Antenna

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Royal Entomological Society

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Exploring Butterflies in Gua Tempurung: The first and not the last

STOP PRESS:

Congratulations to Professors Christopher Jiggins and Jane Memmott, who were recently named as Fellows of the Royal Society.

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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).

Cover Picture: 'En garde': Dark-edged Bee-fly, *Bombylius major*, by Peter White.

Editorial

In this issue of your favourite magazine, Stuart Reynolds discusses insect declines and their significance for ecosystems, while Jane Phillips reviews how, to paraphrase the 43rd US President, 'the human being and insects can co-exist peacefully' in agricultural settings.

Meanwhile in horticulture, this year's Chelsea Flower Show benefits from an RES Garden, which features a laboratory to study the numbers of insect visitors. The RES Garden will be transplanted to a permanent location after the show, and some of the key people involved are interviewed on page 99.

There is much more to be said about RES activities, now based increasingly on our Grand Challenges (see the President's letter on page 58, and a further summary on pp. 88–89). These range from governance to outreach and include a report on last year's Insect Week, something that is once more imminent. The winning entries in the Student Award competition appear in this issue, as do the amazing winning photographs in the 2022 photo competition.

In the first of a regular feature on the Library, Rose Pearson invites us to come to see the treasures of the RES archive, where our oldest book dates from 1609. This issue also features another new, regular item to which everyone can contribute. Richard Harrington explains all on page 76. Please do consider contributing.

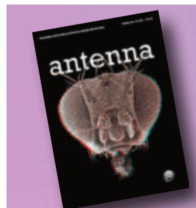
Haziq and Phon review efforts to survey the butterflies near the Tempurung cave, in Peninsular Malaysia, while Richard Harrington has been to see Alice Holt – no, not a person, but the longstanding Forest Research station in Surrey, where several entomologists abide. There are also summaries of our two most recent monthly online meetings (free for RES members to attend) as well as of the Verrall Lecture, supplemented again this year by the Young Verrall, organised in association with the Amateur Entomologists' Society.

Roger Morris, in an Opinion Piece, provides food for thought in questioning some of our assumptions – in this case to do with pollinators. Is there too much emphasis on their pollinating activities, and not enough on other aspects of their relationships with particular foodplants during their lifecycles?

Finally, it is worth noting that two articles had to be held back from this issue, and one article only briefly summarised (though a full copy is available by e-mailing the Society at info@royensoc.co.uk). This was entirely due to space constraints, but the continuing richness and diversity of submitted articles is much appreciated.

Enjoy the good weather.

Dafydd Lewis



Antenna
Index and online copies

Index

All articles, correspondence, obituaries and meeting reports published in *Antenna* from 1977–1983 and from 2002 onwards are indexed and can be searched within the library catalogue, Heritage Cirqa. Issues from 1984–2002 are currently being indexed. You no longer need to log in to view the catalogue. To search the indexed articles, visit http://heritage.royensoc.co.uk, select the 'Advanced' 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.

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Antenna

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

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

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Letter from the President

I hope that by now you have all read the paper 'Grand challenges in entomology: Priorities for action in the coming decades' that has recently been published (Luke *et al.*, 2023). This is an important paper for the Society, which sets out the 'Grand Challenges' that we need to address as insect scientists, currently and in future. The paper is published open access in one of our Society's journals – *Insect Conservation and Diversity*. It represents a huge effort by everyone involved, particularly by the lead authors, and it reports on the findings that took a very inclusive approach to gather and prioritise the insect challenges. The multi-stage process started by asking all RES members (1,598 people, from across 51 different countries) to submit their suggested Grand Challenges, which were then grouped into several themes before being prioritised. The outcome of this process over many months resulted in a total of 61 priorities that were grouped under 11 topics within four broad themes:

These four broad themes are:

- Engagement – collaboration, engagement and training
- Curiosity science – fundamental 'pure' research
- Conservation – anthropogenic impacts and conservation
- Human-insect relationships – uses, ecosystem services and disservices.

This is a great paper for setting the scene for the entomological challenges we face, that I am sure we will be referring back to for many years to come and will inspire us in our entomological activities. As the Abstract of the paper notes: "…the challenges provide a diverse array of options to inspire and initiate entomological activities and reveal the potential of entomology to contribute to addressing global challenges related to human health and well-being, and environmental change".

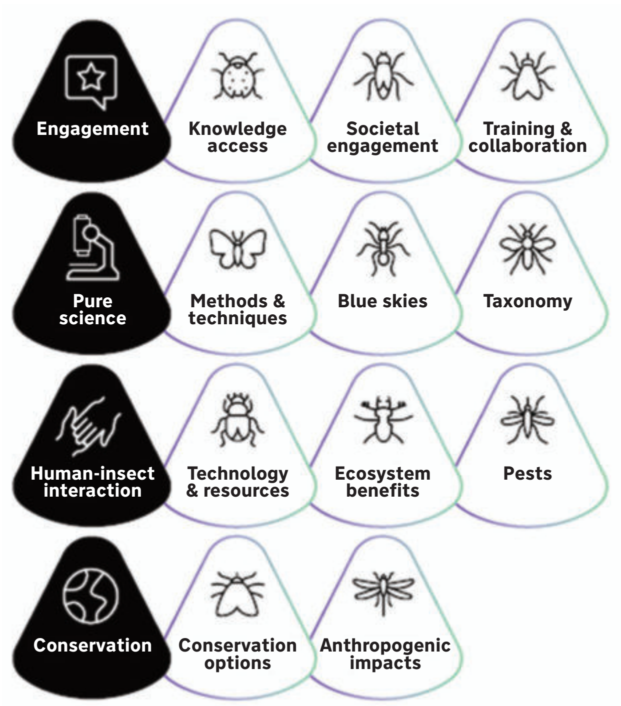
The paper is based on the submission of ideas involving nearly 200 participants and 54 of us are authors of the paper - I am proud to have been involved. My huge thanks to everyone involved, but particularly Sarah Luke and Lynn Dicks who ensured that the project was completed and published successfully. For those of us who were fortunate to know Prof. Simon Leather, it is lovely to be able to dedicate the paper to him "as a heartfelt tribute to his incredible contributions to entomological research, higher education and public engagement". I'm sure Simon would have been delighted to see the paper in print, and published in the Journal that he successfully helped to launch.

This is a lovely time of year in the UK; we have just passed the spring equinox as I write this and insects that have been dormant over our northern hemisphere winter are now starting to be active. We can look forward to interacting with insects, whether that is while we relax in our gardens and local parks, visit our local nature reserve, or out and about where we live and work. It's also great to look forward to the Society's activities this summer, such as RHS Chelsea Flower Show in May in London, RES Insect Week 19th–25th June, and #Ento23 annual meeting in Falmouth in September. Check the RES web site for all our upcoming events – I hope you can attend, and I look forward to seeing you.

Reference

Luke S.J. *et al.* (2023) *Insect Conservation and Diversity* **16**, 173–189. DOI: 10.1111/icad.12637

Grand Challenges in Entomology



Jane Hill
President
Royal Entomological Society

RESEARCH SPOTLIGHT

Insect declines and ecosystems

Insect declines are real, and we urgently need to know more about them

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

Declining insect numbers, biomass and diversity

Over the last twenty years a steady trickle of scientific papers has reported that there are fewer insects than there used to be. In the past six years, that original drip-feed of evidence has become a flood, confirming that although not all insect species are declining, many are indeed in trouble (Wagner, 2021; Wagner *et al.*, 2021). I have written about this subject before (Reynolds, 2019a; 2019b), and I make no apology for doing so again. I think that it is fair to say that there is now a consensus among entomologists that insect declines are real, and we urgently need to know more about them.

Despite the fact that the evidence for declining insect populations had been building up for years (see Leather, 2017), there was initially considerable scepticism among insect ecologists that the apparently large decreases being reported could be real. Insect populations are notorious for fluctuating considerably from year to year and in some early studies of declines, data were based simply on pairwise comparisons between samples taken years apart. Experimental design and methods of analysis were hotly debated by insect population biologists, and it was widely agreed that specially designed long-term studies were needed (Thomas *et al.*, 2019; Didham *et al.*, 2020).

But rather to everyone's surprise, it has turned out that a great deal of data could be mined from long-term monitoring programmes designed for other purposes, which had already been under way for years. When the results of 166 separate long-term studies at sites widely distributed over the globe were synthesised in 2020 (van Klink *et al.*, 2020), there was indeed evidence for a significant widespread decline in terrestrial insect abundance of on average about 0.9% per year. A more recent survey has estimated rates of decline to be slightly higher than this, at rates of between 1 and 2% per year (Wagner *et al.*, 2021).

The declines are, however, very uneven. Even within the same environments, populations of some species have indeed waned, while

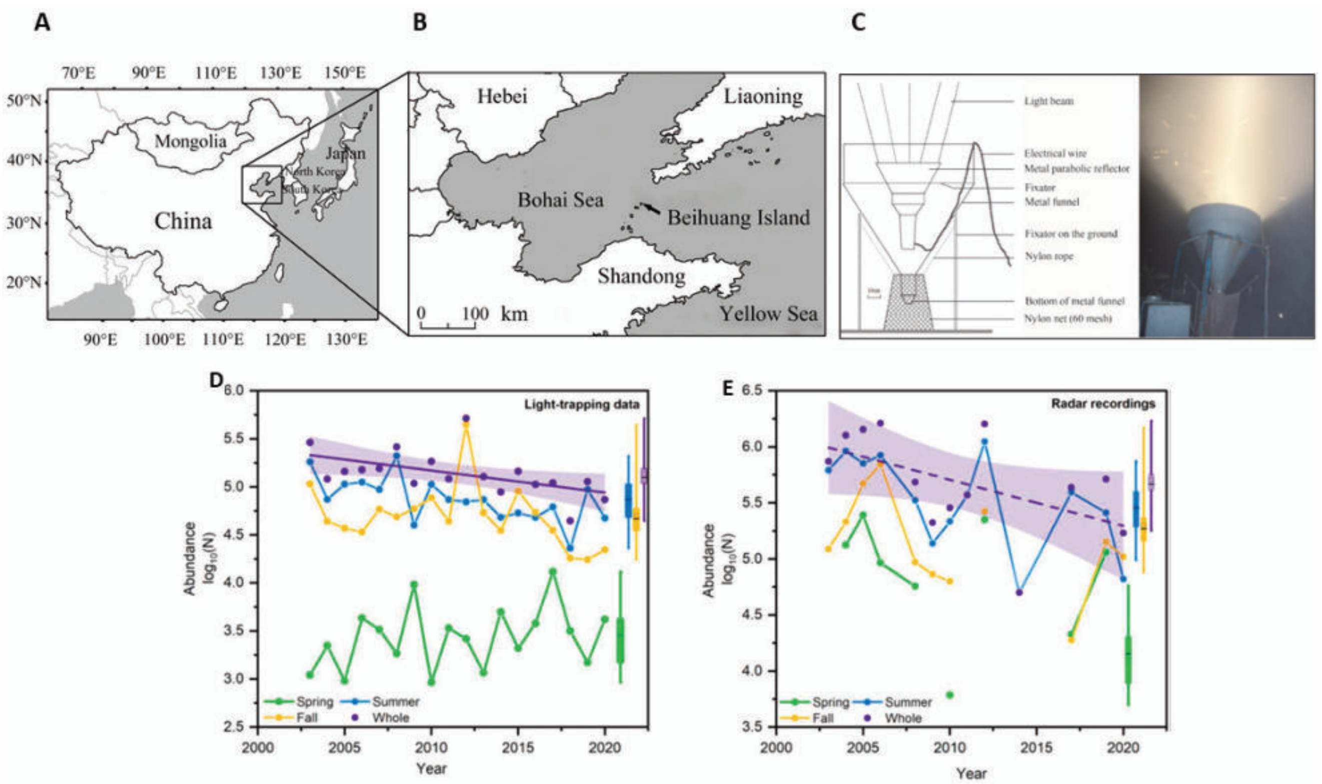


Figure 1. (A, B) Map to show location of Beihung Island, China, from Wu *et al.* (2015), CC BY-NC 4.0; **(C)** Searchlight trap operated at Beihuang Island, from Fu *et al.* (2017), CC BY-NC 4.0. **(D)** Total number of insects trapped in each year. **(E)** Total number of radar-detected insects in each year (data missing in some years). **(D)** and **(E)** from Zhou *et al.* (2023), CC BY-NC 4.0.

others remained stable and still others actually increased. This has been demonstrated in the UK for hoverfly and wild bee pollinators, where although around one-third of pollinators declined, around one-tenth of species actually increased (Powney *et al.,* 2019). Bell *et al.* (2020) have shown that while Lepidoptera suffered a long-term decline between 1969 and 2016 of 31% (*i.e.,* 0.66 % per year), populations of aphids changed hardly at all during the same period. The survey by van Klink *et al.* (2020) found that while terrestrial insects were declining, insects with freshwater stages in general appeared to be increasing in abundance by about 1.1% per year, indicating that insects in different habitats may be differentially susceptible. The reasons for such contrasts are unknown, but evidently some insects, perhaps whole ecosystems, are more resilient than others. A point not made sufficiently often, however, is that for the relatively large losses of insects reported by many recent studies to have occurred, especially in Europe, it must be the case that at least some of the most frequently encountered insect species have declined, not just those that were already rare.

Why decline? Insects and intensive agriculture

It is frustrating that we don't know for certain why insects are in trouble. Although it's tempting to point a finger specifically at pesticides, insect declines almost certainly have multiple causes (Wagner, 2020; Wagner *et al.,* 2021). But the most frequently named suspect is agricultural intensification. This explanation, of course, covers a multitude of sins. Farm mechanisation, reduction in uncultivated areas, eradication of hedges, crop monocultures, increased use of chemical fertilisers and regular applications of pesticides all result in fields without weeds, pests or diseases. Only a reduced range of wild plants and animals survives in the remaining, narrower field margins and neighbouring roadside verges. Since worldwide a high proportion of land is already used for arable or animal farming, there isn't a lot of room for insects. According to the Food and Agriculture Organization of the United Nations (FAO Stat, 2023), about one third of the Earth's land surface is farmed. The total area of agricultural land in 2019 was 4.78 billion ha from a total of 13.00 billion ha. This percentage is much higher in 'developed' countries; for comparison, in England 69% of the land is used for agriculture, and more than half of it (the final percentage of all land is 39%) is used to grow crops (UK Government, 2022).

It isn't surprising that this kind of farming adversely affects insects because intensification is designed to improve agricultural 'efficiency', ensuring that as much of the ecosystem's energy flow as possible is diverted into growing crops and livestock for human consumption. It has been estimated that 24% of the earth's Net Primary Productivity (NPP, *i.e.,* annual net plant growth) is currently appropriated by humans, and this rises to a staggering 69% on cropland (Haberl *et al.,* 2007). These percentages have doubled in the 20th century (Krausmann *et al.,* 2013). It's no wonder that insects don't do well in farmed landscapes like these! Nevertheless, there are additional likely anthropogenic causes of insect declines, including among others climate change, urbanisation and other types of habitat loss, artificial light at night, and the introduction of exotic species, including those that compete with endemic insects or introduce novel insect diseases, which native species can neither resist nor tolerate.

Another way of looking at insect declines is to say that they are the result of widespread anthropogenic biotic homogenisation (Ogan *et al.,* 2022). This is what happens when local, less-common habitats are lost, being replaced by conditions that are found more or less everywhere. As the world's human population increases, it is inevitable that more of the Earth's surface will be devoted to farming, and (from an insect's point of view) will therefore look like a farm. As a result, those insect species that fare least well will be less-common habitat specialists with limited geographic ranges, while those that prosper will be more commonly encountered species associated with habitats that are found over wide areas (Staude *et al.,* 2020). This means that in monitoring the health of insect populations, the spatial scale over which they are investigated is important. Studies of abundance of any organism conducted on too small or too large a scale may simply miss a real overall decline (Jarzyna *et al.,* 2018).

Are insect declines happening everywhere?

Up until now, it has been uncertain whether losses of insects are global or localised. So far, most evidence of marked declines has come from Europe. A notable study in North America (Crossley *et al.,* 2020) found no evidence for statistically significant overall reductions in insect abundance or diversity at a network of 13 US Long Term Ecological Research (LTER) sites. The reasons for this difference from the European condition are unclear. One hypothesis would be that insect declines are restricted to habitats that are strongly modified by humans, and perhaps many of the American studies were mostly conducted in less drastically modified habitats. But while it is true that the majority of the LTER sites were 'natural' ecosystems, one intensively studied site was in an urban location, while another was a widespread sub-network of sites located on Midwest farmland; even in these places, the measured decline in North American insect populations was less than those that have been seen in Europe. It is possible, however, that because agricultural intensification began earlier in North America than in Europe, and because agricultural chemical use is much more prevalent, the measured low values of insect abundance and diversity at US agricultural sites had already declined to low, modern norms even before monitoring began there in 2006.

What about the rest of the world? Blüthgen *et al.* (2022) have suggested that if insect declines are caused by changing agricultural practices, then it's important to look at places where agricultural intensification of the same kind is still happening, rather than those where it has already happened. This leads to the idea that we should focus on the developing nations of Asia, where intensification continues to be very rapid (FAO, 2020).

A new study of seasonal mass migrations of insects in Northeast China (Zhou *et al.,* 2023) has now provided exactly the kind of data that are required. The authors show that East Asian insect populations are declining at an average rate somewhat lower than that seen in Europe, but greater than in North America. The scale of the project is impressive; from 2003-2020, almost 3 million migrating insects from 98 species were identified from high altitude searchlight traps on Beihuang Island off the coast of Northeast China; a further 9 million individual insects were detected in free flight from radar records (Fig. 1).

The evidence of an extensive East Asian regional insect decline is unequivocal. Over the whole 18-year period the yearly tally of all the identified insects fell by 7.6%, with a statistically significant downward trend of 0.4% per year. As 75% of the identified migrating insects were members of a single family of moths, the Noctuidae, this doesn't necessarily mean that all East Asian insects are in decline, but the finding is disturbing because it reveals that declines on a similar scale are happening more or less in parallel in widely separated parts of the world, not only in natural settings but also among insect guilds that feed on agricultural crops, even though the climate and agricultural practices are quite dissimilar.

What will be the ecological consequences of insect declines?

