasmus internship in 2016 when she was studying nutrition in Lille. After obtaining her nutrition diploma, she decided to go back to university, aiming to become a researcher. She has been involved in diverse research projects. Aside from orchids, she studied the pollination syndrome of *Ceropegia* flowers by small flies, and her thesis was about the trophic and thermal ecology of the pest fly *Drosophila suzukii*, seeking to understand its invasion success.

In this study, she and her co-authors focused on the potential role of fallen fruit as a reservoir for fruit flies (Drosophilidae) when other resources are scarce in autumn and winter, finding that eight species were breeding in apples, including two important invasive species, *Drosophila suzukii* and *Chymomyza ameona*. As the decomposition of apples spans autumn to spring, it allowed niche partitioning, meaning that the decomposing fruit can be used by different species across months. They adapted the hierarchical continuum concept, primarily used in plant communities, to explain the coexistence of these flies. This study sheds light on the important role of unharvested fallen crop fruit in maintaining the diversity of this overlooked insect family. It raises questions on pest management strategies and emphasises the importance of multi-scale studies.

Ecological Entomology — Royal Entomological Society

**Pritha Dey:** A trait-based understanding of the vulnerability of a Paleotropical moth community to predation by a sympatric bat with flexible foraging strategies (**49**(5), 635–646)



This study combines trait-based ecology with seasonal dynamics to explore predator–prey interactions between moths and the Lesser False Vampire Bat (*Megaderma spasma*) in India's Western Ghats. By assessing prey vulnerability at the assemblage level, it moves beyond the typical species-level interactions studied in controlled environments.

The judges called the article an "innovative paper", noting that it "is an excellent case of how a trait-based approach can help to understand the community ecology of predator–prey dynamics." Furthermore, they felt that the insights the winning

article revealed about how predators may be affected by the loss of prey with certain traits provide a valuable basis for future research in community ecology and conservation.

Pritha currently works as the Head of Natural History Collections at the National Centre for Biological Sciences, Bangalore, India. Her research journey began with a focus on the taxonomy and community ecology of moths, driven by a fascination with their immense diversity and ecological roles. Through fieldwork in biodiverse landscapes like the Western Himalayas and Western Ghats, she studied moth assemblages and species distributions across environmental gradients. This foundational work deepened her appreciation for the ecological interactions that shape diverse moth communities.

Her current research integrates functional traits with predator–prey dynamics to examine how bats adapt their foraging strategies in response to seasonal changes and prey availability. This shift bridges her taxonomic roots with broader ecological questions about adaptation, selection and species persistence.

In this article, Pritha and her advisor, Rohini Balakrishnan, investigated moth morphology and seasonal availability to develop a novel framework for predicting predation risk. A multi-year analysis of moth remains from bat roosts, alongside seasonal light trapping, revealed new insights into the bats' dietary preferences and selective hunting behaviour. Findings show that larger, less agile moth species are more vulnerable to predation, with seasonal shifts in prey preference. The research enhances understanding of moth–bat interactions and demonstrates the value of trait-based approaches in ecology. It also provides new insights into how *M. spasma*'s foraging strategies adapt to changes in prey availability and season, laying the groundwork for future research on predator–prey dynamics in tropical ecosystems.

## Insect Conservation and Diversity

**Ashley Darst:** Diversity of bumble bees and butterflies in Minnesota roadsides depends on floral diversity and abundance but not floral native status (**17**(4), 690–701)



Credit: Lindsay Kemmerling.

Pollinators are declining globally, and habitat loss and fragmentation are major contributors. One way to combat habitat loss is to restore land currently unsuitable for pollinators. Roadsides provide a great opportunity for pollinator habitat restoration, with over 10 million acres in the United States alone.

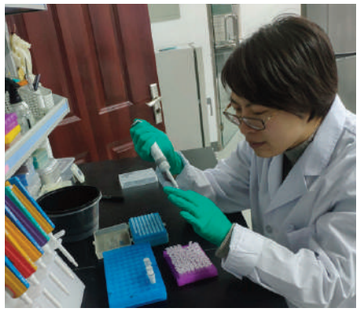
"This is an excellent piece of early career research with solid experimental design and analysis," the judges commented. They added, "The work is especially impressive as it was completed partially at the undergraduate level. The research is a great example of how on-ground collaboration between researchers and land managers can have direct conservation benefits. In this case, the lead author worked closely with their local transport department to link scientific outcomes to management on the ground, resulting in better outcomes for pollinator communities and threatened species on Minnesota roadsides."

Ashley's research focuses on the effects of human-caused changes on pollinators, particularly butterflies. She strives to further our understanding of pollinator declines and how humankind can sustainably coexist with the natural world. She is currently researching whether pollinators prefer sodium-enriched nectar and whether plants with sodium-enriched nectar have a higher pollination rate. These findings will have implications for pollinators using roadsides in which road salts are used as de-icers. She is also researching the lethal and sublethal effects of combinations of pesticides on Monarch butterflies, with the hope to better understand butterfly declines.

In her winning research, she and her co-authors found roadsides supporting many pollinators, including the endangered Rusty Patched Bumble Bee and the Monarch butterfly. Roadsides with greater floral abundance and diversity had greater bumble bee and butterfly abundance and diversity. However, they found similar bumble bee and butterfly abundance and diversity in roadsides planted with high-diversity native seed mixes and low-diversity non-native seed mixes. This is because many native plants never established and unseeded plants colonised the roadsides, likely due to a lack of management after seeding. They recommend planting diverse seed mixes with many flowers in roadsides and budgeting for continued management of pollinator plantings.

## Insect Molecular Biology

**Qianyu He 何倩毓:** Juvenile hormone-induced microRNA miR-iab-8 regulates lipid homeostasis and metamorphosis in *Drosophila melanogaster* (**33**(6), 792–805)



In this study, the authors reveal that the microRNA miR-iab-8, induced by juvenile hormone (JH), plays a pivotal role in regulating lipid metabolism and metamorphosis in fruit flies. They discovered that when miR-iab-8 is overexpressed, it delays development and disrupts lipid storage, which is crucial for successful insect transformation from larva to adult.

The judges said, "This paper investigates the function of a JH-regulated microRNA in lipid metabolism homeostasis and provides mechanistic insights into how JH and microRNA interface to regulate larval growth and metamorphosis. It was chosen for its in-depth mechanistic insights into a broadly important topic."

Qianyu He is a faculty member at Heilongjiang Bayi Agricultural University. Her research focuses on unravelling the regulatory mechanisms of JH in controlling insect metamorphosis, with particular emphasis on its molecular pathways and epigenetic modulation. Building upon these fundamental discoveries, she dedicates efforts to developing novel insect growth regulators targeting this hormone signalling axis, aiming to create environmentally friendly alternatives for pest control. Her work has identified key miRNA that mediate the JH anti-metamorphosis effect during larval–pupal transition, providing new targets for precision insecticide design. Currently, she is leveraging molecular docking techniques to screen natural products derived from traditional Chinese herbal medicine that specifically target the JH receptor and its associated signalling pathways. This innovative approach aims to identify bioactive compounds capable of disrupting JH-mediated insect development, with the ultimate goal of developing novel insect growth regulators for sustainable pest management.

This discovery highlights the intricate relationship between miRNAs, hormones and lipid metabolism in insect development, offering new insights into the regulatory mechanisms governing insect metamorphosis.

## Medical and Veterinary Entomology

**Denise Wawman:** Ornithomya biloba, Pseudolynchia garzettae and Pseudolynchia canariensis (Diptera: Hippoboscidae): three new United Kingdom colonists and potential disease vectors (**38**(2), 160–171)



This study used data collected by the *Mapping the UK'S Flat Fly* project that was set up by the author to document the northward shift of three louse fly/flat fly species (Diptera: Hippoboscidae). The judges noted that the impact of climate change on species of importance to wildlife is crucial, especially as two of the species prefer bird hosts that are long distance migrants (Nightjars, Swallows and Sand Martins) and could import new avian diseases or zoonoses, and the third lives in close association with humans (pigeons). They also noted, "The author was personally responsible for the whole project, which is particularly impressive given that they are still a graduate student. We were especially impressed with the author's analysis, presentation and interpretation of the data."

After ill-health forced early retirement, Denise trained as bird ringer, noticing that the peak in avian pox in Dunnocks followed the peak in flat/louse flies (Hippoboscidae), but discovered there was nothing published about whether they transmit Avipoxvirus. The species' presence and their current UK ranges were also unknown and likely to have shifted due to climate change.

Consequently, in 2020, Denise started the *Mapping the UK's Flat Fly* project and suddenly found herself UK recorder for the Hippoboscidae. In 2021, she started a DPhil at the Edward Grey Institute for Field Ornithology, at the University of Oxford, looking at the changing ecology of louse flies and their role as vectors.

The ecology of many species is changing in response to climate change, but if the new species are parasites, like the louse flies/flat flies, which live on birds and are capable of transmitting diseases, this can be a cause for concern. Amongst the expected louse flies recorded by bird ringers, there were three species that had previously only been recorded as vagrants: the Swallow Louse Fly, the Nightjar Louse Fly and the Pigeon Louse Fly. The presence of these flies on migrant birds, which may bring new diseases into the UK, and amongst the large population of feral pigeons in London, may increase the risk to bird, and possibly to human, health, highlighting the importance of this research.

## Physiological Entomology: How Insects Work - Linking Genotype to Phenotype

**Robert Holdbrook:** The transition from diet to blood: Exploring homeostasis in the insect haemolymph nutrient pool (**49**(3), 227–243)



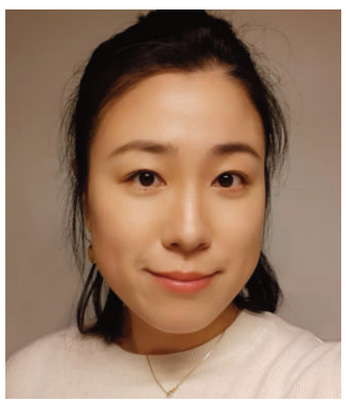
Nutrition is vital to health, but while the link between diet and body nutritional composition is well explored in humans and other vertebrates, this information is not well understood in insects, despite the vital roles they play in ecosystems, and their increasing use as experimental models.

The judges pointed out that the winning article "provides new information on the relationship between diet and nutrition using a polyphagous lepidopteran insect." Furthermore, they found that the research shows how diet can change nutrient levels in the blood, and that protein levels and amino acid composition were particularly affected by diet. They stated, "This is important because these nutrients are often limiting factors for insect fitness. The implications of this allostatic, rather than homeostatic, response to diet in a generalist insect open up questions for future research such as if this is an adaptation for polyphagy, the consequences for fitness, and whether polyphagous insects are better adapted to variation in amino acid levels." Formerly at Lancaster University, Robert is now a director at Thrive Sciences Ltd, and draws on research from his PhD, which focused on providing sustainable alternatives to harsh chemicals and wasteful practices in order to reduce harm to natural ecosystems. His primary interest is in biotechnology and his current focus involves developing biological solutions that tackle the challenges of human-made pollution.

His winning article used nutritional geometry to explore the rapid physiological response to ingested nutrients in the haemolymph nutritional profile of *Spodoptera littoralis* (Cotton Leafworm) caterpillars. The authors asked whether blood nutrients are maintained homeostatically in the face of variable nutritional intake, or if regulation is more flexible for some nutrients than others (allostasis), which allows animals to adapt to stress by responding in a way that prioritises efficiency of responses in the face of trade-offs. Rather than strict homeostasis of blood nutritional properties, an allostatic model seemed to be a better fit for blood nutrient regulation in this generalist herbivore. This flexibility in response to the nutritional composition of the diet may, in part, explain how this species has evolved to extreme dietary generalism and may play a role in its worldwide pest status.