It might be thought that less abundant insects would be good news for farmers, but this turns out not to be the case. Indeed, the East Asian migratory insect study shows that insect declines can lead to pest

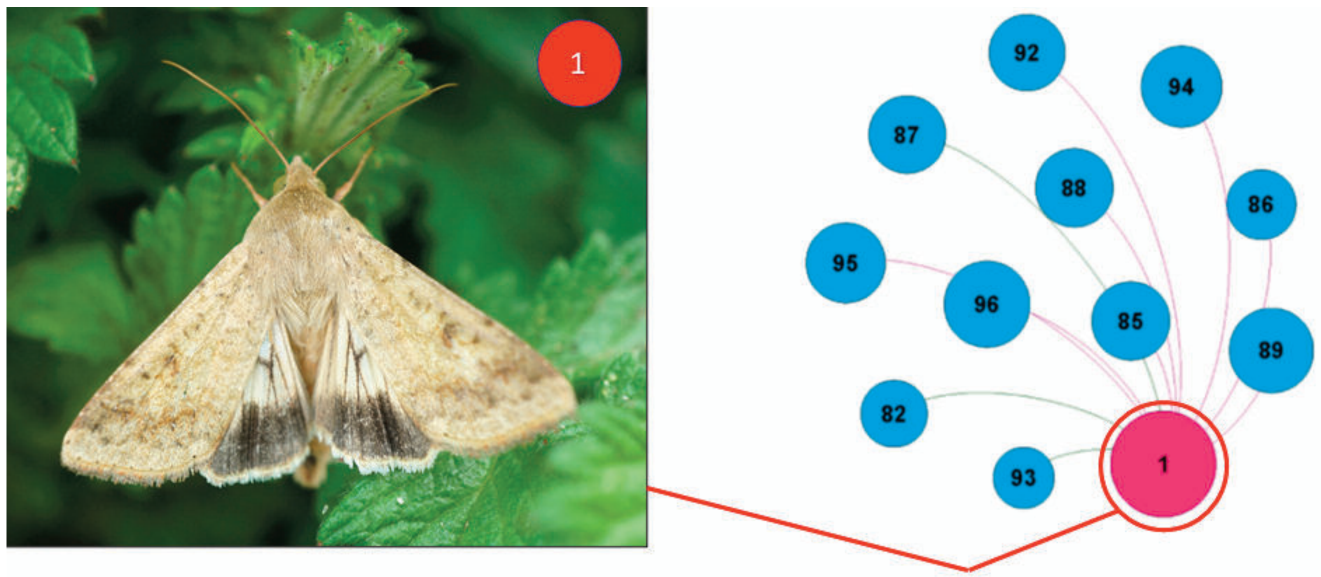


Figure 2. (**Left**) *Helicoverpa armigera, herbivore* #1 in food web; photo by xulescu_g, CC BY-SA-2.0. (**Right**) Trophic network from Beihuan Island insect catch, centred *on H. armigera.* The red circle is herbivorous, blue circles are natural enemies. From Zhou *et al.* (2023) CC BY-NC 4.0.

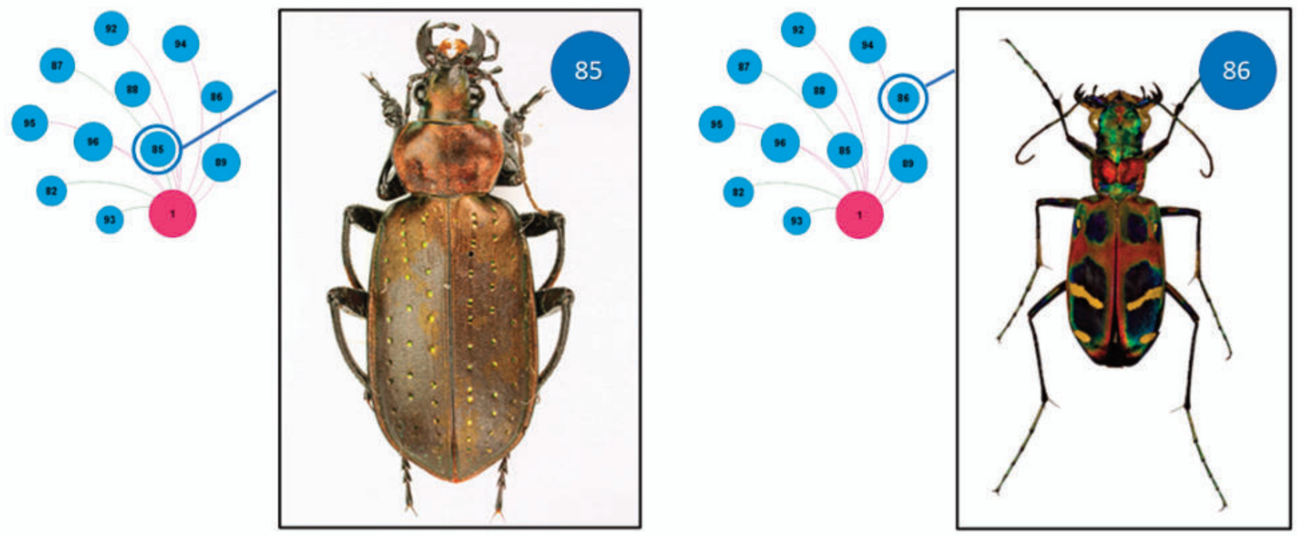


Figure 3. Natural enemies of *Heliothis armigera*. Insets show the food web dependent on *H. armigera*. Left: *Calosoma chinense*, natural enemy #85 in food web, photo by Sandro Brusschi, https://www.calosomas.com/Campalita/cal_chinense.html, reproduced with permission. Right: *Cicindela chinensis*, natural enemy #86 in food web, photo by Didier Descouens, CC BY-SA 3.0.

outbreaks occurring more frequently, with larger year-to-year changes in pest population size.

The Beihuang Island study reports declines among species assemblages that include some of the most serious pests of crops in the world, including for example the noctuid Cotton Bollworm moth, *Helicoverpa armigera* (Fig. 2), identified by Antonelli *et al.* (2020) as the single most intensively studied insect crop pest. Despite the overall decline in insect abundance, this insect's East Asian population oscillated wildly from year to year in typical 'outbreak' style, and there was no obvious overall trend in numbers, even though other frequently encountered noctuid species (such as the Black Cutworm Moth, *Agrotis ipsilon*) showed clear evidence of a steady decline in numbers over the same period.

Zhou *et al.* (2023) hypothesised that herbivorous insects like *H. armigera* might escape the general declining trend because their natural enemies (predators and parasites) are affected by the general decline more than the pests themselves. Since an important ecological 'function' of these natural enemies is the density-dependent negative regulation of other species, we may expect that reduced numbers of natural enemies would adversely affect their ability to provide the ecosystem service of natural pest control (Oliver *et al.*, 2015), thus enabling pest species to prosper even during an overall decline of all insect species.

Zhou *et al.* (2023) tested this idea by analysing the population dynamics of 124 identified pairs of insect species in their catch; in each pairing, a single herbivorous species was linked to a natural enemy known to attack it. Often a single pest could be paired with several enemies, thus constructing a food web (trophic network). In the example network shown in Fig. 2, *H. armigera* is paired with 11 species of natural enemy that were also trapped in the Beihuang Island study. Some of these enemies were predatory beetles (Fig. 3), while others were parasitic wasps or predatory insects like lacewings (Fig. 4). When all 124 species pairs were considered (Fig. 5A), the abundance of natural enemy species was found to have fallen significantly faster than that of their paired herbivorous prey species (Fig. 5B); enemies declined in number at a rate of 4.4% per year (a loss of 80% over 18 years) while crop pest populations diminished at a rate of only 3.5% per year (63.7% over 18 years).

Ecosystem stability

Zhou *et al.* (2023) also hypothesised that large-scale losses of insect species diversity might adversely affect the stability of natural trophic networks (*i.e.*, year-to-year fluctuations in population size), and/or their resilience to externally imposed constraints, such as extreme weather events, gradual climate change or biological invasions (McCann, 2000). Such a

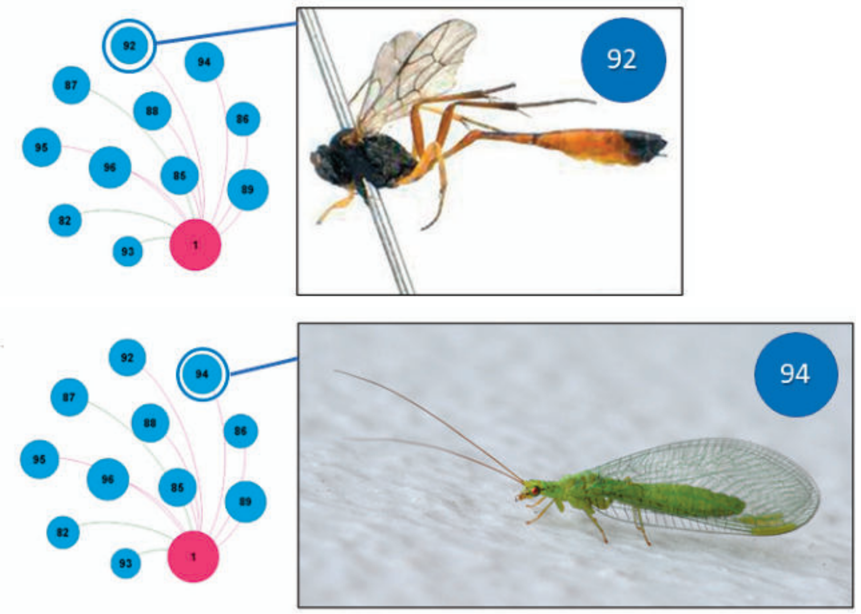


Figure 4. Natural enemies of *Heliothis armigera*. Insets show the food web. Top: *Charops bicolor*, natural enemy #92 in food web, photo by Digital Insect of Taiwan Agricultural Research Institute (TARI), https://catalog.digitalarchives.tw/item/00/65/a5/1c.html; Bottom: *Chrysopa septempunctata*, natural enemy, #94 in food web, photo by alvesgaspar, CC BY-SA 4.0.

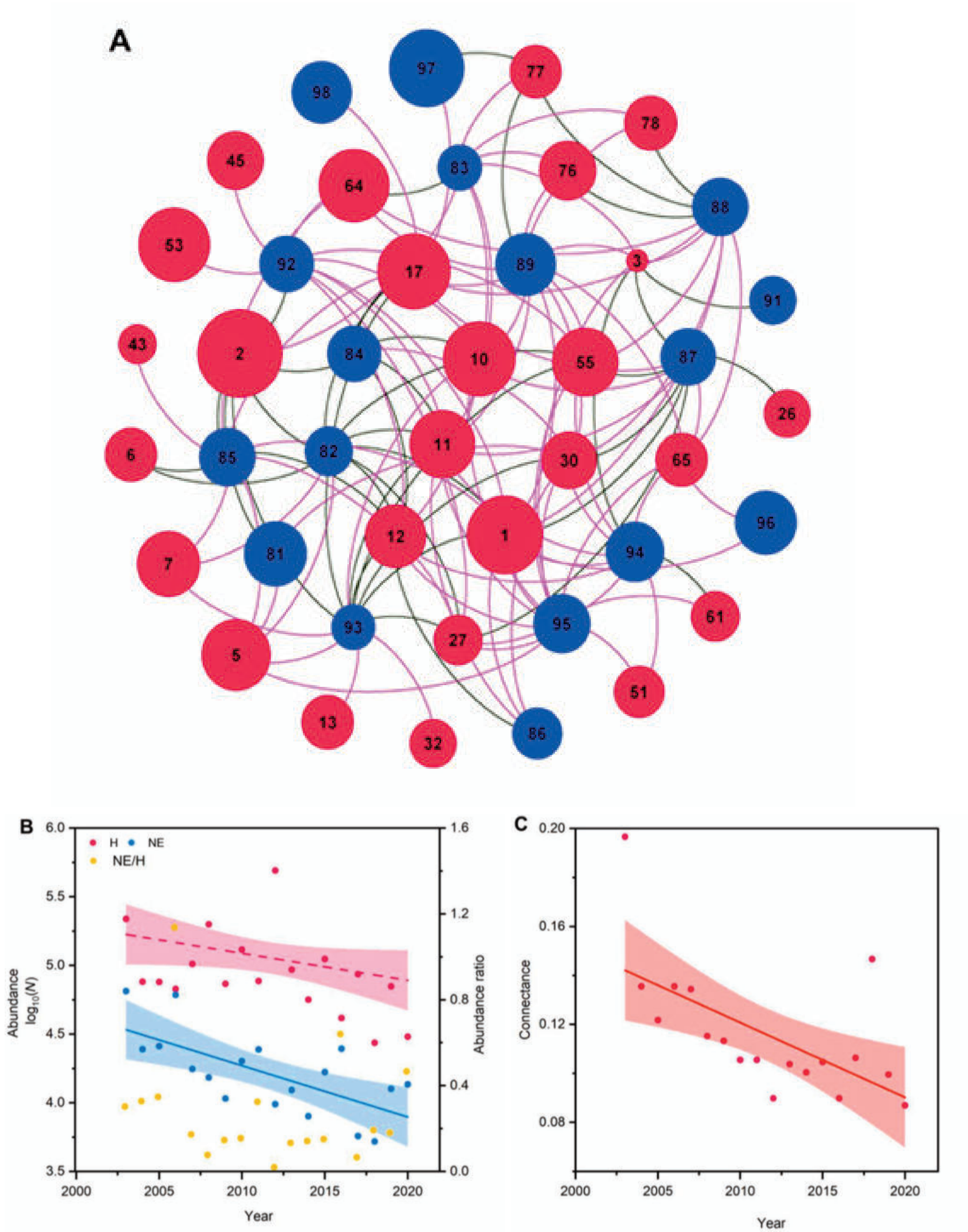


Figure 5. Multiyear trends in (relative) species abundance and network connectance for a food web composed of 124 bitrophic H × NE couplets from the Beihuang Island migratory insect study. (**A**) Quantitative food web composed of migratory herbivores (red circles) and natural enemies (blue circles), captured with searchlight traps over 2003–2020. Digits within a given circle indicate species identity. Circle size reflects the relative annual abundance of each species. Interspecies links comprise positive (magenta lines), negative (black), or both positive and negative (purple) NE × H correlations. (**B**) Temporal shifts in annual abundance of the H (red) and NE (blue) species that constitute the 124 couplets (H: $F_{1,16} = 4.29$, $P = 0.06$; NE: $F_{1,16} = 13.39$, $P = 0.002$) together with the associated NE/H abundance ratio (yellow). (**C**) Temporal decline in 'connectance' of the assembled NE × H food web ($F_{1,16} = 9.81$, $P = 0.006$). Solid and dashed lines with a shaded 95% CI indicate statistically significant ($P < 0.05$) or marginally significant ($0.05 < P < 0.1$) trends based on linear regression models. Reproduced from Zhou *et al.* (2023); CC BY SA 4.0.

relationship between food web diversity and stability has been experimentally demonstrated to occur under more or less natural conditions in at least some cases (*e.g.*, Polis *et al.*, 1996; Otto *et al.*, 2008), although not on an ecosystem scale. Zhou *et al.* (2023) hypothesised that the large-scale declines found in the Beihuang Island study would cause a loss of connectivity within herbivore-enemy food webs. In accord with this idea, they found that during the 18 years of sampling there was a steady and significant decline in the 'connectance' (a measure in which the total number of connections is divided by the square of the number of species) within the overall trophic network of migrating insects (Fig. 5C).

Does this mean that all ecosystems in which insect diversity declines will be less stable? I'm afraid that we can't jump to that conclusion. Unfortunately, ecological theory is insufficiently well-developed to enable strong predictions as to whether an observed reduction in the complexity of interconnectedness necessarily reduces the stability or resilience of the network concerned. The intuitive confidence of early ecologists (*e.g.*, Elton, 1927) that increased complexity in ecological networks must always confer greater stability (*i.e.*, reduced temporal fluctuations in population size) as well as greater resilience (*i.e.*, reduced sensitivity to external perturbations) was long ago shattered by the mathematical demonstration that increasing size and complexity in model networks inevitably leads to destabilisation (May, 1972). Despite this, many ecologists have continued to believe that ecosystem complexity (or at least connectivity) really does confer stability and resilience in practice, and that the theoretical objections to this conclusion are a 'paradox'. This subject has recently been reviewed by Landi *et al.* (2020) in a paper that highlights the "theoretical debate and lack of consensual agreement" on this controversial topic.

It is now recognised that species coexistence in complex ecosystems is dependent not only on the degree and complexity of connectivity between species, but also on several other variables, including the body size, foraging strategies and other behaviours of the interacting species (Ho *et al.*, 2021). An additional complication is that network theory assumes random interactions between participating elements, but the fact that, essentially, all adult insects are equipped with sophisticated sense organs, brains and wings, and are therefore capable of oriented flight, inevitably means that their interactions are *not* random. Learned prey preferences are also likely to contribute to density-dependent effects, and behaviour of this kind has been shown to promote the co-existence of multiple prey species in complex food webs (Ishii *et al.*, 2012). Further, experimental perturbation studies of insect food webs find that trophic links known to occur under experimental conditions do not necessarily occur when other components of the community are present, so that an apparently complex trophic web can collapse to what is effectively a simple linear food chain (Torres-Campos *et al.*, 2019). Even in modelling studies, the stability of food webs has been found to be better predicted by 'trophic coherence' (*i.e.*, similarity among trophic pathways in their average trophic level) than by network size or complexity (Johnson *et al.*, 2014). I think it's probably fairly safe to say that for the foreseeable future we will have to make judgements about the stability of insect trophic networks based mostly on empirical data (rather like the financial 'stress-tests' that are performed on banks).

The wider significance of insect declines

A general decline of all insects would surely be worrying. While it's true that a few insects are a menace to humans (disease-carrying mosquitoes come to mind), and most people take little notice of them, the vast majority of insects are our friends. There's no question that a continued general decline in insect abundance and diversity would have serious implications both for humans and for the rest of life on land. Insects are essential components of all land-based ecosystems. Firstly, this is because there are so many of them. Insects are by far the most numerous of all animals on Earth. Together with other land-based arthropods (small invertebrates with jointed legs) there are at any one time an estimated 10^{19} individuals (that's 10 million, million, million!). They have an estimated total dry weight biomass of about 300 million tonnes (fresh weight 1,000 million tonnes), equivalent to 150 million tonnes of stored carbon (Rosenberg *et al.*, 2023). To put this in context, the estimated dry weight biomass of all humans alive today is about 120 million tons, less than half of the total biomass of insects (Bar-On *et al.*, 2018).

Moreover, insects are the food of other animals. They are mostly short-lived, and the standing crop of insects turns over more than once in each year, so that the estimated global total of new insect growth in each year is about 500 million tonnes of dry mass. Most of this production is almost immediately consumed by an upward food chain of predators and parasites, so that the towering superstructure of all the Earth's animal-abundant diversity is almost entirely built on a foundation of insects and their arthropod relatives.

It isn't just the biomass of insects that is declining, but also their diversity. This means that animal diversity as a whole is declining too. More than 95% of animal species are invertebrates, and insects alone represent roughly half of all kinds of animal. This is of course a guess, because around 80% of an estimated total of 7 million insect species remain undescribed and unknown to science (Stork, 2018).

It isn't hard to see that the ecological resilience of the rest of the animal kingdom depends on insects. The implication is that if there are fewer insects to eat, then there will also be fewer wild animals of other kinds. There is already evidence that this is happening. Insectivorous birds have declined strongly in number in the human-dominated Anthropocene age. For example, the European Common Cuckoo *Cuculus canorus* has progressively declined along with the Lepidoptera, whose larvae are known to be its preferred prey (Denerley *et al.*, 2019). In North America, those birds for which eating insects is essential at some point in their lives (304 species) each experienced an average decline in population size of almost 10 million individuals, while those for which insects are not essential (64 species) did not experience a significant decline at all (Tallamy *et al.*, 2021). In Europe, the parallel declines of insectivorous swallows and martins (Hirundinidae) and swifts (Apodidae) have been linked to insect declines through the use of pesticides and fertilisers (Møller, 2019; Møller *et al.*, 2022).

As you would expect from this, populations of insectivorous bats (Chiroptera) are also in trouble; of 1,236 species of bat around the world 180 (15%) are considered by the IUCN to be threatened (Frick *et al.*, 2019). This is not a new problem; Kervyn *et al.* (2009) found that bat diversity at 195 sites in Belgium declined by about half during the second half of the 20th century. A large-scale survey in Canada of bats killed by wind turbines (supposed to be a random sample of the population) found a 21% decline per year in bat numbers between 2010 and 2017 (Davy *et al.*, 2020). The factors causing these declines are almost certainly multifactorial, but it is an obvious hypothesis that the reduced availability of insect prey is an important contributor to bat declines. Yet in a recent review of the subject, Browning *et al.* (2021) did not even list insect declines as a factor. Published data relating to this hypothesis are scarce, but it is known that bat numbers are lower over conventional farms than over organic farms (Wickramasingh *et al.*, 2003) suggesting that bat populations are limited by prey density at least in some circumstances, and Akasaka *et al.*, (2009) found a strong correlation between bat numbers and the density of flying insects above aquatic habitats. It seems to me that more research needs to be done to investigate this link.

A big question so far unaddressed is whether the declines that have been measured in insects that live above ground also apply to those that live in the soil. It may come as a surprise to most readers of *Antenna* (it was news to me!) that the biomass of underground insects is considerably greater than that of aerial insects (Rosenberg *et al.*, 2023). An all-too often undervalued ecosystem service provided by soil animals relates to the maintenance of soil structure and fertility and the cycling of nutrients in the soil. Without soil, human farmers could not grow crops. Termites, ants, springtails (Collembola) and other tiny arthropods (mostly mites) are numerically dominant among soil animals; it has been estimated that the global total dry weight biomass of arthropods in the soil is in the order of 200 million metric tonnes, about twice that of those living above ground. Intensive farming is known to adversely affect soil invertebrates including insects (Menta *et al.*, 2020). Unfortunately, although surveys of soil animal abundance are in progress on a global scale (*e.g.*, Antunes *et al.*, 2022), we do not yet know whether the abundance of below-ground insects is declining in parallel with the more spectacular and obvious insects that fly in the air. A problem here is that extracting insects from the soil is technically difficult and standardisation of sampling protocols over space and time is challenging.

Insect declines continue to be of intense interest to researchers in insect biodiversity, ecology and conservation. With improved data we're beginning to see the global shape and size of the problem. The next, even bigger challenge will be to figure out what to do about it.

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The Big Agricultural Transition:
How farming could deliver for insects

The most significant agricultural policy reforms in decades are underway as we transition from the EU Common Agricultural Policy (CAP), that paid farmers for how much land they managed or owned, to new agri-environment schemes designed to achieve beneficial outcomes for the environment and climate alongside food production.

In the UK, 17.2 million hectares, making up 71% of total land, is used for agriculture (DEFRA, 2022), presenting a substantial opportunity for farming to make a significant positive impact, with farmers and land managers set to play an integral role in species recovery and habitat restoration.

Jane Phillips

Since the 1947 Agriculture Act, farming became gradually more intensified and specialised (Robinson & Sutherland, 2002). Some experts anticipate agricultural production to double by 2050, increasing pressure on farmland species (Arnott *et al.,* 2022). The conversion of habitat to homogenised farmland, and subsequent reduction and fragmentation of semi-natural habitats, as well as the use of agrochemicals, are identified as contributing factors to insect number declines (Kuussaari *et al.,* 2011; Arnott *et al.,* 2022). Less diversity in farmland ecosystems has inevitably led to a reduction in habitats for insects to complete their lifecycles, and fewer pollen and nectar sources. Yet, many insects have a functional role in agroecosystems, from decomposition, nutrient cycling, and maintaining soil structure, to biological control of crop pests and pollination (Arnott *et al.,* 2022).

The policy

England and the devolved nations are now in the process of developing and rolling out schemes, with all four closely aligned in their goals for the environment, sustainability, and nature recovery. In the devolved nations, payment rates have not yet been divulged, with some questioning whether underfunding will lead to a more limited rollout of sustainable actions.

In Northern Ireland, DAERA outlined plans including a Farm Sustainability Payment as an ongoing area-based payment, a Farming with Nature scheme to support the restoration of habitats important for species recovery, and a Farming for Carbon scheme (DAERA, 2022). Compared to the rest of the UK, they are not yet implementing a new Agriculture Act to underpin new policy, with conservationists fearing this will jeopardise the transition to more sustainable practices due to an absence of legislation (Billington, 2023).

Scotland set out proposals for a new Agriculture Bill and published their *Vision for Agriculture* with ambitions to become 'a global leader in sustainable and regenerative agriculture' (Scottish Government, 2022). Their policy remains closely aligned with Europe, reflecting their hope of re-joining the EU. While England and Wales are phasing out direct payments with a move to a 'public money for public goods' approach, Scotland will continue direct payments for farmers and crofters as part of their Tier 1 support as long as basic sustainability criteria are met, with the following three tiers paying for additional actions (AHDB, 2022; Scottish Government, 2022).

The Sustainable Farming Scheme outline in Wales involves Universal, Optional and Collaborative actions, and closely aligns food production with their Sustainable Land Management objectives, the guiding principles underpinning policy in their 2022 Agriculture Bill. They include a baseline habitat survey and carbon assessment to identify actions to be paid for, and have requirements for 10% tree cover, and 10% habitat creation (Welsh Government, 2022).

In England, DEFRA has already started rolling out ELMs (Environmental Land Management schemes) consisting of three schemes. In 2022, three initial standards under 3-year contracts were launched for the Sustainable Farming Incentive (SFI), targeting grassland and arable soils, and a moorland standard, with an additional six standards added in 2023. Originally, DEFRA had planned for the second tier of ELMs to form a Local Nature Recovery scheme; however, later in 2022 it was decided that, instead, it would be replaced by the existing Countryside Stewardship (CS). With lower and mid-tier options, CS will continue with some evolution, paying farmers for more targeted actions specific to locations, features and habitats. Finally, Landscape Recovery will support large, bespoke projects involving multiple farmers and land managers, aimed at making landscape-scale impacts on the environment over the longer term.

As yet only around 34% of agricultural land in England is currently farmed under Countryside and Environmental Stewardship schemes. There has, however, been a 94% increase in CS agreements since January 2020, with goals to increase this to 70% of farmland and farms under the schemes by 2028 (DEFRA, 2023).

How will ELMs impact insect biodiversity?

Agriculture is the main driver of soil habitat change (Crotty, 2021), and a reduction in soil fertility across Europe has been linked to a decline in soil biota, such as earthworms, caused by intensive farming and climate change (Plaas *et al.,* 2019). Yet, a functioning biodiverse soil food web promotes healthy soils able to provide ecosystem services and deliver for agricultural food production. The new soils standards will pay for measures to improve the health of agricultural soils. Actions include a soil assessment and management plan, and testing and adding soil organic matter by growing cover crops and incorporating as green manure. There is also a requirement to minimise bare ground during the winter by establishing multispecies cover crops, contributing to the health of soil fauna, while creating a habitat and food source for pollinators.

Soil health may also be impacted by the new annual health and welfare review. It encourages better use of medicines, including the selective use of anthelmintics. Used to control gastrointestinal parasites such as nematodes in livestock, anthelmintics are not fully metabolised, leading to residues in excreted dung. This has a detrimental effect on invertebrate fauna dependent on dung for all or part of their lifecycle and can lead to inhibited oviposition and motility. It can also limit the colonisation of dung pats, reducing dung degradation, in turn affecting nutrient cycling and soil ecology (Cooke *et al.,* 2017). Targeted treatment of only a section of the herd or flock, therefore, has beneficial implications for both farm performance and the environment, while slowing the development of parasite resistance to the drug. In Wales, support will be offered for Faecal Egg Counts to inform worming strategy, in addition to the growing and feeding of forages such as chicory or sainfoin, high in condensed tannins, a plant metabolite found to have natural anti-parasitic properties (Welsh Government, 2022).

Many farmers already undertake these measures, as an annual health and welfare review is a requirement for the farms part of the Red Tractor scheme, or Farm Assured Welsh Livestock schemes, but incorporating them into actions that will be rewarded as part of the scheme will hopefully lead to a wider reduction in use across farms.

Permanent grassland used for grazing livestock accounts for 76% of agricultural land in Wales (Welsh Parliament, 2022), and 41% in England (DEFRA, 2022), while many farms also integrate temporary grassland into their rotations. The SFI improved and low input grassland standards include support for the establishment of grassy field corners or blocks. Grassland systems have seen a reduction in invertebrate diversity due to homogenisation of the grass sward, higher stocking rates, and increased fertiliser use. Fritch *et al.* (2017) studied the impact of field margin establishment on invertebrate biodiversity and found that exclusion of grazing led to increased abundance and taxon richness, potentially due to increased food resources, habitat provision in the more diverse sward structure, a reduction in disturbance from grazing, and changes to the botanical composition of the sward.

Managing grassland under SFI's low input standard could contribute to invertebrate numbers across fields, rather than just field margins. In a study on upland grassland in Northern Ireland, management under agri-environment schemes with lower fertiliser inputs was associated with greater invertebrate abundance and richness, connected to more diverse grass swards containing greater coverage of native grass species and lower dominance of perennial ryegrass *(Lolium perenne)* (Arnott *et al.,* 2022).

The Arable and Horticultural Land standard entails similar actions. Methods such as these all contribute to, arguably, the most impactful element of ELMs on insect biodiversity, the Integrated Pest Management (IPM) standard.

According to the FAO, pests cause 40% of global crop production losses each year (FAO, 2021). Under SFI, farmers are being offered £989 per year to create an IPM assessment and plan. A coordinated whole farm strategy, the goal of IPM is to implement a variety of sustainable crop protection methods to minimise the harmful effects of pesticides on non-target species, soil health and water quality. This approach is also driven by the revocation of many plant protection products, and the development of resistance to their active ingredients (AHDB, 2023).

Building on previous Countryside Stewardship offerings, farmers are being offered £673 per hectare to establish and maintain flower-rich grass margins, blocks, or in-field strips, providing habitat and foraging sites for invertebrates, including natural crop predators, and wild pollinators. Tschumi *et al.* (2016) assessed the impact of similar actions under the Swiss agri-environment scheme and found that species-rich wildflower strips grown near winter wheat led to a significant reduction in *Oulema sp.* (cereal leaf beetle) density, and a subsequent 40% decrease in crop damage, while average crop yield increased by 10% in the wheat located up to 10 m from the wildflower strips. The Centre for Ecology and Hydrology carried out similar trials in the UK. Their 5-year trials, however, planted wildflower strips in the middle of fields. By planting in-field 100 m apart, the beneficials were able to predate upon aphids and other crop pests throughout the field rather than on the outer edges only (Carrington, 2018).

Pollution, mainly from synthetic pesticides and fertilisers, has been identified as the second most important driver of insect species declines (Sánchez-Bayo *et al.*, 2019). As part of the IPM standard, farmers are now being offered £45 per hectare not to use insecticide. The area of oilseed rape (OSR) grown in the UK has seen a significant decline following increased pressures from the crop pest *Psylliodes chrysocephala* (Cabbage Stem Flea Beetle), since the banning of neonicotinoids, in addition to resistance developing to pyrethroid sprays (AHDB, 2023). Regulation has driven the uptake of alternative, environmentally friendly approaches to tackling crop pests. The new SFI scheme will pay £55 per hectare to establish a companion crop, with the aim to act as a trap crop for pests, to suppress weeds, and to provide a habitat for invertebrates, including pollinators and natural crop pest predators. In a Swiss trial, growing a companion crop with OSR led to a reduced larval density of *P. chrysocephala*, and a reduction in egg laying and damage by *Ceutorhynchus napi* (Cabbage Stem Weevil), with an overall significant increase in OSR yield (Breitenmoser *et al.*, 2022).

The new SFI hedgerows standard will pay farmers to restore and manage hedgerows for wildlife, further supporting an IPM approach through habitat provision. Around 50% of hedgerows have been removed over the years (Robinson *et al.*, 2002), but DEFRA has set targets to create or restore 30,000 miles of hedgerows a year by 2037, and 45,000 a year by 2050 (DEFRA, 2023). A study by Garratt *et al.* (2017) found that continuous unbroken hedgerows, with a high diversity of woody species and rich in plants in the understory, are an important reservoir for natural enemies of crop pests, such as staphylinids, linyphiid spiders and lycosid spiders. The abundance and activity of lycosids and linyphiids were greater in proximity to better quality hedgerows without gaps. A healthy hedgerow can also provide a wildlife corridor and forage resource for pollinators, with over twice as many bumblebees detected on 'healthy' hedgerows.

Hedgerows also provide important ecosystem services such as natural flood management, while combatting nutrient run-off, a critical function when considering that up to 80% of nutrients applied to farmland as fertiliser are lost to the air and water. DEFRA has set a target of a 40% reduction in agricultural pollution from nitrogen, phosphorus, and sediment into waterbodies by 2038. Farmers will be paid £589 per year to complete a nutrient management assessment and review report to improve nutrient use efficiency and identify opportunities to maximise crop nutrients on the land, such as creating a legume fallow to naturally fix nitrogen. The fallow crop creates habitat and a source of forage for beneficials and pollinators, host plants for butterfly larvae, and nesting and overwintering sites for wild bees (Kuussaari *et al.*, 2011).

Accumulated nitrogen deposition indirectly affects insect species, causing plants to produce more biomass, resulting in lower temperatures, less airflow, and more shade at soil level. With damper and cooler conditions at ground level, the altered microclimate can result in slower development and a longer lifecycle for insects, with the risk that those with a longer lifecycle are unable to complete it within the season. Invertebrates preferring the increased moisture and colder environments may as a result outcompete insects preferring drier,

brighter environments, as has been witnessed with ground beetles (Guthrie *et al.*, 2018). The Welsh Sustainable Farming Scheme aims to reduce ammonia emissions by supporting the integration of trees to capture ammonia and providing funding for improved infrastructure.

Improving water quality is a central tenet of the schemes. Agricultural pollution entering waterbodies can lead to a reduction in the biodiversity of aquatic insects, whereby species tolerant to pollution, and dietary and habitat generalists, are replacing other species (Sánchez-Bayo *et al.*, 2019). ELMs will build on current CS support for waterbody management and creation. Having a network of farmland ponds, temporary scrapes and dew ponds provides habitats for a range of aquatic and semi-aquatic insects at different stages of their lifecycles, allowing species to breed, feed and move around farmland. Some hoverflies, such as *Helophilus pendulus* (Common Tiger Hoverfly) rely on aquatic vegetation to lay their eggs. Their larvae then live in the water, and, in southern England, drainage ditches are home to *Hydrophilus piceus* (Great Silver Water Beetle) (Buglife, undated), studied in agro-ecosystems as an indicator species given its sensitivity to environmental factors (Gioria *et al.*, 2010).

Under ELMs, DEFRA also plans to evolve existing Countryside Stewardship payments for a range of other habitats, from coastal habitat creation and management, and peatland, through to lowland heathland supporting rare species such as *Cicindela sylvatica* (Tiger Beetle), *Plebejus argus* (Silver-studded Blue) and *Coenonympha pamphilus* (Small Heath).

Landscape-scale change

Landscape Recovery is the third facet of ELMs, offering support for radical projects covering between 500 and 5,000 hectares. The projects initially focused on two themes, recovering and restoring native species, including improving the status of *Euphydryas aurinia* (Marsh Fritillary) and *Bombus sylvarum* (Shrill Carder Bee), and restoring rivers and streams. Initially, DEFRA had planned to support 15 projects, but this was increased to 22, showing the determination and engagement of hundreds of landowners and farmers working together. The aim is for these to be long-term projects of 20 years plus, with safeguards, such as conservation covenants, in place to protect them into the future. While the projects are in their infancy, collaborative, landscape-scale restoration of habitat over the long-term could have more impact on species recovery than fragmented conservation measures on individual farms, unless there is widespread uptake of actions on a national scale. This will be necessary to create a healthy network of diverse, interconnected habitats to help the movement of insect species through the landscape, provide feeding and breeding areas, and for different stages of lifecycles.

With such a diverse mosaic of habitats, land types and agroecosystems across the UK, the efficacy of the new schemes on insect conservation will be varied. By creating and restoring habitats, improving soil health and biodiversity, and optimising nature's toolbox, farmers could see increased yields, productivity and profitability, demonstrating that food production and biodiversity do not need to be at odds with each other.

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Exploring Butterflies in Gua Tempurung: The first and not the last

A flutter of Common Albatrosses (*Appias albina albina*) puddling with other butterflies on an old logging track.

The importance of conserving Mother Nature for future generations

Gua Tempurung (Tempurung Cave), one of the largest and longest caves in Peninsular Malaysia, stretches approximately 4.5 km in length and 200 m high and is located 25 km south of Ipoh, near Gopeng, Perak. This cave is located at the base of a limestone hill, Gunung Tempurung (Tempurung Hill), and Sungai Tempurung (Tempurung River) flows through the hill along the cave. In the mid-90s, approximately 1.9 km of the cave was made accessible to the public and thereafter it became a popular attraction to spelunkers, or caving enthusiasts, because it comprises five giant domes with different formations of stalagmites and stalactites that bring wonder to the visitors.

Limestone habitat in Peninsular Malaysia is vulnerable due to economic development and lack of legal protection. There is a dearth of information on butterflies in limestone habitats; thus, Forest Research Institute Malaysia (FRIM) is carrying out studies on selected insect groups in selected limestone areas across Peninsular Malaysia. Gua Tempurung is one of the selected sites.

A butterfly survey at Gua Tempurung was conducted during the fasting month from 20^{th} to 22^{nd} April 2021 after a permit to cross state borders was obtained. The efforts to study the effects of seasonality on butterfly diversity were not hampered by the Covid-19 pandemic, and all precautionary measures and social distancing guidelines were always complied with. Fasting did not curb our enthusiasm for butterflies and they were indeed fascinating. Much of the forest around Gunung Tempurung has been cleared and the surveys were conducted in some of the disturbed sites consisting of narrow strips of vegetation bordering the base of the hill, except for the southern area due to quarry activities. The quarry area is bordered by different sizes of ponds, too. According to our ranger, Tajul, who works as a tourist guide at Gua Tempurung, there is no existing trail on the hills or to the summit because the hills have never been

Haziq, A. & Phon, C.-K.
Entomology Branch of Forest Research Institute Malaysia (FRIM), 52109 Kepong, Selangor, Malaysia

fully explored before, thus we did not attempt to climb them. Weather during the surveys was good except on the last day where it was cloudy and windy after 3:00pm. The survey involved collecting selected specimens for identification and recording purposes.

On the first day, the survey took place at the site next to the North-South Expressway, which was an old logging track with a few cattle farms nearby. It is a heavily disturbed open area with some stretches of vegetation. The day could not have begun with a better sighting as several magnificent Rajah Brooke's Birdwing (*Trogonoptera brookiana albescens*) were observed flying, as if they were welcoming us to their home. The Rajah Brooke's Birdwing, well-known for its large black jet-like wing shape with metallic green stripes, is protected under the Malaysian Wildlife Conservation Act 2010—Act 716. Commonly known as Malaysia's national butterfly, they gather in large numbers on the ground, known as mass puddling behaviour. Males congregate at geothermal seepages to imbibe nutrients from the water. The nutrients are thought to be transferred to females for reproduction during mating. Unfortunately, this behaviour was not observed at Gua Tempurung. The majestic birdwings continued to amaze us with their flight behaviour; however, collecting specimens for identification purposes near the river was not sidelined. This site had a higher number of Rajah Brooke's Birdwing sighted compared with other areas, possibly due to its locality adjacent to Bukit Kinta Forest Reserve where we usually find them in larger numbers. This site is, however, separated by a highway. There are a few small streams and rivers along the old logging track.