Systematic Entomology — Royal Entomological Society

**Kyung Min Lee:** Complex evolution in thin air: Investigating female flightlessness and diel behaviour in geometrid moths (Lepidoptera) (**49**(4), 596–609)



This article asks the question, 'how do insects survive in extreme mountain environments?' It explores how alpine moths have adapted to life at high altitudes – often above 2,000 meters – where conditions are harsh.

The judges noted that the research integrated molecular, ecological and behavioural data to investigate the adaptive nature of diel activity patterns and female flightlessness in Gnophini, a tribe of geometrid moths, to high-elevation environments, also revising the taxonomic classification of these moths. The paper was selected "because of the innovative evolutionary questions addressed and its significant contributions to understanding how environmental pressure drives insect adaptations."

Kyung Min is a university researcher and Head of the DNA Laboratory at the Finnish Museum of Natural History (Luomus), University of Helsinki. Originally from South Korea, since moving to Finland in 2015 she has focused on integrating genomic approaches into biodiversity research. Her current work centres on Lepidoptera and Hymenoptera, applying tools such as ddRAD-seq and museomics to investigate species boundaries, evolutionary history and environmental adaptation in both extant and historical specimens.

By analysing DNA from 157 moth species found in the European Alps, she and her co-authors discovered that some have evolved unique traits to cope. In several species, females have lost the ability to fly, while others have shifted from being nocturnal to diurnal, taking advantage of warmer daylight hours. Remarkably, these changes evolved independently multiple times over millions of years, suggesting that moths repeatedly found similar solutions to surviving in tough conditions. In some cases, species even reversed course, switching back to nighttime activity after becoming active during the day. This study not only reveals how insects respond to extreme environments but also improves the scientific classification of alpine moths, therefore refining our understanding of their evolutionary history.

**Highly Commended:**
Several Early Career Researchers received Highly Commended awards for their articles: Rebecca Innes, Jakub Špoula and Luca Deganutti (*Agricultural and Forest Entomology*); Samm K. Reynolds and Franciélli Cristiane Gruchowski Woitowicz (*Ecological Entomology*); Stephanie A. Rivest and Serena Magagnoli (*Insect Conservation and Diversity*); Cesar Augusto Diniz Xavier (*Insect Molecular Biology*); Angela Valcárel (*Medical and Veterinary Entomology*); Andrés Taucare-Ríos (*Physiological Entomology*); and Joan C. Hinojosa (*Systematic Entomology*).

Read the Virtual Special Issue celebrating our winning articles:





# Meetings

## Insects in Culture

**20th May 2025**

**Natural History Museum, London**

**By Peter Smithers**
peter@royensoc.co.uk

London tube stations are not usually destinations that inspire a sense of excitement and anticipation, but South Kensington is an exception. It's the gateway to one of the largest natural history collections in the world, so a visit to the Natural History Museum (NHM) is always an occasion to relish. This time, it was the first RES meeting to focus exclusively on the many and diverse links between entomology and the arts.

**How did we get here?**
Back in 2021, Prudence Maltby, Lis and Michael Derby invited a diverse group of artists to make artwork based on an entomological book (described in *Antenna* **46**(3)). These works formed an exhibition that ran in Salisbury Museum throughout the summer of 2022 and was a great success. It was at the closing tea that I realised how enthusiastic this group of artists was, and it seemed criminal to let this enthusiasm dissipate. Working with Max Barclay, a meeting was organised at the NHM where we would have a series of talks from both artists and entomologists in the morning and a tour of the Coleoptera collection in the afternoon. Max gave an outline of his interactions with artists at the museum, I offered a glimpse of how insects had been used by 20th century artists, and Rhea Thierstein and Susan Francis gave talks about their artwork. Last year we repeated the meeting, hosted by Beulah Garner, who offered a tour of the small orders collection.

Having arranged this year's meeting with the help of Erica McAlister (NHM's Principal Curator, Diptera and Siphonaptera), we decided to extend our audience and invite members of the RES. Twenty places were available when an email was sent out at 10am, and by 4pm all of these tickets were gone; a clear sign that entomologists have a keen interest in this aspect of entomology.



Black Arches, by Vikki Rose.

For the 2025 event there were seven 10-minute talks given by artists and scientists.

**Lead, light and Lepidoptera. Vikki Rose**
Moths drew Vikki into entomology when she participated in the Oxford moth project and was introduced to the magical practice of moth trapping. This sparked an interest, which grew into a passion, and she is now undertaking a PhD with UKCEH and the University of Reading, looking at insects in hedgerows. Her other passion is stained glass, which initially focused on the natural world in general but has focused more and more on moths and other insects. She concluded her talk by explaining the painstaking process of selecting and cutting the glass before assembling it with lead strips and soldering them in place. The Oxford moth project had brought moths and butterflies flying into her life and then onto her stained-glass panels, which illuminate the insects that have inspired her.

**Art before science: closely observed insects in 16th and 17th century European painting. Stuart Reynolds**
This talk focused on a number of Renaissance artists (1500–1700) who painted insects, many of



Maria Sibylla Merian.

which were involved in the north European (especially Netherlandish) 'Still Life' movement. Within their combined works, they represented the structure and appearance of insects and other natural history objects (especially plants) with great accuracy, so it's usually possible to determine the species of the insects that they painted. Despite the fact that in these paintings the presence of an insect carried religious messages of death and decay, the artists evidently enjoyed painting insects for their own sake. Artists featured included Joris Hoefnagel, Giovanna Garzoni, Jan van Kessel the Elder, Abraham Mignon and Jacob Marrel. The flamboyant Northern Renaissance superstar Albrecht Dürer was also featured, although he does not quite fit this model, and while Maria Sibylla Merian came from the 'Still Life' tradition, she transcended this by incorporating mostly-accurate new information about the ecology and life histories of the insects that she represented. Despite the fact that Merian was a religious person, there's no hint in her work that insects are symbols of mortality. An interesting artistic theme that ran through this presentation was the importance of artists who had been trained as engravers. Perhaps this craft emphasised the importance of accurate drawing to reproduce insect structures?