Butterflies were abundant near the rivers, and they were observed puddling in a few spots along the way; these included the Chocolate Albatross (*Appias lyncida*) and Yellows (*Eurema* spp.). A few Club Beaks (*Libythea myrrha*) puddled singly near streams, with their wings always closed. There was a large gathering on the old logging track consisting of mainly pierids (Common Albatross, *Appias albina*; Chocolate Albatross; Orange Albatross, *Appias nero*), papilionids (Common Jay, *Graphium doson*; Spotted Zebra, *Pathysa megarus*), and nymphalids (Little Map, *Cyrestis themire*). They were having a feast on the puddling spot and the butterflies seemed unperturbed by our presence. They would disperse for a while then return to the same spot again.

The second day was quite interesting yet exhausting because two sites were surveyed. In the morning, the trail next to the limestone wall from a Chinese temple to an oil palm estate was explored. Along the way, interesting behaviours of *Rohana parisatis* and a species of *Bassarona* were noticed where they landed on a spot close to the wall and flew back and forth to surrounding vegetation when we tried to collect them. They were extremely sensitive to our footsteps. It is unsure whether they

Trees at the open field in the second site surveyed on the second day looked freshly pruned.

A checklist of butterflies collected or sighted from the trip

All specimens collected are curated in the FRIM Entomological Reference Collection

PAPILIONIDAE
Trogonoptera brookiana albescens (Rothschild)
Troides helena cerberus (C. & R. Felder)
Pachliopta aristolochiae asteris (Rothschild)
Papilio (*Princeps*) *demoleus malayanus* Wallace
Papilio (*Princeps*) *helenus helenus* Linnaeus
Graphium (*Graphium*) *sarpedon luctatius* (Fruhstorfer)
Graphium (*Graphium*) *doson evemonides* (Honrath)
Graphium (*Graphium*) *evemon eventus* (Fruhstorfer)
Graphium (*Graphium*) *agamemnon agamemnon* (Linnaeus)
Graphium (*Pathysa*) *megarus megapenthes* (Fruhstorfer)
Graphium (*Pathysa*) *delessertii delessertii* (Guérin-Méneville)
Lamproptera curius curius (Fabricius)

PIERIDAE
Leptosia nina malayana Fruhstorfer
Cepora iudith malaya (Fruhstorfer)
Appias lyncida vasava Fruhstorfer
Appias nero figulina (Butler)
Appias albina albina (Boisduval)
Appias indra plana Butler
Eurema (*Terias*) *hecabe contubernalis* (Moore)
Eurema (*Terias*) *blanda snelleni* (Moore)
Eurema (*Terias*) *andersonii andersonii* (Moore)
Eurema (*Terias*) *lacteola lacteola* (Distant)
Gandaca harina distanti Moore

NYMPHALIDAE
Parantica aspasia aspasia (Fabricius)
Parantica agleoides agleoides (C. & R. Felder)
Ideopsis (*Radena*) *vulgaris macrina* (Fruhstorfer)
Euploea mulciber mulciber (Cramer)
Euploea radamanthus radamanthus (Fabricius)
Elymnias hypermnestra agina Fruhstorfer
Orsotriaena medus cinerea (Butler)
Ypthima baldus newboldi Distant
Ypthima horsfieldii humei Elwes & Edwards
Xanthotaenia busiris busiris Westwood
Zeuxidia aurelius aurelius (Cramer)
Thauria aliris pseudaliris (Butler)
Neptis clinia leuconata Butler
Neptis harita harita Moore
Tanaecia pelea pelea (Fabricius)
Bassarona recta monilis Moore
Bassarona dunya dunya (Doubleday)
Cyrestis themire themire Honrath
Cyrestis cocles earli f. *earli* Distant
Chersonesia rahria rahria (Moore)
Rhinopalpa polynice eudoxia (Guérin-Méneville)
Hypolimnas bolina bolina (Linnaeus)
Junonia iphita horsfieldi Moore
Junonia orithya wallacei Distant
Cirrochroa tyche rotundata Butler
Terinos clarissa malayana Fruhstorfer
Cupha erymanthis lotis (Sulzer)
Phalanta alcippe alcesta Corbet
Rohana parisatis siamensis (Fruhstorfer)
Libythea myrrha hecura Fruhstorfer

RIODINIDAE
Paralaxita telesia lyclene (de Nicéville)

LYCAENIDAE
Allotinus (*Paragerydus*) *unicolor unicolor* C. & R. Felder
Curetis bulis stigmata (Moore)
Curetis santana malayica C. & R. Felder
Castalius rosimon rosimon (Fabricius)
Caleta roxus pothus (Fruhstorfer)
Neopithecops zalmora zalmora (Butler)
Megisba malaya sikkima Moore
Euchrysops cnejus cnejus (Fabricius)
Jamides celeno aelianus (Fabricius)
Jamides pura pura (Moore)
Jamides malaccanus malaccanus Röber
Jamides philatus subditus (Moore)
Jamides caeruleus caeruleus (H. Druce)
Jamides elpis pseudelpis (Butler)
Jamides alecto ageladas (Fruhstorfer)
Jamides cunilda nisanca (Fruhstorfer)
Prosotas aluta nanda (de Nicéville)
Anthene emolus goberus (Fruhstorfer)
Arhopala democritus lycaenaria (C. & R. Felder)
Amblypodia narada taooana Moore
Loxura cassiopeia cassiopeia Distant
Cheritra freja frigga Fruhstorfer
Drupadia ravindra moorei (Distant)
Drupadia rufotaenia rufotaenia (Fruhstorfer)
Hypolycaena thecloides thecloides (C. & R. Felder)
Hypolycaena erylus teatus Fruhstorfer
Rapala varuna orseis (Hewitson)

HESPERIIDAE
Celaenorrhinus asmara asmara (Butler)
Gerosis limax dirae (de Nicéville)
Halpe porus (Mabille)
Koruthaialos sindu sindu (C. & R. Felder)
Ancistroides nigrita maura (Snellen)
Notocrypta paralysos varians (Plötz)
Isma bononia bononia (Hewitson)
Plastingia pellonia Fruhstorfer
Taractrocera ardonia sumatrensis Evans
Potanthus omaha omaha (W.H. Edwards)
Pelopidas mathias mathias (Fabricius)
Baoris farri farri (Moore)

Redtail Marquis (*Bassarona recta monilis*).

were basking or feeding on the ground as their movements were extremely fast. On the way out of the forest, a unique stingless bee's nest resembling a three-petalled flower was observed. The stingless bee was later identified as *Tetragonula* sp. There were some nests entirely made up of red soil or laterite with holes on the walls which we believed belonged to birds. After completing the first site at 2:00pm, the second was an open field behind a vegetable farm with swampy ponds. The vegetation was recently cleared as the cuttings were fresh. Most of the trees were cut and the field was left barren and parched. Sampling was done at the outskirts of the field where there is still some greenery. Despite the condition of the area, butterflies were present and what came to our surprise, was a single Rajah Brooke's Birdwing flying near us.

On the last day, the sampling commenced from the Gua Tempurung Recreational Park compound, traversed through a Pondok Sekolah Agama (Religious School Hut), some unmanaged abandoned land filled with many shrubs, and finally ended at the foothills of Gua Tempurung which we believe was not much disturbed. We trailed through the forest fringe next to the limestone walls and observed colourful butterflies flying gracefully before reaching the compound of Pondok Sekolah Agama. Among the butterflies found were Common Albatross, Chocolate Albatross, Common Bluebottle (*Graphium sarpedon*), and Lesser Jay (*Graphium evemon*). Common Jays and Spotted Zebras puddled in an emptied fishing pond in the vicinity of the school. Thereafter, we

Small and black *Rohana parisatis siamensis* puddled on the cow dung.

A few Blue Glassy Tigers (*Ideopsis vulgaris macrina*) imbibing juice from the injured part of the stem for alkaloids.

Gerosis limax dirae

walked along a small stream before entering the unmanaged abandoned land. Here, a beautiful, rare species of butterfly commonly known as White Dragontail (*Lamproptera curius curius*) was observed. Part of its forewing is transparent, with an exceptionally long and narrow hindwing tail in comparison to the very small forewing. The wings vibrated rapidly in flight, and even when it settled on the ground. Males are usually found in the vicinity of running waters, often puddling on the sandy shores or riverbanks. This genus usually puddles away from other butterflies, and they are very sensitive. Their flight pattern resembles a dragonfly, but they often fly closer to the ground. As we trailed into the forest, towards an abandoned field, lo and behold a 'minefield'. This had to be treaded cautiously as the field was full of cow dung. Butterflies were actively flying around the field, but what took our attention were the few *Rohana parisatis* that had landed on the cow dung in many spots. They uncoiled their probosces and imbibed the nutrient from the dung, unaware of our presence. This contrasts with the very sensitive behaviour when they were not feeding on dung on the second day. Along the way out, a few Blue Glassy Tigers (*Ideopsis vulgaris*) were seen to be attracted to a plant (possibly *Chromolaena odorata* (L.)) that had an injured side on the stem. This plant was reported to contain secondary metabolites—alkaloids that are used by some butterfly species as a chemical defence, causing them to be distasteful to predators and/or to produce sex pheromone to enhance male mating activity.

This maiden trip to Gua Tempurung had a fruitful outcome with more than 90 species of butterfly recorded. It was a big achievement for some of us to experience our first butterfly sampling and to learn proper sampling methods during fieldwork. The various landscapes such as limestone walls, forest strips, open fields and streams look promising for a high diversity of butterflies. We will come back again to complete the seasonality study when inter-state restrictions are eased. It is with great hope that more research can be carried out on the biodiversity of Gua Tempurung to create public awareness on the importance of conserving Mother Nature for future generations.

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Featured Insect

Introducing what I hope will become an *Antenna* staple – a featured insect! The aim is to highlight extraordinary aspects of selected species, that even many hardened entomologists will be unaware of. Please submit your own choice to antenna@royensoc.co.uk. Ideally, the articles will comprise 500 to 1,000 words, together with one excellent picture. For style guidelines, please see https://www.royensoc.co.uk/antenna-author-guidelines/.

Richard Harrington

Photo credit: Graham Shephard, Rothamsted Research.

The Giant Willow Aphid, *Tuberolachnus salignus*

My favourite insect species is the Giant Willow Aphid, *Tuberolachnus salignus* (Gmelin, 1790) from the subfamily Lachninae, a group of aphid species known to feed mostly on trees. It is probably not the most obvious choice, but hopefully I can convince you that it is a good one. It may not be charismatic or dangerous, and I cannot say it is an unsung hero either; there is not to my knowledge any positive ecosystem function associated with it, and it could even be argued that it is a bit of a nuisance on willow trees. I fell for it when it was the subject of study for my PhD. Now, everyone falls for their study species you might say, but I would disagree. I can think of at least a handful of insect species I would be happy never to encounter again. What *T. salignus* evokes in me is a sense of wonder, and I will explain why.

Although large for an aphid, it is only small in real life (up to 5.8 mm) and looks to my eyes like a miniature dinosaur, with its beautiful markings, the shark fin-shaped tubercle that we don't know whether has any function, and the cone shaped cornicles. It has a narrow host range, the main host being willow (*Salix* spp.), but it has been recorded on poplar (*Populus* spp.) and apple (*Malus* spp.), and last year there was a record of it on Quince (*Cydonia oblonga*) (Blackman & Eastop, 1994; Salisbury *et al.*, 2022). *Tuberolachnus salignus* is believed to be entirely parthenogenetic, with no records of oviparae or males reported (Blackman & Spence, 1996). This is where the mystery begins. In the UK it disappears for part of the year. It is not normally seen from late winter until summer and we do not know where it goes or how it 'overwinters'.

When I started my PhD, my supervisor Richard Harrington told me I wouldn't be allowed to complete my studies without solving this mystery. Well, I hate to disappoint, but I didn't. I did try very hard to find out as I outline below, and had the help of a great supervisory team (in addition to Richard, there were Tilly Collins, Simon Leather, Steve Hanley, Angela Karp and Ian Shield), but to no avail, and the conundrum remains.

Firstly, we did a population genetics study using microsatellite markers to confirm or otherwise the parthenogenetic nature of the species, and we only found 16 separate genotypes in 660 specimens from 27 populations in five countries. Two genotypes dominated, constituting over 65% of all individuals sampled. These two genotypes were also geographically widespread, and one of those was found in the U.K. from Dorset to the Orkney Islands, as well as in the U.S.A., Canada, Spain and Sweden (Aradottir *et al.*, 2011). We concluded that this avenue was therefore closed, and that *T. salignus* was unlikely to overwinter as an egg.

As part of the work, I had a field trial of coppice willow running for two years, so my next avenue was to monitor the populations over time. Despite at least weekly inspections, the aphids appeared in my field trial only in August or September and disappeared in December or January in 2007 and 2008, respectively (Aradottir, 2010). I remember intently following the last remaining adult and her two nymphs into January in the second year until they disappeared without a trace, so that came to a dead end also.

The next avenue was to take some aphids and set them up in a controlled environment cabinet at Rothamsted Research and slowly bring the temperature down. This also failed to give any hints of overwintering behaviour before the cabinet gave up the ghost after a period at 5°C and I became rather unpopular with the facilities staff.

The last avenue I pursued was to get the farm staff at Rothamsted with a JCB to help pull up established willow trees from other trials, after which I painstakingly sifted through the soil and looked around the root mass to see if I could find any evidence of them going to ground, so to speak. This didn't yield any results either, and by this point I had managed to get enough other data on its host preferences, chemical ecology, population genetics and dynamics to submit a thesis that passed muster, so my efforts stopped there.

In the 13 years since I completed my studies, there hasn't been a single year that I haven't been asked about this. The remaining mystery niggles away at entomologists and those that learn about this enigmatic species. Scientists from New Zealand, where *T. salignus* was discovered in 2013 and has quickly become widespread, have reported similar population dynamics, but they find them on willows all year round, with low populations hidden between petioles and stems in July to September (Sopow *et al.*, 2017). Could I possibly have missed that in my field trials?

The team at Harper Adams appealed through the media to ask the public to help, by sending records of any sightings of the aphids in 2016 (Gregory-Kumar, 2016) and this spring the Royal Horticultural Society are once again asking for help with tracking this elusive aphid species (Horton, 2023).

I believe the readership of *Antenna* would be the perfect group to help solve this puzzle once and for all.

Gia Aradottir
Mamore Research and Innovation Ltd.

Photo credit: Graham Shephard, Rothamsted Research.

Latin name: *Tuberolachnus salignus* (Gmelin, 1790)
Common name: Giant Willow Aphid
Order: Hemiptera
Family: Aphididae

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OPINION PIECES

An obsession with ‘pollinators’: is this missing the point?

Common Angelica (*Angelica sylvestris*) with large numbers of Calliphoridae and Scathophagidae in attendance – a not uncommon sight in north-west Scotland where the climate is cool and wet (the large species with a yellow face is *Cynomya mortuorum*).

Introduction

Anybody scanning the voluminous list of papers on ‘pollinators’ might be forgiven for thinking that bees (Hymenoptera, Anthophila) and hoverflies (Diptera, Syrphidae) are only of any value as pollinators, and that all bees and hoverflies are pollinators. Is this really the case? Moreover, is the research agenda so overwhelmed with pollinator projects that more critical ecological functions of some pollinating insects are being overlooked?

In the case of bees, perhaps the emphasis on pollination is justifiable because there is a direct link between flower availability and breeding success, as most bees depend upon a pollen source to provision their brood chambers. Measures to increase ‘floweriness’ are arguably ‘good for bees’ – or are they? After all, healthy bee populations require a combination of landscape attributes to maintain populations. Not only do they require suitable (and adequate) nectar and pollen sources but they also require suitable nesting sites such as bare ground or short turf, snail shells, exposed dead timber with beetle burrows, hollow-stemmed plants or cliffed bare ground (See Else and Edwards, 2018 for detailed life-histories).

Not only are nesting habitats important but the composition and pH of the soil can be significant, as can aspect and drainage, some of which may relate to the presence of particular plant species. Some bees have very close relationships with individual plant species, *i.e.*, they are ‘oligolectic’. Within the British bee fauna, species such as *Andrena clarkella* (visits *Salix* flowers), *Andrena florea* (visits *Bryonia dioica* flowers), *Melitta haemorrhoa* and *Chelostoma campanularum* (both visit Campanulaceae flowers) are clearly close associates but may not be the major pollinator. For example, Red Bartsia (*Odontites vernus*) is visited by a wide range of bumblebees (*Bombus* spp.) but also supports the oligolectic bee *Melitta tricincta*. Similarly, male catkins of sallows (*Salix* spp.) are visited by a huge range of bees and flies; so, in itself, *Andrena clarkella* is unlikely to be a critical pollinator. In these and many other oligolectic species, general measures to increase flower availability may be of little or no consequence. In my local ‘patch’ for example, *Andrena clarkella* is very scarce, yet there are plenty of male *Salix caprea* and *Salix atrocinnerea* bushes; some other factor is affecting what used to be a thriving population in the 1980s.

The burgeoning ‘pollinator’ literature rarely, if ever, pays any attention to such issues. So, one has to ask whether the research agenda is really aimed at ‘pollinator’ conservation and enhancement or whether it is just an easy way of attracting research grants to generate more papers that will have little or no benefit to the specialists within the pollinator assemblage. Measures such as ‘bee hotels’ attract a lot of research interest, but the value of such measures is unproven (MacIvor and Packer, 2015; Geslin *et al.*, 2020; Rahimi *et al.*, 2021; Hodge *et al.*, 2022). This developing research suggests that such measures are highly unlikely to benefit specialists but arguably give the wider public the idea that they are solving the pollinator crisis. They are not! So, there is a fundamental difference between increasing the opportunities for ‘pollinators’ and improving the fortunes of the rarest and most specialised ‘pollinators’.

Roger Morris
Hoverfly Recording Scheme
syrphid58@gmail.com

Are ‘pollinators’ a distraction or an opportunity?

The issue of pollinator research being a distraction is arguably far more serious for other flower visitors such as flies and beetles. Increasing the numbers of flowers may mean that more ‘pollinators’ are observed; but do more pollinator observations equate to more pollinators? Equally, is the highest priority to extend studies of flower-visiting when so little is known about the larval biology of the majority of ‘pollinators’. Surely, if the ‘pollinator crisis’ is to be fully understood and resolved, much more needs to be known about the vulnerabilities of juvenile stages that exist for far greater lengths of time than the short lives of the reproductive and dispersive stages.

In the case of insects that rely on flowers as a source of energy and protein for egg maturation (as in the case of some hoverflies – Rotheray and Gilbert, 2011), is flower availability necessarily the limiting factor? For example, there has been extensive research into the ecology of the hoverfly *Hammerschmidtia ferruginea* that has shown that the hoverfly’s abundance is a direct reflection of available larval breeding resources (Rotheray *et al.*, 2008). In this case, the larvae develop in decaying sap under the bark of large fallen Aspens (*Populus tremula*). Early research suggested that Aspen woods of at least 4 ha were required to maintain a constant supply of fallen Aspen, but latterly it has been found that the hoverfly will travel several kilometres in search of suitable habitat (Rotheray *et al.*, 2014). As such, it seems more likely that at least some specialists exist as metapopulations rather than as discrete populations associated with a definable ‘site’.