**Insect by design: the process behind scientific illustration. Emily Carter**

Emily's passion for insects and wildlife has always been there. As a girl, she wanted to be a biologist but instead decided to channel her love of the natural world into her art. She developed a career as a fabric designer, but always with the natural world as her focus. Her latest project, illustrating the book *Insectarium* (written by Dave Goulson), has reconnected her with entomology. In her presentation, she described the design process behind some of her drawings. Each specimen was initially drawn in black and white, but then it was scanned, and colour was added digitally to give the vibrant and radiant hues that are the hallmark of her work.

Of the day, she commented, "Events like this 'Insects in Culture' meeting are so important in bridging the gap between art and science, I believe that visual storytelling and creativity play such an important role in the way that we engage with natural history".







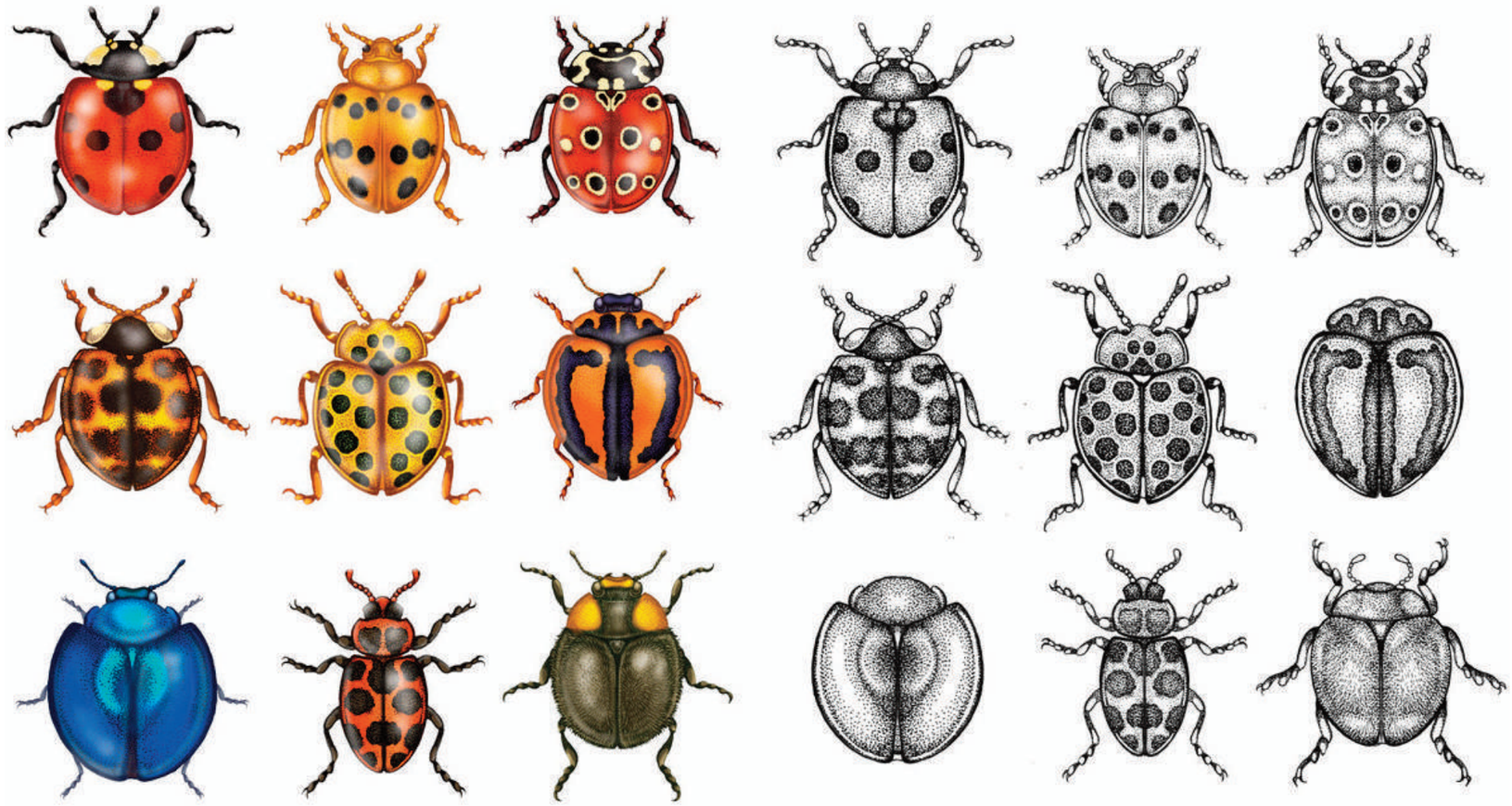


Money spider genitalia, *Lepthyphantes leprosus*.

**Natural complexity in the microcosm: genitalia as art. Peter Smithers**

The natural world is beautiful, complex and often bizarre, but is unappreciated by many. At a time when the natural world faces multiple challenges, it is important to raise public awareness, and art can be a powerful method to generate change.

How can art convey the beauty and complexity of natural systems? Scientists use complex diagrams that are difficult for the public to interpret. Diagrams displaying the relationships between all living organisms are prime examples. Artists such as Carim Nahaboo and Emily Carter have produced wonderful paintings that show the diversity of form and size in insects, while John Walters produces watercolours that capture the complex behaviour of the insects that he tracks in the field. Michael Derby



Ladybirds with and without colour, by Emily Carter.



Dead fly, by Bridget Bailey.

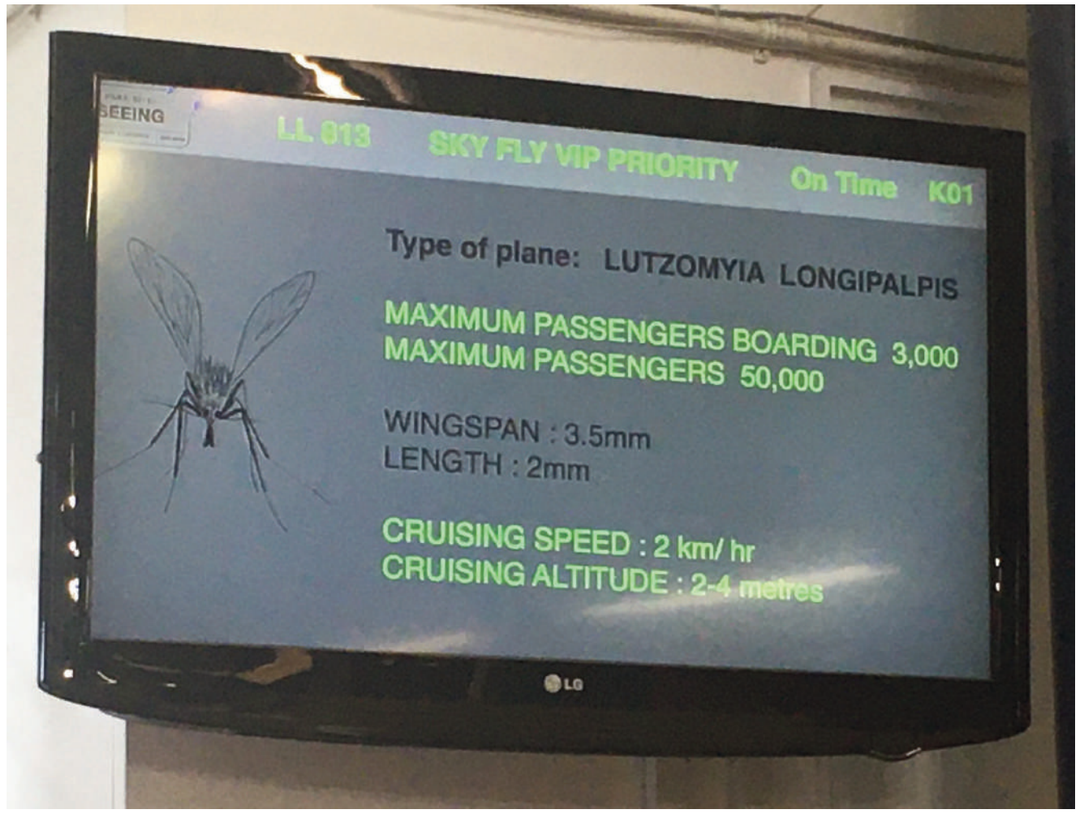


Early trials for the Blue Ground Beetle by KT Yun.

produced images of beetles' faces and presented them at a human scale. These images revealed the microscopic detail and curious morphologies of faces that were previously unknown to a wider public but represent just one aspect of natural complexity. I then came across the drawings of Frank Nelson Pierce, an authority on the genitalia of Lepidoptera. Having drawn a vast number of these, he saw in them beauty, as well as a means to identify a species. So, he added colour and sent these drawings as Christmas cards to friends and relatives. Having spent my career looking at the genitalia of spiders, this was a 'road to Damascus' moment. The genitalia of male spiders are exquisitely complex; they definitely pose a discrete charm and are always very strange. Could these present a unique vision of the natural world that would arrest the gaze of a viewer? Can a technical drawing be transformed into a vibrant and engaging image that encapsulates the beauty, complexity and strangeness of the








Airport lounge installation, by Rod Dillon.

natural world? I tentatively offered my attempts to a room full of artists. Many artists focus on whole invertebrates as their muse but, viewed at the microscopic level, details of invertebrates can offer artists a galaxy of exciting opportunities.

**Diptera with a twist: flies from the wire. Bridget Bailey**
Bridget talked about the process involved in making the delicate representations of insects that are her hallmark. Trained as a milliner, she brings a range of unusual skills to bear on her work that results in a delicacy and ephemerality unique to her. She also discussed her outreach work with schools to enable children to build insects from cardboard packaging and old tools (which make wonderful mouthparts).

She commented, "What can art and craft bring to our understanding and appreciation of insects? Making a dead fly with iridescent fibres, peacock feathers, wire and time-consuming delicacy can encourage people to lean in close and be curious about something they might not notice or go near in reality, that gives a tiny window of opportunity to inspire people to notice and appreciate the small things in nature".

**The Blue Ground Beetle: a journey in glass. KT Yun**
KT Yun is a glass artist and educator. She grew up in a remote area of Scotland where the natural world was her playground and encounters with the local insects led to a lifetime's fascination. After attending art school in Farnham, she was introduced to hot glass and has worked with it ever since. Combining her love of glass and insects, she decided to model an iconic species, the rare Blue Ground Beetle (*Carabus intricatus*), a nocturnal slug predator only found in the remnants of ancient woodlands in South-West England. KT was awarded a scholarship from The Queen Elizabeth Scholarship Trust to study and learn techniques that would enable her to create a large study of the Blue Ground Beetle, using solely glass as her medium. Anatomically correct sections of the beetle are under construction and the completed work will appear in an exhibition in Bath in February 2026.

**Challenging perspectives: insect-centred art in an anthropocentric world. Rod Dillon**
During the past 20 years, Rod has developed an arts portfolio based on his experience as a research scientist studying insect microbiology and parasitology. In his presentation, he described work collaborating with academic and freelance artists, and also his own art commissions. Rod's work is centred on exploring non-human perspectives. For example, his airport lounge installation presents air travel from the perspective of a sand fly, showing how it accidentally stows aboard aircraft and is dispersed. His presentation showed examples including art performance and installations in art galleries, and discussed issues raised when working across diverse disciplines.