Thus, there is a need to think about conservation of at least some ‘pollinators’ as the provision of suitable habitat within a wider patchwork of habitat. The guild of decaying sap-feeders is useful because it highlights how ephemeral some habitats are. There are several similar examples amongst hoverflies, including the elusive genus *Brachyopa* that is rarely seen by any but the most skilled recorders. Beyond hoverflies, this relationship has largely been unexplored, but the concept of high dispersal characteristics seems likely to occur amongst other Diptera such as the Lonchaeidae and some specialist Stratiomyidae whose larvae also utilise decaying sap. These animals are a useful proxy for many other assemblages such as those that feed on fungal fruiting bodies and hyphae that are in themselves simply a stage in a continuum of habitat evolution.

In ecological terms, one must therefore think about the transience of suitable habitat and the need for habitat continuity in a wider matrix of ever-changing habitat. Species that utilise transient habitats must be highly mobile and capable of seeking out new exploitable resources, whereas those that inhabit long-term features have less need to do so. Yet, it might be suspected that those species that inhabit long-term features are potentially even more vulnerable if those features depend upon critical physical drivers. An obvious example is aquifers that support seepage lines and permanent wet features that disappear during extended periods of drought.

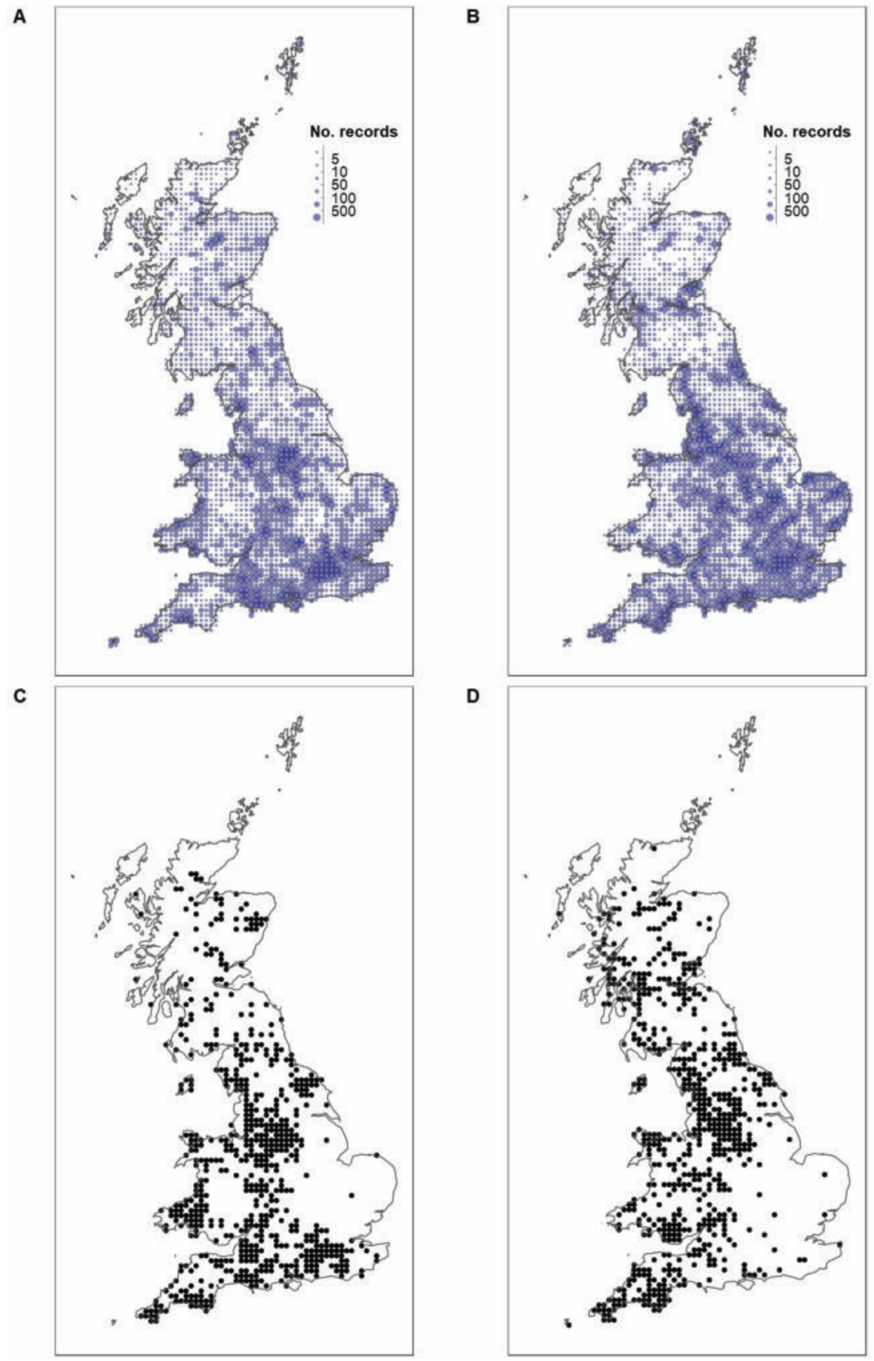

Figure 1. Observed distribution in GB: number of records of all species of hoverflies received from each hectad represented by the area of the symbol (capped at 1,000) and hectads from which *Leucozona glaucia* was recorded. A – total records of all species per hectad 1980-1999; B – total records of all species per hectad 2012-2021; C – hectads where *L. glaucia* was recorded 1980-1999; D – hectads where *L. glaucia* was recorded in 2012-2021. (After Ball & Morris, 2022)

Shifting attention onto a wider suite of drivers of 'pollinator' decline is arguably essential if the full range of pollinating insects is to be conserved and enhanced. Do we know that an absence of flowers is really the pivotal factor in the loss of, for example, the 'Hogweed fauna' (Hogweed = *Heracleum sphondylium*)? In my formative years, a bank of Hogweed flowers in June and July in southern England was a great recording opportunity, with innumerable flies, beetles, solitary and social bees and wasps in attendance. Some of those species are still present but in much-reduced numbers, whilst others have almost entirely disappeared from southern England (*e.g.*, the spectacular bluish hoverfly *Leucozona glaucia*) despite there being no shortage of the Hogweed that they visit. *Leucozona glaucia* remains widespread and often abundant in northwest England and Scotland but has gone from southeast England (Ball and Morris, 2022) (Fig. 1). Those traditional enemies of insects, pesticides and land-use change, might be blamed, but the loss of species that are fundamentally confined to the forest-belt in southeast England raises the possibility that other factors beyond traditional culprits are at least partly to blame. What are they? A possible answer is climate change (Morris and Ball, 2021) – but where is the evidence? Apart from opportunistic data, that have innumerable biases (Ball and Morris, 2021; Ball *et al.*, 2021), there are precious few long-term datasets that shed light on anything other than moths, butterflies and aphids, almost all of which are phytophagous and therefore are poor proxies for a huge wealth of saprophages, filter-feeders, predators and parasites, many of which are also part of the 'pollinator' guild.

A need to shift the debate and research agenda

Pollinators have been a very effective way of generating research grants, but the question must be posed: is the current level of interest generating answers that will solve the crisis, or are research directions acting as a distraction from the bigger questions? Are flower shortages the real issue, or have habitats changed so much that once-common species have disappeared? The changes need not necessarily be in physically-visible features such as a decline in hedgerows or in woodland cover.

Leucozona glaucia (and the beetle *Rhagonycha fulva*) at hogweed. Once a common sight in woodlands in Surrey and Sussex, it has now almost completely disappeared.

Hammerschmidtia ferruginea at Rowan (*Sorbus aucuparia*) blossom. Females rely on pollen to supplement protein levels for egg production.

They might be far less visible but equally pervasive, such as extending the duration and intensity of soil moisture deficits during the summer months.

If a change in the duration of wet/dry seasons can be proposed as a driver of insect decline in the tropics (Janzen and Hallwachs, 2021), why cannot an increase in the intensity and duration of soil moisture deficit be considered important in temperate ecosystems? After all, in northern Europe, and especially on Europe's humid Atlantic coast, the fauna has a strong association with rainfall and humidity, with gradations between species favouring Mediterranean, Boreal and Atlantic climates, as illustrated by the Corrine vegetation classification that underpins the European Union's *Habitats Directive* (European Environment Agency, 1991).

Soil moisture can have a huge bearing on insect abundance. This is well-proven by work on re-wetting uplands (Carroll *et al.*, 2011, 2015) and by studies of soil invertebrate abundance in relation to feeding thrushes (Peach *et al.*, 2004). Yet, there seems to be very little published information on the effects of drought on soil insect faunas, especially upon flies whose larvae inhabit such media (some, such as the Bibionidae, feeding on plant roots *etc.*, and others, such as the Empididae, as predators of plant feeders). The most frequently-quoted paper on this subject appears to be Briones *et al.* (1997), but with very little subsequent work. This lack of detailed research appears to be an important oversight if progress is to be made on better understanding why pollinating insects are in decline and why higher parts of the food chain such as birds are also in decline (Pearce-Higgins and Morris, 2023).

An equally important issue concerns changes in humidity levels in woodlands and changes in the distribution, duration and intensity of water-saturated soils across Britain and northern Europe. Flies, in particular, offer important research opportunities because they occupy a wide variety of niches, often occur in considerable numbers and underpin a substantial part of the vertebrate food chain (Pearce-Higgins and Morris, 2023). Some are doubtless 'pollinators', but is this really the most important attribute when their overall abundance suggests that they are more critical to ecosystem function as decomposers, regulators and as a food source?

Whilst the range of habitat associations of the Diptera is vast, hoverflies are a useful proxy for other Diptera families because they have so many different life-histories. This range extends from internal stem- and leaf-feeders to miners of roots, rhizomes and bulbs; external grazers on roots; carnivores feeding on aphids, beetle and lepidoptera larvae; filter and detritus feeders, and consumers of fungal hyphae and inhabitants of dung and other decaying organic material. It does not include internal parasites, for which the closely-related Pipunculidae are useful examples. The fact that some, but not all, are active flower visitors simply allows them to be labelled as 'pollinators' rather than as bellwethers of ecosystem function. They arguably offer an important and accessible opportunity as such, providing an avenue of research that utilises the 'pollinator' label to drive potentially important investigations into the multifarious factors that are potentially driving catastrophic insect decline.

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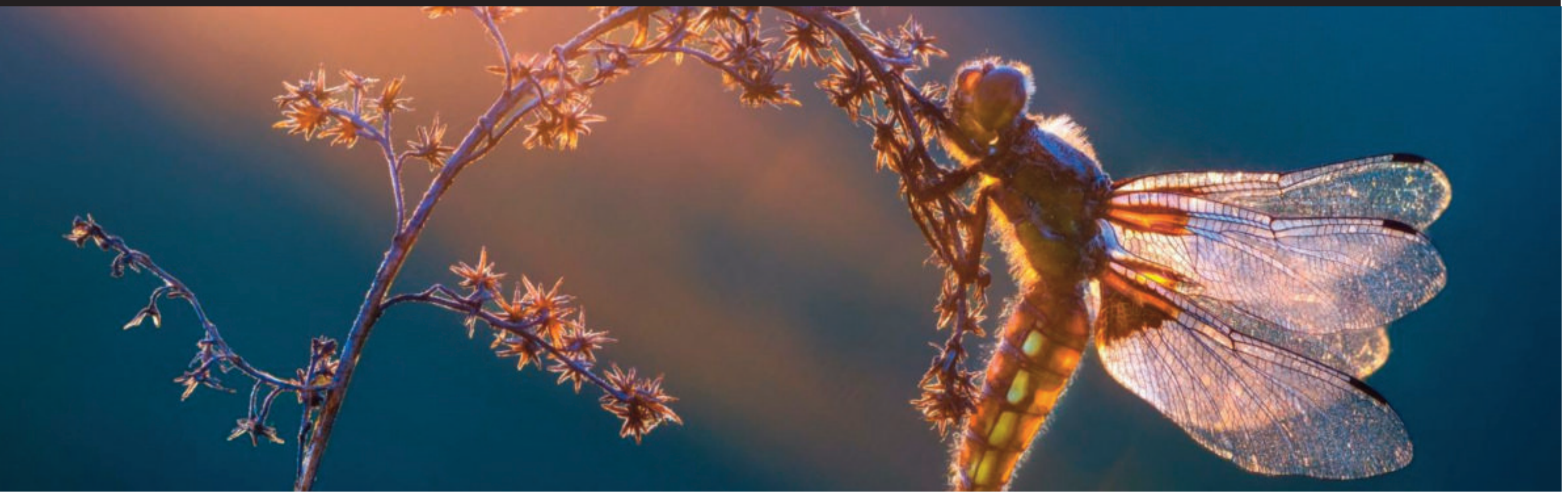
Royal Entomological Society

Society News



Libellula depressa Credit Petar Sabol

News from Council

Council Meetings

Council met online on 8th February and 27th March 2023. All agreed on the desirability for an option to meet in person for one of the next two Council meetings.

CEO's Report

Simon Ward presented a RAG (Red, Amber, Green) analysis of key objectives of the Society's strategy. Most were green and a few were amber, indicating good progress overall. Of particular note was that membership had exceeded 2,000 for the first time, with members in 69 countries. The Chelsea Flower Show garden was proceeding well, although there were issues around its relocation. The data protection policy and privacy notices had been updated to comply with legislation. Legal advice had been received that the Society should trademark its name and logo. Funding had come through from Natural England's Species Recovery Fund for work at Daneway Banks. The RES team had attended various events to promote the Society and forge links. The new Events Manager and Business Development Manager had started work.

Matters for Discussion

Draft policies on acceptance & refusal of donations, complaints, conflicts of interest, ethics, fundraising, due diligence, and partnerships & business were discussed, amended and accepted. There was also discussion on how to proceed with a reserves policy.

Plans for the future of the headquarters were considered in further detail following receipt of relevant information, and the decision-making process moved forward.

Matters for Decision

Following a review of investment management, advised by the Society's auditors, a decision was made to appoint Barclays Private Bankers to manage the Society's investment portfolio. This followed a tender process resulting in eight bids, which were considered by a subcommittee of the Finance Committee against performance, investment style, volatility and fees.

Following a review by the Finance Committee to take account of changes in the external economic landscape, a revised budget and business plan with a lower deficit for 2023–2024 was presented and accepted.

The signing of a new 25-year lease jointly with the Gloucestershire Wildlife Trust for the management of Daneway Banks was approved.

Following the withdrawal of a sponsor, a decision was made to underwrite the cost of relocating the Chelsea Flower Show garden to the Olympics Park area in London, although it was expected that alternative sponsors could be found. Relocation is a requirement of the grant received from Project Giving Back to fund the garden.

It was agreed to licence the digitisation of the RES archive to Wiley, but the Society will maintain full ownership.

Matters for Information

Brief reports were received from the Library Committee, Membership Committee, Finance Committee and Health & Safety Group.

Simon Ward
Chief Executive Officer

RES Committee Changes

The RES strategy that was launched in 2022 is ambitious, with the aim of increasing the impact and relevance of the Society as well as ensuring its future sustainability. To help ensure the success of the strategy and to build on the governance review of 2020 and 2021, the Society undertook a full review of its committee structure.

As part of this, each committee has new terms of reference and criteria to ensure that the structure of each includes those in their early career as well as more experienced Members and Fellows. In addition, there are clear criteria around equity, diversity and inclusivity. Each committee has a stated membership number and an open application process for roles.

Some committees have significant changes. The remit of the Outreach Committee was too big and that made it unwieldy to manage. It was agreed to split this committee, and so a new Education and Training Committee is being created. This committee will oversee areas such as professional development for members, new education programmes for schools and the review and development of the university student bursary scheme.

The Conservation Committee is becoming part of a wider Science, Policy & Society Committee. This is partly to reflect the direction of universities and institutions which are taking a more interdisciplinary approach, but also to ensure we can represent all areas of insect science when it comes to commenting on societal issues. Conservation will be a significant part of the remit of this committee and the RES remains strongly committed to this area, with the addition of David Simcox as the RES Conservation Manager and Sarah Meredith as RES Conservation Project Officer. The new Science, Policy & Society Committee is chaired by Dr Lynn Dicks, who has also recently been appointed to the board of Natural England.

The Publications Committee has also changed as all editors of each publication sat on the committee, which meant it was very large. The new committee has a more strategic focus and represents each journal, handbooks and *Antenna* as well as having some new independent members.

The Society will advertise any positions on committees as they become available and would welcome applications across the membership. Often these will be displayed on the RES website and through the monthly newsletter.

Simon Ward
Chief Executive Officer

RES Success at the Transform Awards Europe

Following the RES brand strategy development work over the past two years, the Society and its partner, Threerooms, were shortlisted for two awards at the Transform Awards Europe. The awards ceremony took place on the 22nd March in London. The RES and Threerooms won silver for 'Best internal communications during a brand development project' and bronze for 'Best visual identity by a charity, non-government organisation or not-for-profit'. The RES is extremely proud to have won these two awards which will help to increase our impact.

We are also waiting to hear if we have been shortlisted for any awards at the Memcom awards in September. Memcom is the senior leadership network for the professional membership sector.

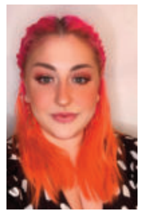
Raising our profile with these awards allows us to gain more attention, which can help to build global partnerships and funding opportunities and further our vision to enrich the world with insect science.

Simon Ward
Chief Executive Officer

Royal Entomological Society

RES Student Award 2022

1st



Duran Nanson
Harper Adams University

THE ENTOMOLOGIST

theentomologist.com *Delivering insect news on the fly* Est. 2022

Could the Pygmy Hog-Sucking Louse be the new mascot of conservation?

Sat by the roadside feeling the glorious December chill, I explained to the recovery driver rescuing me after an unfortunate incident involving an exploded tyre that I was so far from home due to university. He politely asked what I was studying, but instead of the usual confusion and thinly-veiled distaste I've come to expect from my answer, I was taken aback by his delight. "Entomology! That's amazing! I mean, without insects we'd be doomed*, right?". Noticing my reaction, he told me, "I'm not like other people, y'know. I really understand how important bugs are."

This simple and brief exchange has been on my mind for weeks. How can it be that insects are thought to constitute up to 90% of all animal species[1], yet are often disregarded as nothing more than mere pests and carriers of disease by the general public? Why are they so greatly undervalued and underrepresented within conservation strategies worldwide[2]? When you think of endangered animals and the charities that seek to protect them, what do you envision - pandas, leopards and rhinos, or grasshoppers, beetles and flies? Whilst the former undeniably do a fantastic job of attracting attention and catalysing the necessary action, it seems as though they undermine the perhaps less obviously visible decline of smaller organisms that are critical in the proper functioning of our ecosystems[3,4] and negatively impact the wider public perception of wildlife in general[4].

So, why don't we see more insects as the figureheads of conservation?

Is it because they simply aren't as cute as little baby turtles, as engaging as great apes or as awe-inspiring as the giant whales? In a word, yes. Picture this, if you can (or take a look at the image above if you can't!) - the famous panda we've all seen fronting a leading

conservation charity, replaced by the image of the charmingly named Pygmy Hog-sucking Louse. Pin badges or cuddly plush toys of this mascot may be a little harder to shift, I feel – societal preferences play a huge role in conservation strategies, and the simple truth is that it's far more difficult to prioritise or obtain funding for researching animals that don't interest or warm the hearts of the general public[5]. Consequently, this means there are huge groups of insects that are poorly studied (if at all), making it exceedingly challenging to protect or even understand them at a basic level. The IUCN, the organisation responsible for curating the Red List as a tool for collating data on current endangered species, have themselves acknowledged that their surveys favour terrestrial animals within certain ecosystems and have vowed to prioritise invertebrates such as butterflies and bumblebees in future assessments[6]. A step in the right direction, of course, but still displaying that there is a preference towards the creatures that benefit humans through food security (*i.e.,* pollination) as opposed to invertebrates in their entirety[2]. This raises the question - are insects only appealing/important to us as humans when they serve an obvious purpose? If that is the case, have our views really evolved since Descartes proposed that animals are no more than automata, simply existing in a world to assist with the functions that benefit mankind[7]?

Scientists have estimated using the fossil record that current extinction rates are around 1,000 times higher than expected, making the protection of our biodiversity perhaps more important now than ever before[8]. Alas, as with many things in life, it is critical to find balance in order to achieve success. Whilst it is somewhat frustrating as an entomologist to see the charismatic megafauna fronting conservation efforts and channelling funds away from the less visible but ecologically significant invertebrate species, I would be remiss to deny that they highlight vital global issues and capture the hearts of the public, drawing interest in conservation science that may not otherwise be there.

Until more research is carried out and gaps in invertebrate knowledge are at least partially filled, it seems almost unreasonable to expect people to care about a tiny world below our feet that we don't yet fully understand. Until that day comes and insects can stand alone in their fight to be recognised, I will remain hopeful that I meet more people like that recovery driver and that the ignorance of 'the other people' he spoke of can steadily be dispelled. Although I have to admit, I'm not sure that even then we'll see lice representing any organisations - perhaps a parasite isn't the best place to start with winning hearts and minds in a world that is already challenging for our insect species.

*actually, much more colourful language was used but changed for the purpose of this article - rest assured, the sentiment remained the same.

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2nd

Alexander Wellington
Cardiff University

You'll either love them or hate them – and I'm not talking about 'Marmite'.

Maggots!

Yes, you heard correctly … maggots; dipteran larvae or simply 'grubs'.

The mere mention of maggots will make your stomach churn like an out-of-balance washing machine, and without a second thought you've labelled them as vile and repulsive. Whilst their beige and unassuming looks seem unthreatening and are often the perfect practical joke whenever rice is on the menu, when they are munching on your open wounds, you can't help but scream, "*ewwwww*!"

At any given time, the common Greenbottle fly (*Lucilia sericata*) can smell decaying flesh from up to 10 miles away and can lay up to 150–200 eggs[1] (a total of 2000–3000 eggs in her lifetime!). Maggots feed for the next 3–-5 days and if you thought they needed teeth, you're in for a surprise! They are "nothing more than a basic eating machine," as Erica McAlister, author of 'The Inside Out of Flies'[2] simply puts it. They exude antimicrobials and digestive enzymes which liquefy decaying tissue and kill any harmful bacteria. They rub their entire rough exterior like gooey Brillo pads and extend their mandibles or 'mouth hooks' to burrow into and scrape off any decaying tissue they can slurp up[3].

Try to imagine these small, squirmy creatures as tiny healers which, when all else fails, work tirelessly to treat wounds, remove dead tissue, and combat bacteria. Moreover, with increasing rates of diabetic ulcers and superbugs sweeping hospitals, it's no surprise they're making a comeback.

A 2009 UK study of 267 persons with venous leg ulcers found that maggots outperformed conventional therapies at debriding infected wounds[4]. Furthermore, according to a study conducted at the West Cumberland Hospital, all infected ulcers recovered after just one session of maggot therapy, but 66% of patients who received conventional therapies remained in hospital for an additional month. Needless to say, maggot therapy was more effective and vastly more cost efficient![5,6] More recently, a team of surgeons at the University of Southern California demonstrated the potential of maggot therapy via telemedicine.

You may be asking yourself: why are we just hearing about it? The short answer is – we're not. Maggots have been used to treat wounds as far back as man could write (5,000 years!), with some of the earliest accounts dating back to ancient Native American, Aboriginal and Mayan societies. Mayans would soak their bandages in cattle blood and wait for them to squirm underneath. Legend states that Genghis Khan never entered battle without a wagon full of larvae close behind. But it wasn't until the American Civil War when Dr J.F. Zacharias, a confederate medical officer, purposefully exposed his patients' wounds to maggots, that the first documented therapeutic use of maggots occurred. Fast-forward to the golden age of maggot therapy: the 1930s, when maggots were widely used by thousands of physicians and mass produced by renowned pharmaceutical conglomerates like Wyeth (currently Pfizer). However, this was short-lived, as Alexander Fleming's 1928 discovery of penicillin became commercially available in the mid-1940s, forcing maggots into early retirement – "a therapy the demise of which no one is likely to mourn" said microbiologist, Milton Wainwright.[7,8]

It wasn't until 50 years later that parasitologist Mumcuoglu saved a patient's left leg from amputation by advising the physician on the possibility of maggot therapy. And just like that, maggots were resurrected form the history books.[7] Maggot factories were soon established in Wales, Germany and Belgium and in 2004, maggots became the first living creatures and only one of two (the other being leeches) to be approved for medical use by the Food and Drug Administration.[9]

Even so, maggots can't seem to get past their own *grossness*! According to Swansea University's newly launched campaign, 'Love a Maggot!', only 30% of people would agree to maggot therapy and many were only willing if the pain was too great[10]. In contrast, as part of a shocking investigation conducted by Dutch physicians in 2002/3, 94% of patients who had received maggot therapy said they would recommend it to others despite the itching and the odour.

So, the real question is: how can we make maggots more appealing? The solution, according to researchers at BioMonde in Bridgend, South Wales, is maggot 'tea-bags'. Maggots can be prepared for next-day delivery to hospitals and health facilities across the country through suspending the larvae in saline and concealing in a net dressing or 'biobag'[11].

Still, maggot therapy is rarely used despite studies having linked pre-amputation maggot therapy to saving 40–50% of limbs. With an increase in diabetes-related lower limb amputations of over 18% across England, that's more than 176 leg, foot or toe amputations being carried out on a weekly basis[12], should we really be so squeamish and give nature's miniature healers a fighting chance?

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3rd

Gaia Mortier

University of Reading

TO FLEA, OR NOT TO FLEA:

The Curious History of Flea Circuses

Step right up and stay to learn about the strange history of these famous insect performers! Flea circuses found their origins back in the 16th century, at a time when watchmakers and blacksmiths took to making miniature sculptures[1]. In order to demonstrate their skills, they made intricate metal designs, such as functioning locks, weighing 'but one grain of gold' (c. 65 mg)[2]. Human fleas (*Pulex irritans*) were chosen to show off these lightweight works of art, being attached to them with tiny harnesses – as they lifted them off the ground with ease. This set in motion a domino effect, and several centuries later, in the early 1800s, Louis Bertolotto became one of the first and biggest names in the flea circus world. Yet, to many of us living in the 21st century, flea circuses are but a distant memory, merely a fairy tale hinted at in modern media. So – what happened?

I hope that I shall never see
A poem as ugly as a flea
- Savino, n.d.

To fully understand this mysterious rise and fall, it is important to question why, out of all the millions of insects, the human flea was chosen as star of the show. They don't exactly have the most charismatic appearance and have been considered a nuisance for thousands of years[3]. Furthermore, in the 19th century they were retrospectively blamed for the spread of the Black Death; a 14th-century outbreak of the bubonic plague (caused by the bacterium *Yersinia pestis*) that ultimately led to the death of more than 200 million people. However, this has since been contested and researchers are now pointing the finger at alternative explanations[4,5].

The first, and most straightforward, reason was ease of access. The aptly named Human Flea (*P. irritans*) lives in intimate proximity to humans and their settlements. Mere centuries ago, they were one of the most common household pests across the globe[5]. It was therefore easy for the circus ringleaders, or flea professors as they preferred to be called, to maintain a steady stream of new performers. Yet, the human flea was chosen out of more than just convenience.

They have a trick up their small sleeve that makes them the ideal circus performer: the ability to jump up to 38 times their body size in only 1/1000th of a second[2]. They evolved this ability in order to access hosts to feed on their blood and to avoid predation, as they are wingless and thus lack the ability to fly. Unlike lice (small wingless insects that spend their entire life cycle on a host), fleas only attach to their host during feeding, after which they jump off[6,7].

For decades the strength possessed by these small beasts puzzled researchers, as jumping fleas seemed to exert a force more powerful than their muscles alone should allow them to. The secret was found to be a rubber-like protein called resilin, which is capable of bending and storing great amounts of energy[8]. In fleas, resilin is stored in their large hindlegs. When this great burst of energy is released, fleas are catapulted forwards – allowing them to glide through the air like true acrobats. It furthermore allows them to push, pull and drag objects numerous times their body size in order to amuse the circus-loving masses.

The supporters of the women's rights movement will be delighted to know, that my performing troupe all consists of female (fleas), as I have found the males utterly worthless, excessively mulish, and altogether disinclined to work.
- Bertolotto, n.d.

Alas, nothing lasts forever, and there is a rather simple reason behind the disappearance of this fantastical form of entertainment. The flea circus craze reached its peak in the early 20th century, as the travelling shows featuring fleas performing various tricks and stunts had taken Europe and the United States by storm. But the post-WWII widespread distribution of the vacuum cleaner led to an increase in hygienic conditions in people's homes, resulting in a rapid decline of Human Flea populations.

"So," you wonder, "*why not just use a different type of flea*?". After all, there is more than one species of flea, around 2,500 worldwide, in fact. As it turns out, they tried exactly that, but found that other species (such as the Cat and Dog Flea) lacked the strength needed to pull forth the circus contraptions[9]. And thus, the art of the flea circus slowly died out. With its final breath, it spread the popularity of the 'fake flea circus'. Instead of real, live fleas, small magnets or mechanics (sometimes containing dead fleas for added realism) were used to simulate the experience. The few remaining shows that were still using live fleas were accused of faking the acts, spreading the idea that *real* flea circuses must have been nothing but a popular myth.

Throughout the decades that followed, this is what people started to think the flea circus shows had been all along – nothing but a facade. But, for those who know and understand their complicated story, Furgurson[2] did an excellent job at summarising the curious truth:

"In the beginning, there were fleas."

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Investigations on the biology of predatory mites (Acari) and an awareness campaign of these biocontrol agents to the local community

Fazeela Saleem and Bilal Saeed Khan
University of Agriculture, Faisalabad
fazeelasaleem928@gmail.com, bilalentomologyuaf@gmail.com

(Left to right) Muhammad Hashim (grower of potatoes and sugarcane), Ali Hussan (grower of wheat and cotton), Fazeela Saleem (ORF award recipient), Muhammad Aneeb (grower of ornamental plants and M.Sc. student), Abu Bakar (grower of wheat and vegetables), all displaying the leaflet developed as part of the Outreach grant.

With the help of a grant from the Society's Outreach Fund, Fazeela Saleem and Bilal Saeed Khan (Department of Entomology, University of Agriculture, Faisalabad) investigated the potential of a range of predatory mite species in the control of phytophagous mites on various crops in Punjab, Pakistan, sharing their findings with the local community.

A full copy of their informative and interesting report is available directly from the Society. Please contact info@royensoc.co.uk for your copy.

Grand Challenges in Entomology

Emilie Aimé
emilie@royensoc.co.uk

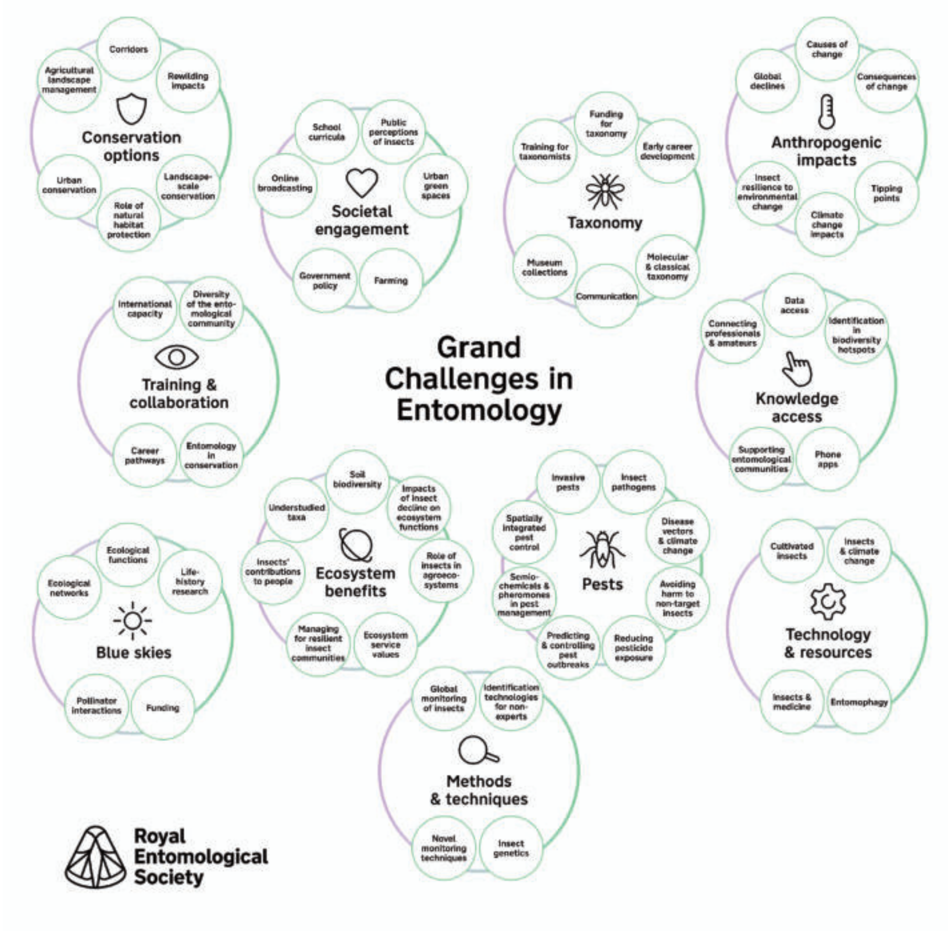
In March a paper was published in *Insect Conservation and Diversity* which was the culmination of several years of hard work from the authors. The Open Access article **Grand challenges in entomology: Priorities for action in the coming decades**, sets out the areas of insect science that require the most urgent attention to conserve insects and the important services that they provide, helping people and global biodiversity to flourish.

RES Members and Fellows, and members of our Special Interest Groups were invited to submit suggestions for what the grand challenges in entomology should be, resulting in an initial list of 472 topic suggestions after removal of duplicates. After a further process of prioritisation by the RES membership, the authors of the paper came together in an online workshop to group and further prioritise the challenges, resulting in a final list of 61 challenges, grouped under 11 themes, within 4 larger groupings (see infographic below and included with the President's letter on page 58):

1. Engagement – the need for everyone, everywhere to notice and be curious about the miniature world of insects and the responsibility of entomologists, those who study insects, to share their knowledge and inspire learning and discovery.

Grand Challenges in Entomology

Members of the Royal Entomological Society have developed the priorities for action in insect science. 61 challenges grouped into 11 themes were identified to addressing global issues related to human health and well-being, and environmental change. Find out more details at https://resjournals.onlinelibrary.wiley.com/doi/10.1111/icad.12637



2. Curiosity science – a shift in the scientific approach to insects is evident with a clear desire for better identification, understanding and research into species with greatest potential for human benefits.
3. Conservation – recognition that global insect decline, brought about by human impacts, is a serious problem and that we have a collective responsibility to protect and encourage insect life in order to safeguard our global future.
4. Human-insect relationships – a desire to better understand how humans and insects can and should co-exist and how one cannot thrive without the other.

The work was led by Sarah Luke at University of Nottingham and Lynn Dicks at University of Cambridge, and Vice President of the RES. Lynn said of this work:

"As an active and thriving community of scientists, who have often gone quietly about the business of increasing knowledge and advising policy, we must become much more vocal about the importance of insects, highlighting their vital importance to the lives of much better-known and documented (usually larger) animals and plants. Put simply, ecosystems rely on insects, and humans have an essential role to play in their survival – it's now up to the entomological community to inspire and enthuse people everywhere to look more closely at the fascinating miniature worlds that insects inhabit. After all, the vast majority of animals on Earth *are* insects."

Commenting on the significance of this report in setting the agenda for insect science over the next decade, Professor Jane Hill, RES President, said:

"This is a watershed moment for the Royal Entomological Society and our diverse membership of insect scientists across the world. As a global community, we have never been clearer about our knowledge gaps and the challenges we face in closing them to achieve the 30x30 goals agreed at COP15 in December 2022. This is our roadmap for insect research and education outreach for the next decade and beyond, and we now have a collective responsibility to channel global scientific effort, attract sufficient funding and inspire the next generation of insect scientists to meet the priority challenges we have identified and agreed."

Simon Ward, RES CEO, said:

"It is no coincidence that this report is published at a time when biodiversity loss, including the unprecedented loss of insects in the UK over the past decade, is in the media spotlight. The climate emergency and its associated environmental damage can seem overwhelming. Yet we know that given the right habitats and food sources insects can and will recover. The endangered Large Blue butterfly, which will star in BBC Wild Isles this week, is thriving at Daneway Banks, the nature reserve in Gloucestershire we manage in partnership with Gloucestershire Wildlife Trusts, and this is just one example of how resilient and adaptable these incredible creatures are. Our mission is to enrich the world with insect science and with the support of insect champions everywhere, we can and must meet the challenges set out in this new report."

The grand challenges outlined in this paper will inform the future strategy and activities of the Society, from our publications, to our events, to our engagement work. The published article is a fantastic output from a fantastic team, and it's exciting to have clear scientific grounding for our future endeavours – this paper is just the start.

ENTEAM

Entomology at Forest Research, Alice Holt

Richard Harrington
richard@royensoc.co.uk

Five years ago, there were eight entomologists with Forest Research (FR), explained Head of Entomology, Max Blake. Now there are 22, not including students and interns. They are based at Alice Holt Research Station near Farnham in Surrey, and at the Northern Research Station, near Roslin in Midlothian. In addition, there are three entomologists with FR's Tree Health Diagnostic & Advisory Service. This sharp rise has been partially due to recognition by the government of the need to plant and protect more trees, and of the ever-increasing threat to ecosystems, human health, and the economy posed by invasive pests.

This was my first visit to Alice Holt, and I was hugely inspired by the team's research and enthusiasm. Daegan Inward, one of the group's Senior Entomologists, kindly showed me round, and introduced me to the members of the Alice Holt Entomology team. All the research has a very applied angle and customer focus, such as horizon scanning work, looking for likely future pests and detecting and responding to the appearance of the wide range of insects intent on making British forests their home. Daegan's team, for example, is interested in the ecology and potential impacts of invasive forest pests, with emphasis on the susceptibility of UK host trees and a changing climate.