**Fantastic flies. Erica McAlister**
Erica's talk was a walk along a fly's body. Beginning at the head, she revealed the many complex, unlikely and bizarre aspects of dipteran morphology and behaviour as she voyaged along the thorax and abdomen, explaining what these weird and wonderful structures were used for: eyes on stalks in the Diopsids to curious antler-like structures that erupt from the heads of some of the Tephritidae; no mouthparts at all to the great chitinous swords of the stable flies (*Stomoxys*); flies with no wings to the Tephritidae with highly patterned wings that present an image of a spider to deter predators.

Everyone then adjourned for lunch which many took in the recently opened museum garden. Sitting in the sunshine, the morning was discussed and plans for the future formulated.

**Tours**
Delegates could select one of the two tours that were on offer, either the Diptera with Erica or the Lepidoptera with Alessandro Giusti (a curator within the Lepidoptera section). Each of the tours could only accommodate ten people so each tour was repeated to accommodate all the delegates.

**Lepidoptera tour, with Alessandro Giusti**
There are over 30 million specimens belonging to the class Insecta in the Museum's stores. Alessandro shared these wonders by showing part of this vast collection from the order Lepidoptera, from the collection stored inside the famous cocoon-shaped Darwin Centre of the Museum. Here, groups were presented with an attractive exhibit of display drawers of the major groups of Lepidoptera, and of some art works inspired by insects. Alessandro talked about his work as a curator, highlighting the various projects he is involved in, and how nature has often served as a powerful stimulus for artistic creation throughout history.

Alessandro noted, "Insects, in particular, thanks to their astounding diversity of forms and behaviours, unusual and bizarre colours and patterns, and the symbolic significance they hold across cultures, can be a strong source of inspiration for many artists."

**Diptera and Siphonaptera tour, with Erica McAlister**
The tour began with a visit to the Rothschild collection of fleas, a small alcove that houses elegant wooden cabinets containing thousands of glass slides on which fleas are mounted. Erica explained how Charles Rothschild had amassed the collection and then his daughter Miriam had catalogued it, producing the definitive work on this group of insects.

Moving to the Diptera lab, Erica introduced wax models of a sand fly, *Drosophila* and the life cycle of the House Fly (*Musca domestica*), which presented Diptera at a human scale. Erica then passed around a range of curious flies ranging from the pure white furry bee fly to a jar of botfly larvae found only in rhinoceroses (probably one of the rarest insects in the world; see also page 167).

**Discussion**
The company then adjourned to the lecture theatre to discuss the future. Did the audience want more days like these? A resounding 'yes'. A discussion followed as to how this might be achieved, and the consensus was to explore a repeat of the meeting next year at the NHM. There was a brief discussion amongst the artists regarding the organisation of the Bath exhibition and the meeting closed in anticipation of many more days exploring the links between entomology and the arts.



Diptera tour with Erica McAlister.






# Obituary



## Prof. Christopher Peter Haines
### (1946–2025)

**BSc, PhD, CBiol, MRSB, Hon.FRES**
**RES President, 2002–2004**

**By Rick Hodges**

Professor Chris Haines was a postharvest entomologist who served as President of the Royal Entomological Society (2002-2004) and was elected Honorary Fellow in 2010. After being unwell for some time, he passed away in hospital on 24th May 2025 surrounded by his family.

Chris's first love was entomology, and he self-funded his PhD on ground beetle ecology at the University of Southampton. This involved spending much time at the crack of dawn emptying pitfall traps in the New Forest. In 1971, with this entomology background, he was recruited by the Tropical Stored Products Centre (TSPC). This was a unit of the scientific civil service under the Tropical Products Institute (TPI) serving British overseas development programmes with training and research on the preservation of durable stored products in the tropics. Chris's appointment marked changing times, as did most of his career, as fully trained scientists were now being recruited directly from universities to replace staff who had learnt their trade on the job, often as colonial district officers. His early projects focused on alternatives to the conventional control of pests with insecticides and fumigants. In particular, he spent time in Kenyan and Nigerian maize stores investigating the use of pheromones, synthetised by his colleague David Hall of TPI's Insect Products Section, for the control of the moth *Ephestia cautella* by mating disruption and the potential for the predatory mite *Blattiscous tarsalis* to limit moth populations by consumption of their eggs. These types of studies defined TSPC's Pest Biology and Inspection Section of which Chris subsequently became head. TSPC was located near Slough on the same site as the Ministry of Agriculture's Pest Infestation Control Laboratory, that had been led by Dr Alec Parkin, and Chris clearly had time to become fully acquainted with the social scene as he married Linda, the old boss's daughter.

It was during further recruitment of staff that I first met Chris, across the table of a civil service appointment board. Luckily for me, on the coffee table in the waiting room had been a newsletter describing Chris's work on *Ephestia* control, so I was well primed to ask questions at the end of the interview. Subsequently, working with Chris, I got to know him better as in those days a visit to the pub on Friday lunchtime was *de rigueur* and Chris always insisted on driving there in his Triumph Spitfire, open top if possible. Besides the research aspects of the job, there were opportunities to contribute to TSPC's training programmes for grain industry professionals for which Chris created teaching units on pest identification and biology. To enliven these teaching units, we commissioned a set of large-scale models of storage pests from model makers at the Natural History Museum, who benefited from their new insights into insect anatomy by incorporating them into the creatures in the 1982 movie 'Dark Crystal'. To accompany the courses, we also developed a training manual that Chris subsequently edited and published (Haines, 1991). This manual has served as a primer for those interested in the identification and biology of storage pests in the tropics and is possibly still in use to this day, although now out of print.

Interestingly, it was the bostrichid section of an early edition of this manual that in 1980 enabled Isiah Magizini to identify a beetle pest that was devasting farm-stored maize in Tanzania. This pest was being called a large strain of Lesser Grain Borer (*Rhyzopertha dominica*) but with the new manual Isiah was able to identify it as a meso-American endemic, the Larger Grain Borer (*Prostephanus truncatus*). This discovery set in train a whole new chapter of stored products entomology as the Larger Grain Borer spread out across Africa.