I was surprised to learn of the UK's strong reliance on imported wood products – the total value of wood product imports in 2021 was £8.5 billion. We just can't grow enough of it. Imported wood in various forms is a potential source of pests that could threaten our own forests and thus imports must be carefully inspected, and various regulations are in place to minimise risk. For example, wooden packaging material must be heat-treated before export to the UK, and conifer wood entering the UK must be bark free. Such measures do not guarantee complete success, and any suspect material is sent to Alice Holt for assessment. The Advisory Entomology Team needs to respond rapidly, as delays to the release of consignments at ports can carry hefty charges. Around 200 samples a year are received from inspectors, with many more (perhaps 2,000) from the industry and from members of the public participating in citizen science projects such as TreeAlert (https://www.forestresearch.gov.uk/tools-and-resources/fthr/tree-alert/) and Observatree (https://www.observatree.org.uk/). Indeed, some queries arrive at Alice Holt via the Royal Entomological Society's Insect Identification Service. Thank you!

Sitka Spruce (*Picea sitchensis*) is by far the most important commercially grown tree species in the UK, accounting for about 50% of conifer forestry by area. It grows best in cool, damp habitats and is grown mainly in upland Wales and Scotland, with Norway Spruce (*Picea abies*) replacing it further south. European Spruce Bark Beetle (*Ips typographus*), a 5 mm brownish-black beetle in the subfamily Scolytinae, is a massive threat to spruce forestry and an appropriate case study for response strategies. Sarah Facey, Entomology Response Manager, told me that its main native host is Norway Spruce but that there is great

Figure 1. (Most of!) The FR Entomology team in the grounds of Alice Holt (credit Forest Research)

Figure 2. *Ips typographus* galleries (credit Forest Research)

Figure 3. *Ips typographus* (credit Forest Research)

Figure 4. Norway Spruce tree killed by *Ips typographus* (credit Forest Research)

concern that it might spread to Sitka Spruce, a prospect being investigated by Kerry Barnard and other members of Daegan's team. Surveillance for *I. typographus* has been in place since the 1990s, but the first evidence of a breeding population in England was only discovered in 2018 in a woodland in Kent. This finding triggered a huge response from the Forestry Commission (FC), FR, Defra, and the Animal and Plant Health Agency, as the government attempts to eradicate the beetle – it is a designated quarantine pest across Great Britain. All potential host trees in the area were cut and chipped on site, before being burned at the Sandwich Biofuel Plant. High-density trapping was then required for three years to prove the success of the eradication efforts. As for where the breeding population had come from, it was initially assumed that infested wood products, such as packaging material, were the likeliest sources of entry into the UK. It has, however, since been shown – using a network of traps across the southeast, and along the south coast of England as well as the north coast of France – that the beetle can fly across the Channel under its own steam. There have been catastrophically large populations of the pest in central Europe in recent years, driven by multiple years of drought stress weakening their host trees.

In 2021 and 2022, multiple small-scale breeding establishments of *Ips typographus* were found in the southeast through surveillance and monitoring activities carried out by FR and the FC. There are multiple strands to the surveillance work, including a network of pheromone traps across the country from which samples arrive at Alice Holt every two weeks throughout the flight season. A high local catch triggers a ground survey to look for material suitable for colonisation, particularly diseased, stressed or wind-damaged trees. The FC also carries out aerial surveillance by helicopter over the whole country, looking for signs of decline in areas of spruce woodland. Lastly, felling inspections and movement licences check spruce material before authorisation is granted to fell/move spruce within the demarcated area for the pest. If the pest is found through any of the surveillance streams, the landowner is responsible for felling and destroying infested material, and the mandated felling of nearby healthy material is also required. Recent policy changes that reflect the findings from the research and surveillance work on this pest now mean that, in certain situations, healthy material from establishment sites can be inspected before milling (instead of destruction), which is far less costly to growers. No evidence has yet been found of spread of the pest occurring from any of the known establishments.

Much of the FR-led ground surveying of Norway Spruce in the southeast is organised by Brenden Beckett. He liaises with contractors and site owners to ensure permission to survey, and deals with health and safety issues. He also works with Owen Vaughan and Venkatesh Vemulapati on the thousands of incoming trap samples, identifying *I. typographus* and other beetles from the subfamily Scolytinae, and Andrei Manea who conducts important forest site surveys.

There is still debate about the role of damage caused by the Two-spotted Oak Borer (*Agrilus biguttatus*) in Acute Oak Decline disease, and much work has been conducted by both entomologists and pathologists at FR over the years exploring this relationship. The two

Figure 5. Brenden Beckett, Talor Whitham and Abi Enston with various traps.

certainly occur together in what appears to be a symbiotic relationship whereby damage by one favours the other, but the lesion-causing bacteria do not seem to be vectored by the beetle. Dave Williams, Senior Entomologist, and Abi Enston are currently developing traps for both native and invasive species of *Agrilus* beetles, using various designs and plant-volatile lures. They are also investigating the factors that may prove influential in improving monitoring, and are developing novel management approaches for Oak Processionary Moth (*Thaumetopoea processionea*), which has huge costs to London's parks because of the risk to human health from allergy to the larval hairs. Abi has also become proficient at identifying forest-associated sawfly species by identifying samples collected from previous research trials established in Sitka Spruce forests across elevational gradients.

In several countries around the world where it has become established, the highly damaging Pine Wood Nematode (PWN, *Bursaphelenchus xylophilus*) is vectored by members of the longhorn genus *Monochamus* (sawyer beetles). Originally native to the USA, the nematode causes affected trees to die rapidly from vessel blockage and wilt, and it is one of the largest threats to pine forestry worldwide. Both PWN and *Monochamus* are currently absent from the UK, but PhD student Talor Whitham is investigating whether we have any potential native beetle species that have similar life habits to *Monochamus,* which could vector PWN if it were to establish here through trade. PWN is now found in Spain and Portugal and is hence a looming threat to pine forests across Europe. Talor is funded via a novel joint initiative with Kew Gardens and Defra, the Centre for Forest Protection, and this work has been made possible by the recently built and very impressive containment facilities at Alice Holt – a multi-million pound investment also funded by Defra. These are also used by Ana Uglow to look at potential resistance in European Ash (*Fraxinus excelsior*) to the buprestid beetle Emerald Ash Borer (*Agrilus planipennis*) which we don't currently have in the UK but has caused widespread destruction in North America and Russia. Katy Reed is looking ahead at the potential for various parasitoids to control Emerald Ash Borer if and when it arrives in the UK.

I also met Gemma McDonald, who just happened to be emptying the Rothamsted light-trap at the time. On behalf of my former colleagues in the Rothamsted Insect Survey, thank you Gemma! That trap produces one of the most diverse moth samples of the network, an indication of the delightful grounds of Alice Holt.

Outputs from Alice Holt's entomologists are many and varied: outreach events; webinars; student lectures; industry events; conferences; peer-reviewed papers; trade journals *etc.* In a single day's visit, I learnt a huge amount, and it quickly became clear that the UK's forests and timber industry are in very dedicated and capable hands with regard to pest management. Perhaps it's no surprise that the UK managed to eradicate a new forest pest; the Asian Long-horned Beetle (*Anoplophora glabripennis*) was contained in a small area and knocked on the head, probably helped by our relatively cool climate and the rapid action of Defra and the FC, supported by the skills of our entomologists.

Their dedication and enthusiasm are about to benefit the RES directly, in that Daegan, Abi, Talor and Brenden have taken on responsibility for our Forest Invertebrates Interest Group and have some wonderful ideas to take it forward following the great things done by Anne Oxbrough, the previous convenor, and her colleagues.

Many thanks to all the entomologists who gave me their time, and for the great work that you are doing for our forests – and are about to do for our Special Interest Group!

Figure 6. Gemma McDonald emptying the Rothamsted light-trap

Meetings

Monthly Evening Meetings

Why Bees Make Honey

1st February 2023

May Berenbaum
University of Illinois

Report by Richard Harrington
(Chair of Meetings Committee)

"The only reason for being a bee is to make honey. And the only reason for making honey is so that I can eat it." Thus said Winnie the Pooh, a bear of very little brain, of whom May is rather fond but wishes to correct. Humans have eaten honey for over 9,000 years and used it for medicinal purposes for over 5,000 years. It is claimed to treat anaemia, jaundice and ulcers, heal wounds, regulate the heart, help weight reduction and even relieve hangovers. But what benefits does it have for bees? This was the subject of May's talk.

Collecting nectar is energetically expensive for Honey Bees (*Apis mellifera*), which may make 30 foraging trips each day, visiting up to 100 flowers on each trip. Once collected, the water content has to be reduced from about 85% to about 15%, which is aided by workers fanning their wings. Enzymes convert disaccharides to monosaccharides, increasing fructose and glucose at the expense of sucrose. This reduces the likelihood of crystallisation. The salivary enzyme glucose oxidase converts oxygen to hydrogen peroxide, which has antimicrobial properties, and it converts glucose to gluconic acid which lowers pH and discourages microbial growth. Honey then has to be packaged into wax cells and capped. May described honey as the first processed food. It facilitates the bees' energy-intensive lifestyle.

Nectar is packed with secondary metabolites, which defend plants against bacterial, fungal and arthropod pests. Flavonoids, phenolics and carotenoids are antioxidants which stabilise free radicals and confer a wide range of human health benefits. But do these chemicals also help bees? The answer appears to be 'yes'. Antioxidant phytochemicals in honey enhance worker longevity, and honey improves bee health. Bees can even select the flowers they visit such that the resulting honey is best suited to dealing with the particular pathogens that are troubling them at the time. Honey also promotes detoxification of some pesticides by upregulating the CYP9Q genes that detoxify flavonoids.

To summarise, bees benefit from honey through nourishment, antimicrobial properties, enhanced detoxification, immunity gene activation, increased cold-tolerance, faster wound healing and greater longevity. Pooh was certainly wide of the mark.

As a result of monoculture agriculture, nectar and pollen are becoming harder to find, and bee diets are becoming less diverse, driving bees to unnatural food sources. For example, red honey appeared in Utah as a result of bees foraging on candy canes, and M&Ms produce green honey!

A lively Q & A session followed May's talk. Chris Williams asked when bees evolved honey-producing behaviour, and May outlined the various steps leading to the extreme specialism in *Apis*. Liam Crowley asked if much is known about honey production in non-*Apis* bees, to which the answer was that not much work has been done because of the difficulty of getting enough honey to work on. Melittid bees in Central and South America make less-concentrated honey but with a similar phytochemical profile to that of apids. Gia Aradottir asked if commercial wildflower mixes are optimal for bees. May said that legumes are excellent but that most mixes are aimed more at a colourful display for humans. Stuart Reynolds wondered whether antioxidants are needed because of the long duration of sperm storage. May thought this unlikely as Queens mainly eat royal jelly, although the quality of this will be influenced by the workers' foraging habits, so there may be an indirect impact.

Fran Sconce asked what the most common misconceptions among the public are when it comes to bees. May gave three examples. First, the widespread belief that all bees produce honey is far from true. Second, most people don't know that 85% of bees are solitary. Third, most people are not good at identifying bees – many native bees are not recognised as bees at all, and many species such as hoverflies and hornets are mistaken for bees.

When introducing May, our president mentioned that May founded the Insect Fear Film Festival. Peter Smithers wanted to know more. The idea came to May when she was at Cornell, but didn't come to life until 1984, by when she was at Illinois. Indeed, in 1988 she married the man from the Cinema Club who helped her get it started! On March 4th 2023, the 44th festival was held, and it has spread to other universities. The festival aims to dispel fear of insects by introducing some entomological reality into an evening of watching films that portray insects as monstrous. For more details, see https://en.wikipedia.org/wiki/Insect_Fear_Film_Festival.

May is an Honorary Fellow of the RES and it was a delight to listen to her. She may not know that she is partially responsible for the current look of *Antenna*. I used to read avidly her informative and amusing column *Buzzwords* in *The American Entomologist*. As a result, I realised that the whole magazine was far more attractive in style than was *Antenna* at the time, and I lobbied for a change from the A5 colour-free format to the glossy A4 publication that we have today.

For a review on why bees make honey, see Berenbaum, M.R. and Calla, C. (2021) 'Honey as a functional food for *Apis mellifera*'. *Annual Review of Entomology* **66**, 185–208.

Edible Insects: Progress And Prospects

5th April 2023

Arnold Van Huis
Wageningen University, Netherlands

Report by Dafydd Lewis

I was privileged to be able to access Professor van Huis's talk on 5 April. The fact that it was accessible online was especially helpful, as I was travelling at the time and was able to watch and listen to most of it despite broadband issues. RES Members and Fellows are, of course, able to access these monthly talks free of charge, which is a great member benefit.

I say 'privileged' because this talk was a real *tour de force* of the status, literature and benefits of 'edible insects' by a foremost authority on the subject. Whilst the practice of eating insects is widespread in many places around the globe, consumer attitudes in the West are a hindrance to the adoption of this protein source. Here and there, organisations (I thought in particular of the example of Dr Beynon's Bug Farm, a tourist attraction in Wales) have begun serving up insects as meals, but on the whole these remain more of an occasional snack than a regular part of the diet. Consumer reluctance in this regard is due to 'food neophobia' and associated disgust – although marine arthropods (prawns and lobsters) are commonly eaten.

Nevertheless, studies in western Europe have indicated that up to a quarter of people asked to try insect-based products are willing to do so, with men and younger people being less reluctant. Various strategies have been tried to encourage the eating of insects, such as the use of role models in marketing, and attempts to overcome reluctance have included formulations such as healthy insect-containing ice cream and flavoured milk. France is probably the current global leader in the edible insect business, and insect farming as a source of protein has been publicised as a 'French success story'. This contrasts with the situation in the tropics, where eating insects is often commonplace: insects there are more readily available, are larger, and can be harvested throughout the year. People in Africa and Asia also tend to be closer to nature, and insects can occur 'in clumps', thereby facilitating harvesting.

Whilst Prof. van Huis cited one early publication from 1885 entitled *Why Not Eat Insects?*, the subject area has only become particularly prominent in the past ten years, including due to concerns about the environmental impact of meat production. For example, beef production requires 50 times the amount of land needed to farm vegetable protein, and involves one hundred times the associated greenhouse emissions. Indeed, the world appears to be running out of land for conventional farming, with demand continuously increasing and livestock emitting significant amounts of greenhouse gases and ammonia. Other drawbacks of 'livestock's long shadow' include deforestation, soil erosion, loss of plant biodiversity, and water pollution. Thus, alongside the development of insects as food, there needs to be a reduction in meat consumption, a shift from cattle and sheep towards pigs and poultry, and an emphasis on alternative protein sources, including plant proteins, mycoprotein, algae and cultured meat. Various studies have shown that land use, the potential to increase global warming, and inadequate feed conversion is much lower in the case of insects than in all of the above vertebrate species. They can also digest and convert many organic side streams contributing to a circular economy.

Current academic interest in the subject is reflected by an international conference held last year in Canada, and by the high impact-factor *Journal of Insects as Food and Feed* edited by Prof. van Huis (a special issue of which is available online, on open access: 2021 Vol. 7, Issue 6). From 2017 to 2022 the number of papers published on the subject increased substantially, especially those on the Black Soldier Fly, *Hermetia illucens* (BSF).

The use of insects as 'alternative' animal feed is another area of potential and was the subject of a paper published this year (van Huis and Gasco, 2023). The most common species used are BSF, housefly larvae and the yellow mealworm. The sustainability of both soy and fishmeal has been questioned, and the use of plant protein as animal feed has been said to be suboptimal, both nutritionally and in terms of digestibility. Health and welfare effects have been cited when insect feed has been given to pets, poultry, pigs, fish and ruminants. There is also published evidence that BSF larval frass and exuviae can have beneficial effects as fertiliser, stimulating beneficial soil microbes such as nitrogen fixing bacteria and reducing drought effects on basil production.

As part of a careful and detailed overview of how insects as food are processed, Prof. van Huis reviewed the forms in which whole insects could be made available as human food. They could be eaten fresh, or dehydrated, roasted and ground in the form of a flour. For decontamination they need a thermal treatment (boiled, steamed, dried or toasted). Powdered they can be used in crackers, pasta, energy bars (containing crickets), snacks, burgers, meatballs or as milk. Additionally, proteins, fat and chitin could be isolated, and data are available on fermentation. The health and safety aspects of producing insects for feed were also reviewed, including aspects of current EU legislation and ongoing issues to be resolved.

Numerous factors need to be taken into consideration in insect production. For example, some insects (such as the BSF) have favourable disease resistance profiles, and companies are able to select genetic strains which can convert feed more efficiently, resulting in significant improvements in larval weight gain. Additionally, there are methods and additives to increase, for example, vitamins A and D and omega-3 levels, with corresponding health benefits to both humans and animals, including pets. Of particular interest is the fact that BSF larvae contain antimicrobial peptides, which suggests the possible use of alternative, resistance-free antibiotics in animal diets, and at least one compound, cecropin HC1, has the potential of becoming an antipseudomonal drug.

The benefits of processing insects for human use does not stop with eating them. BSF lipids can be used in the production of biodiesel or biofuel; as cosmetic skin care products and surfactants; proteins can be used as bioplastics and BSF chitin and chitosan can be used as polymeric films for food packaging.

Finally, Prof. Van Huis reviewed the challenges ahead. The use of insects across the areas mentioned above presents several challenges and the need for commercial and legislative engagement. Given the recent upsurge in interest and activity in this area it is perhaps not surprising that the RES has just launched a new Welfare and Ethics SIG, which among other things will be particularly concerned with insect rearing and husbandry. Nociception, pain, insect behaviour and communication, and even the long-running philosophical debate on consciousness, are among the issues to be addressed, and will be an area of ongoing research and debate.

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The Verrall Lecture

Managing Tropical Ecosystems For Insect Biodiversity

1st March 2023

Presented by Edgar Turner

Curator of Insects, Cambridge University Museum of Zoology

Report by Richard Harrington

Was it really three years since we last met at the Natural History Museum for the Verrall Lecture? One hundred turned out in person to enjoy Ed's talk and then head across the road for the Verrall Supper. Another 50 listened online from around the world.

Much has been discovered about long-term changes in insect abundance and diversity, but mostly from temperate regions. Using oil palm plantation as a model system, Ed has set out to look at such changes in tropical ecosystems, where insect diversity is much greater, and to understand how best to manage tropical agricultural systems to protect this diversity as far as possible.

Oil palm is by far the world's most important source of vegetable oil, with 72 million tonnes being produced in 2018, mostly from Malaysia and Indonesia, most of it at the expense of tropical rainforest. Palm oil, though, can be part of the solution to biodiversity issues as it is very productive per unit area compared to other oil crops. There is an increasingly robust certification scheme to assist biodiversity and the environment and hence make production more sustainable.

Ed described three projects aimed at informing management.