The philosophy of TSPC was that its staff should have direct experience of the practical problems that they were trying to solve, and this translated into an expectation that its officers would serve extended periods overseas, although Chris never really relished the working conditions associated with life in the tropics. A suitable position for Chris's academic skills arose at BIOTROP (the Southeast Asian Regional Centre for Tropical Biology) based at Bogor in Indonesia, its most illustrious resident being Sir Stamford Raffles while governor of Java in the early 19th century. So, in 1979, Chris put his beloved Spitfire on blocks, vacated his house and moved with his family and a second set of large-scale insect pest models to Bogor for five years. The appointment was a supporting role to TSCP's long-term involvement with Indonesia's rice marketing board BULOG. Chris was now in a position to develop teaching programmes for BIOTROP students and research activities on storage arthropods with his field assistants, Rennie Roesli and Rafael Pranata. The research involved the use of a Land Rover specially converted as





**Figure 1.** Storage pest identification in Indonesia with Chris Haines and Rennie Roesli - (left) a mobile identification lab in a converted Land Rover, (right) a teaching lab for use at BIOTROP complete with anatomically accurate insect models. On display at the front is a model of the anthribid beetle *Araecerus fasciulatus*.

a field lab for insect identification, with which he toured Java and Sumatra. From this work he was able to demonstrate a much wider insect fauna in rice stores than had previously been expected. At other times, he undertook field trials in local BULOG storage facilities. One thing to come out of these studies was an understanding that psocids (mostly *Liposcelis* spp.) generate enormous populations in tropical rice stores with cascades of these tiny insects streaming off surfaces and onto your skin, which is very unpleasant in a hot, humid climate not to mention unhygienic in food stores. This was almost certainly associated with poor quality phosphine fumigations that fail to kill phosphine-tolerant psocid eggs rather than poor storage conditions that had hitherto been the explanation for this. Subsequently, this inspired Rennie Roesli to investigate similar problems of psocid infestation in the Australian grain industry for her PhD.

In 1984, Chris returned from Indonesia to take up senior roles in an environment that was fast changing for government research institutions. Mergers with scientific units serving the British overseas development programme, including the Centre for Overseas Pest Research, led to the formation of an institute with fairly regular name changes, eventually settling on the 'Natural Resources Institute' (NRI). Its constituent parts were all relocated in 1990 to The Chatham Historic Dockyard where the Tropical Stored Products Centre, after several name changes, became what is nowadays called the 'Food and Markets Department', of which Chris became head in 1992 when it was called the 'Grain Technology Department'. This gave him his first experience of managing multidisciplinary teams focused on postharvest technology. Then, in 1996, as part of Margaret Thatcher's 'Next Steps' policy reform of the civil service, NRI was transferred into the university sector under the University of Greenwich. The university moved some of its departments alongside NRI to establish the Chatham Campus. These were stressful times requiring frequent reorganisation but at the same time NRI had new opportunities now that it was no longer bound by the civil service. Chris capitalised on this, leading to the award of The Queen's Anniversary Prize in the year 2000, for 'Food security in the developing world: practical projects, education and training' that particularly cited NRI's work in Africa on the Larger Grain Borer and Armyworm. But the financial constraints of relying on funding from British aid sources finally got the better of NRI so that Chris, and many of his colleagues, were obliged to accept voluntary severance in 2001. Nevertheless, Chris turned this setback into an opportunity and was elected President of the Royal Entomological Society in 2002. His tenure of this prestigious position was a great success and especially notable for the launch in 2004 of National Insect Week (now Insect Week) at the Natural History Museum with Kate Humble of Springwatch fame. Insect Week is now a well-established annual event in late June; it is a 'celebration of all things insect', indeed Chris was a man celebrating all things insect, a fitting epitaph.

Besides entomology, Chris had a passion for family history, was a keen and excellent cook, and a lover of music of all kinds. He is survived by his wife Linda and daughters Sophie and Andrea.

## Reference

Haines C.P. (Ed) (1991) *Insects and Arachnids of Tropical Stored Products: Their Biology and Identification (A Training Manual)*. Natural Resources Institute, Chatham, UK, 2nd Edition. pp. 246.





# Obituary

# Charles Frederick Dewhurst

**29 August 1946 – 07 March 2025**

**Mark Collins**
**President, Swallowtail & Birdwing Butterfly Trust**

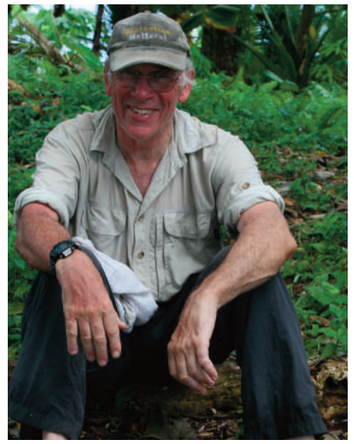
Charles Dewhurst, who recently passed away at the age of 78, was a Fellow of the Royal Entomological Society from 1980 to 2023 and enjoyed an enviable career as an international entomologist. It has been heart-warming to see the exploits and labours of a member of our profession so well covered in broadsheet obituaries as well as online.



Growing up on a farm in Devon, Charles developed an interest in nature, discovering now-eradicated warble-fly maggots (*Hypoderma bovis*) in the backs of cows. His fascination with these gruesome parasites later inspired him to choose the email address *Gyrostigma*, one species of which, the largest adult fly in Africa, parasitises the alimentary canal of rhinoceroses and is, unsurprisingly, a rarity. Some species from Asian rhinos may already be extinct. Charles's working life began as a lab assistant at the Anti-Locust Research Centre in Kensington, but soon led him to Africa, where he worked for the East African Agriculture and Forestry Research Organisation (EAAFRO) in Nairobi, co-authoring the *African Armyworm Handbook*, and in Pretoria, where he assessed dung beetles for introduction to Australia and beyond.

A keen interest in conservation paralleled Charles's career in pest management. As a member of the IUCN/SSC Grasshopper Specialist Group, he co-described the male of the giant stick insect *Eurycantha portentosa* from PNG's eastern islands, and it was his experience in PNG that led to a love for Queen Alexandra's Birdwing (*Ornithoptera alexandrae),* the largest and one of the rarest butterflies in the world.

In 2017, Charles helped establish the Swallowtail and Birdwing Butterfly Trust (SBBT) to set up on-the-ground conservation projects, becoming its first Secretary. He had become intimately familiar



with Queen Alexandra's Birdwing while working as the entomologist at PNG's Oil Palm Research Association, which includes a focus on sustainability in its remit and aims to protect species such as birdwings from deforestation. Charles co-authored *Queen Alexandra's Birdwing Butterfly: A Review and Conservation Proposals*, which helped raise funds for an ongoing captive breeding facility in Popondetta. Prints of a fine painting of Queen Alexandra's Birdwing are available through SBBT, with a generous contribution dedicated in Charles's memory to the Queen Alexandra's Birdwing project.

Charles Dewhurst is survived by his wife Lindsay, their son Rob and daughter Anna.

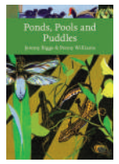


Royal Entomological Society

# Antenna Reviews

If you wish to recommend a book for review, please contact: antenna@royensoc.co.uk.

The following reviews have been added to the *Antenna* website:
*www.royensoc.co.uk/publications/book-reviews/*




**Ponds, Pools and Puddles (New Naturalist, 148)**
Jeremy Briggs & Penny Williams
Published by Harper Collins
ISBN 9780002200851
Reviewed by Arron Watson



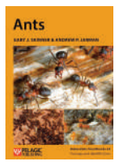

**Biology, ecological importance and diversity of southern African Insects**
Clarke H. Scholtz & Hennie de Klerk
Published by Protea Book House
ISBN 9781485311294
Reviewed by Malcolm Scoble




**A Naturalist's Guide to the Butterflies & Moths of Aotearoa New Zealand**
Carey Knox
Published by John Beaufoy Publishing
ISBN 9781913679668
Reviewed by Richard Harrington




**A Naturalist's Guide to the Butterflies of Hong Kong**
Jason Mann
Published by John Beaufoy Publishing
ISBN 9781913679477
Reviewed by Richard Harrington




**Ants (Naturalists' Handbooks, 24; 2nd edition)**
Gary J. Skinner & Andrew P. Jarman
Published by Pelagic Publishing
ISBN 9781784273040
Reviewed by Juliet Turner




**Fungus gnats (Diptera: Mycetophilidae, Mycetophilinae)**
*Handbooks for the Identification of British Insects Volume 9 Part B*
Peter Chandler
Published by Royal Entomological Society / Field Studies Council
ISBN 9781910159071
Reviewed by Richard Lane




**Exmoor (New Naturalist, 150)**
Flemming Ulf-Hansen
Published by HarperCollins
ISBN 9780008380717
Reviewed by Kenneth Thompson







# EVENTS

Details of the meetings programme can be viewed on the Society website (www.royensoc.co.uk/events) and include a registration form, which usually must be completed in advance.

Offers to convene meetings on an entomological topic are very welcome and can be discussed with the Chair of the Meetings Committee (richard@royensoc.co.uk).

**October 2025**

Thu 9 — 9 October
**Insects as Food and Feed SIG**

Mon 13 — 13-17 October
**XII International Symposium on Aphids** (external event)

**November 2025**

Wed 5 — 5 November
**Orthoptera SIG**

**December 2025**

Mon 1 — 1 December
**Irish Entomologist's Meeting**

**February 2026**

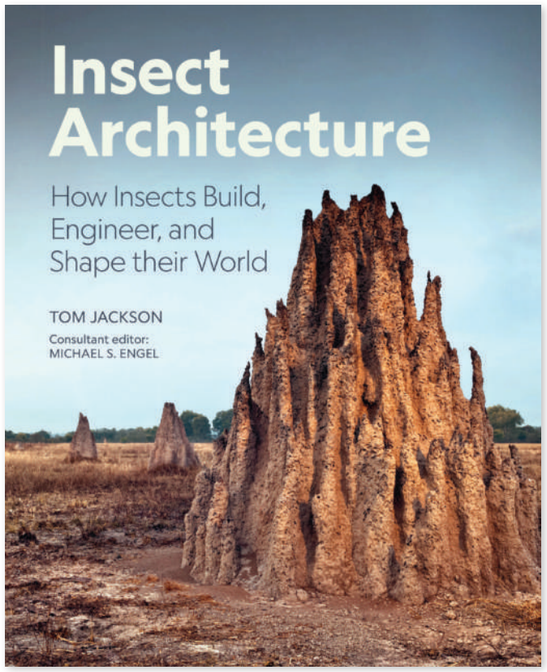
Tue 10 — 10 February
**Behaviour SIG**

Thu 26 — 26 February
**Aquatic Insects SIG**

**June 2026**

Mon 29 — 29 June-3 July
**XIII European Congress of Entomology** (external event)

**For full details on all RES meetings please visit**
**www.royensoc.co.uk/events**




**The essential illustrated guide to the ingenious techniques that insects use to construct an astounding array of natural structures, from nests to shelters to traps**

- Features a wealth of color photos, explanatory diagrams and blueprints, step-by-step sequences, and visual spreads
- Covers all major groups of insect architects and the broad array of structures they build
- Profiles the insect world's most accomplished builders—from beetles, bees, and cicadas to moths, wasps, ants, and termites

PRINCETON UNIVERSITY PRESS




RES members are eligible for a **50% discount on all RES books**. Discount code available via the Royal Entomological Society.

**cabidigitallibrary.org/res**