1) *Stability of Altered Forest Ecosystems (SAFE) (safeproject.net)*
This project examines the effect of habitat change and fragmentation on biodiversity and ecosystem functioning. It is based in Sabah, a state of Malaysia in the northern part of Borneo and includes an 8,000 ha area of degraded forest with pockets of more pristine forest. Over 50 countries are involved in the research, which is led by Imperial College and the Southeast Asia Rainforest Research Partnership. Changes in community structure and carbon storage as a result of disturbance are being investigated. It has been found that as disturbance increases, so does the importance of deadwood habitat in maintaining biodiversity. Logging has variable effects on biodiversity; some groups are badly affected, others are not. There is a huge drop in termites but not ants in disturbed forest and oil palm plantations. There are also declines in abundance and richness of semi-aquatic bugs with disturbance. Rivers with forest buffers in oil palm plantations support more diverse

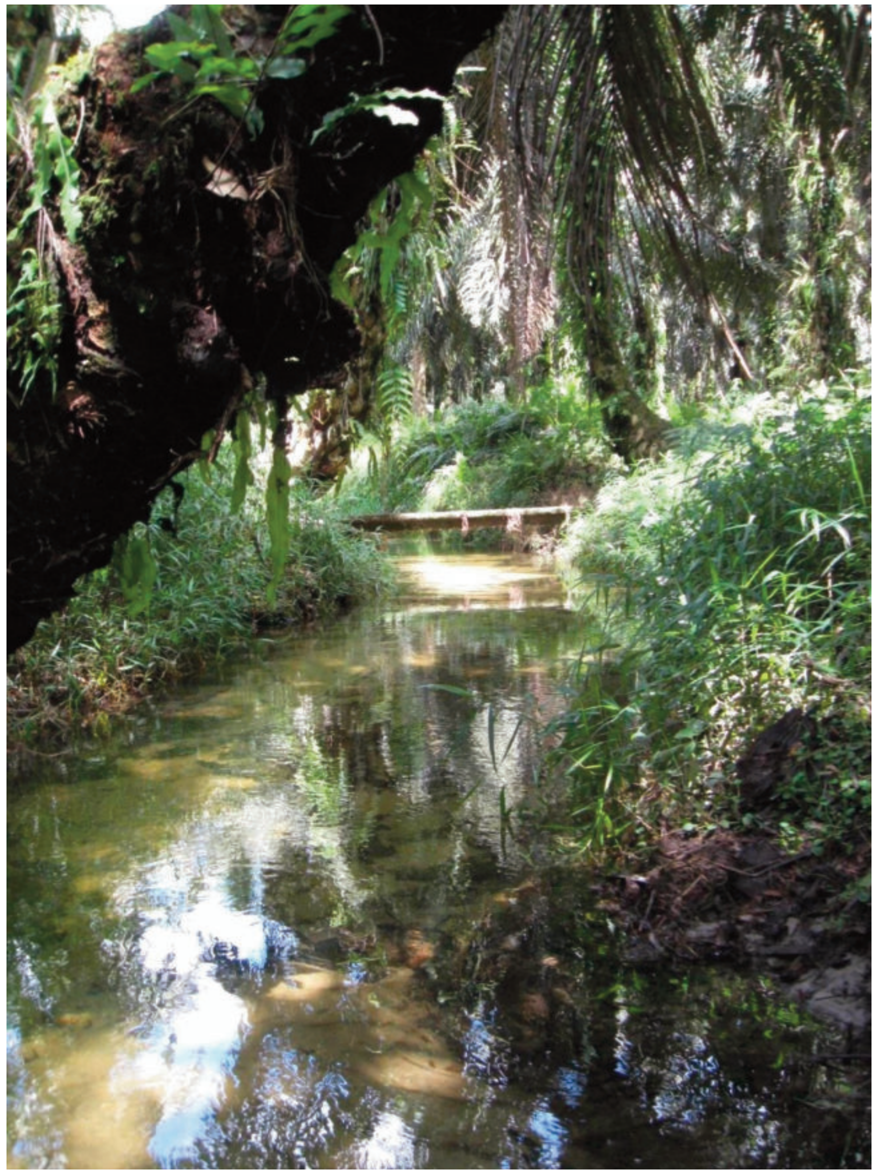
Ed Turner receiving the President's Medal from Jane Hill.

dragonfly communities and a higher abundance of semi-aquatic bugs. Exclusion studies have shown that logging reduces the functional roles of invertebrates.

2) *Biodiversity and Ecosystem Functioning in Tropical Agriculture (BEFTA) (oilpalmbiodiversity.com)*
This is a large-scale experimental project in Riau, Indonesia, set up in partnership with the oil palm industry (Sinar Mas Agro Resources and Technology Research Institute) to test whether increasing structural complexity can enhance oil palm sustainability at little or no cost to yields and profitability. It involves replicated plots (150 m x 150 m) of three treatments: removal of all ground vegetation ('reduced'); business as usual ('normal'); and ground cover allowed to regrow ('enhanced'). Data were collected for a year at all plots and then the three different treatments were assigned at random. Unsurprisingly, the abundance and richness of many groups (*e.g.*, butterflies, assassin bugs, *Nephila* spiders and their cleptoparasitic spiders, most soil invertebrates) are lower in 'reduced' plots. Assassin bugs are useful in control of oil palm pests, so a reduced understory reduces natural pest control. Leopard Cats, which are important predators of rats, also suffer in the 'reduced' plots. Litter decomposition is reduced in plots with lower levels of vegetation. Additional experiments have been done to exclude birds and ants to test the role of these predators on herbivory. There is no clear difference in oil yield between the plot types.

3) *Riparian Ecosystem Restoration in Tropical Agriculture (RERTA) (oilpalmbiodiversity.com)*
This project, which has been running for three years, also in Riau, involves identifying the best ways to restore river margins in oil palm plantations. A control with no buffer zone is compared to three treatments: planting forest trees; leaving mature palms; and both of these. Roughly ten thousand seedlings have been planted. Survival has been greater than 80% but is higher in shaded than open areas. Growth has varied between species.

After a tour of the tropics, we were brought unexpectedly to Totternhoe Knolls near Dunstable. A major project with the Wildlife Trust for Beds, Cambs and Northants is looking at the impacts of


Oil palm stream.

temperature change and the ability of insects to adapt. The ambient body temperature of butterflies has been recorded across a range of species and used to calculate the ability of butterflies to buffer themselves against high temperatures in the field. Species with bigger wingspans are better at buffering than smaller species. Butterflies which rely on microclimate variability for controlling body temperature have fared less well in the past 40 years than those which adjust their temperature by basking / closing their wings, or by flying in and out of shaded spots. Similar factors predict buffering ability in tropical species. Those species that are better at buffering tend to be more sensitive to high temperatures, so there is a trade-off playing out. There is little consistent difference in buffering ability between temperate and tropical species. The *Banking on Butterflies* project has established experimental butterfly banks (large earth structures that alter local topography) in Bedfordshire to manipulate microclimatic conditions and study butterfly responses.

In conclusion, there are no shortages of challenges facing insects globally. Habitat change can have severe impacts, but these vary with species. In oil palm, management practices to benefit insects can also support associated ecosystem processes without reducing yield. Identifying approaches to reduce the negative impacts of temperature change in these systems is an important ongoing challenge.

All the projects outlined by Ed involved large numbers of collaborators, whose praises Ed sang.

A lively Q & A session followed and included discussion of issues around the speed of return of insects to restored areas, the value to biodiversity of land sparing *versus* land sharing, the degree of acceptance of restorative practices by growers, the impact of wing colour on a butterfly's ability to buffer against high temperatures, and the possibility of using HS2 (for our overseas colleagues, this is a controversial high-speed rail project) as a massive experiment to test buffering ability by using the huge soil heaps that are springing up along the route.

And so, over the road to the Rembrandt Hotel for a truly magnificent Verrall Supper, enjoyed by over 100 people, including Ed and the previous two Verrall lecturers, Camille Parmesan and Erica McAlister, to whom we were not able to offer this reward after their online lockdown lectures. Many thanks to Chris Lyal and all members of the Entomological Club for another memorable event. At least, it was memorable to those who didn't overuse the free bar!

The Young Verrall Lecture

Conserving The Little Things That Run The World

4th March 2023

Report by Francisca Sconce

This annual talk is organised by the RES in collaboration with the Amateur Entomologists' Society. Aimed at a knowledge level of 11–14 year olds, Ed shared the main messages of his talk from 1st March, with added context on the importance of insects, live demonstrations of temperature probes with butterfly specimens and calls to action for the audience on how we can all help conserve insects. There were excellent questions, including "How did insect flight evolve?" and "How can someone become an entomologist?". The talk was given in person to an audience of 50, as part of the annual Staffordshire Invertebrate Science Fair, organised by Dave Skingsley and Andy Jukes at Staffordshire University. Ed's talk was also available online. As part of the wider Fair, the Society had a stand with live insects and information to take away such as mini species identification guides and garden entomology booklets.

Francisca Sconce and Jasper Hubert on the RES stand at the Staffordshire Invertebrate Science Fair.

Generating a buzz: The RES goes to Chelsea

Part 2

In the last issue of *Antenna*, we described how the Royal Entomological Society Garden will be unveiled at the RHS Chelsea Flower Show in May, before being relocated as a teaching garden and long-term opportunity for insect study. By the time you read this, the Garden, designed by Tom Massey and supported by Project Giving Back, will have been welcoming visitors to the show, engaging with them about the benefits of insect science and hopefully inspiring them to see how they can accommodate insects of all kinds within their own garden.

Earlier in the year, *Antenna* spoke to garden landscape designer and constructor Richard Curle, and plantsman Mark Straver.

Richard is Managing Director of Landscape Associates, a multi award winning garden design, construction and maintenance company based in Surrey. He has worked in the industry for almost 30 years. Landscape Associates has achieved four gold medals at Chelsea to date.

Mark is a nursery owner and highly experienced plantsman with over forty years in the industry. His Hampshire-based nursery, Hortus Loci, and retail operation, The Plant Centre, grow plants for both trade and retail.


Richard Curle


Mark Straver

Tell us a bit about yourselves. How did you come to work in the horticultural industry and landscaping?
RC: I was lucky. I started working in horticulture immediately after leaving school as a part-time job and fell in love with it. I always preferred being outdoors and the varied work, physical demands and connection with nature all appealed to me. I subsequently returned to education once I'd discovered it was the career for me.

MS: My grandfather was a Dutchman who came over to England in 1933 and he started Roseland Nurseries from scratch in Chobham, so I grew up on a nursery. I started my first Plant Centre when I was 19, and the rest is history!

How did you come to be involved in the RES Chelsea Garden? What about it do you find particularly interesting or exciting?
RC: Tom Massey, the designer of the garden, contacted us. We have worked with Tom previously and he asked if we'd like to work on it. The design really appealed to me; the outdoor lab structure looked striking and technically challenging. I also loved the idea of showcasing recycled materials and brownfield gardens at the Chelsea Flower Show. I think it pushes people to consider something less conventional.

MS: I was always interested in growing plants in bigger pots than most nurseries did, so, when I had my old nursery, designers would approach me to borrow plants for the Chelsea Flower Show. This is how it all started for me. It is the greatest flower show on Earth, the Oscars of horticulture. The reality of our industry is cold, wet, and muddy, so to show off our wares at such a glamorous event is the highlight of the year! Horticulture by default is a green industry and we have always tried to be as environmentally friendly as we possibly can. The demise of insect life over the last 40–50 years is terrifying, so we are doing our small bit to reverse this trend as fast as possible and are excited to be expanding on this by contributing our plant-growing efforts to the RES garden.

What are some of the challenges of landscaping for the RHS Chelsea Flower Show? Have there been new challenges to overcome for the RES garden?
RC: The general challenge with Chelsea gardens is the level of finish required and the restrictive timeframe. As a team (designers, suppliers, specialists and contractors), we need to prepare everything prior to arrival at the show ground. We cannot afford to make decisions once we arrive. This garden has both complex and organic elements, threading them together well is possibly the biggest challenge.

MS: The long and the short of it is that we contract-grow plants for the show to look amazing for one week. The increasingly extreme weather makes this more and more difficult every year. The trend we're going towards is growing plants that are more drought tolerant. This is challenging, as we often have long periods of wet weather, followed by periods of extreme cold, both of which affect drought-tolerant plants. In early March, we had six inches of snow on the ground, so still mid-winter. Even with only six weeks until we start loading for Chelsea, nature is always the boss!

How is the landscaping for the garden making space for insects? Have you seen anything interesting come in already?
RC: The garden aims to create a varied habitat, so we have been collecting fallen trees with root plates attached and are starting to fill wire mesh gabions, which provide a stone retaining wall, with crushed recycled aggregates. We've not seen much yet apart from moss and lichen but I'm hoping we'll see some insects soon.

How are the plants you are growing, and the approaches you're taking, making space for insects?
MS: Every plant has been chosen to be as beneficial to insects as possible. Combined, they provide resources for a wide range of day-flying and night-flying insects throughout the year. Some of the plants being grown for the garden, and which are most beneficial to insects, have often been thought of as weeds. The meaning of a weed, though, is a plant in a place you

Honey Bee on Echinacea 'Mac 'n' Cheese. Reproduced courtesy of Hortus Loci.

Fallen tree with root plate collected from local private woodland. Reproduced courtesy of Richard Curle.

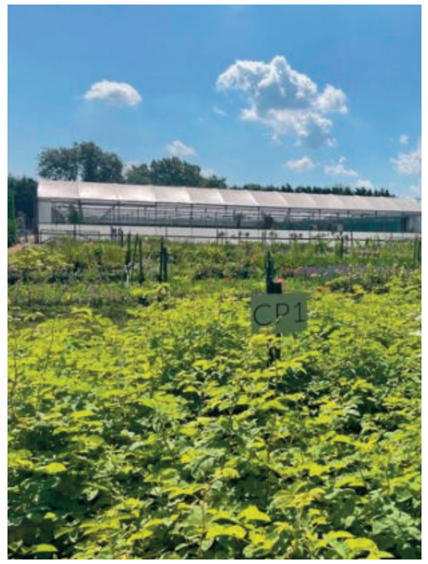
don't want it to grow, so you grow weeds in the same way you would grow any plant! We also went entirely peat-free four years ago on both the nursery and on retail. The peat-free compost we use is just as good, if not better, than peat. Peatlands provide habitat for many different insects and invertebrates, so the change is not only good for the plants we grow, but also helps preserve these resources for insects further afield.

Gabions being filled with recycled aggregate. Reproduced courtesy of Richard Curle.

What is the most important thing to do, in terms of the landscaping in gardens, to support insects and other wildlife?
RC: I think we need to educate firstly, and I think as gardeners we need to relinquish some control. Allowing wilder areas, stopping the use of pesticides and herbicides, and generally taking a softer approach to what we do in gardens would really help. It is getting traction now and people are definitely more interested in creating habitat and using more diverse native plants.

What sustainable approaches are you using to help minimise the garden's environmental impact, and to support insects and wildlife more broadly?
RC: Wherever possible everything has been locally sourced. We are avoiding using concrete footings and are instead using re-usable screw piles for the building. We are also using a lot of recycled materials. The panels on the boundary walls, decaying timber and bare areas of aggregate should all provide habitat for insects.

What is the most important thing to do, in growing for gardens, to support insects and other wildlife?
MS: As a nursery, we don't use pesticides. IPM (Integrated Pest Management) is used on both the nursery and The Plant Centre up to 95% of the time, so that we are using natural predators and organisms to control pests and diseases. We don't use neonicotinoids and never have. Our next-door neighbours have a field of beehives, this is proof that we don't use any nasties! We try to avoid using chemicals where possible, along with having a diverse range of plants to appeal to insects throughout the year.



The Hortus Loci nursery. Reproduced courtesy of Hortus Loci.

How can we engage with the different sectors of the horticultural industry to use more sustainable approaches?
RC: I think the landscaping industry, like all industries, is trying to work more sustainably. I have seen loads of changes recently in terms of the way we go about things, but I still think the biggest barrier is educating the public to embrace more sustainable gardens and techniques. Hopefully this garden will help to that end!

MS: By doing what you're doing, and by spreading the message actively at trade shows.

And, to finish off, what is your favourite insect?
RC: I struggled with this question the most! Can I have two? Firstly, I love Stag Beetles, I remember seeing them every summer as a boy and being fascinated by the size and ferocious looking mandibles of the male beetles and the loud hum of their wings as they flew past. More recently I have discovered Glow-worms at the cottage I moved into two years ago, and I think they are amazing creatures. I'm glad to say the numbers seem to be increasing and they are often around in May, when I get home in the dark from a busy day at Chelsea.

MS: Ladybirds! They eat lots of aphids, so are certainly useful to a grower.

Journals and Library

Treasures from the RES Library and Archive

Rose Pearson
RES Librarian and Archivist

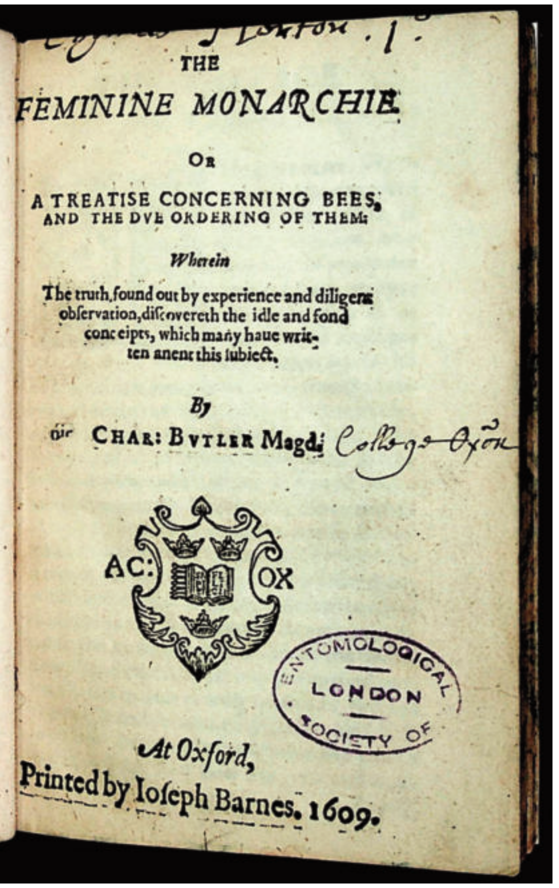
This is the first of a regular column, highlighting some of the more interesting and unusual items from the RES Library and Archive collections. We start with the oldest item in our collection, *Feminine Monarchie: or a Treatise concerning bees and the due ordering of them* by Reverend Charles Butler, of which the first edition was published in 1609.

The first full-length English-language book about beekeeping, *Feminine Monarchie*, remained a practical guide for beekeepers for over 250 years. It focuses on Skep, or basket beekeeping, and includes chapters on the nature of bees, choosing a location for your hives, the 'enimies' of bees, and how to make a profit from beekeeping. Known as 'The Father of English Beekeeping', Butler was one of the first to recognise that the largest bee was female rather than male, which is reflected in the '*Feminine Monarchie*' of the title, although he also believed that worker bees laid eggs.

A schoolteacher, and a priest with a parish near Basingstoke, Butler was a man of eclectic interests and published works on logic, cousin marriage, grammar, and music. He was also a keen advocate of spelling reform. The library also holds the four other editions of this title, including the 1623 edition with musical notations of a bee's hum, designed to be sung in four parts, which he called a 'bee-madrigal'. As was common at the time, two of the parts were printed upside down, so that all four singers could more easily read from the same page. We also hold the 1634 edition which is written in his idiosyncratic phonetic spelling, and a Latin translation published in 1673.

These and other early books on beekeeping can be viewed in our St Albans Library. Email library@royensoc.co.uk or call 01727 899387 to make an appointment.

Musical notation for a four part 'Bee Madrigal' in the 1623 volume.



THE
FEMININE MONARCHIE.
OR
A TREATISE CONCERNING BEES,
AND THE DVE ORDERING OF THEM:
Wherein
The truth, found out by experience and diligent
obseruation, discouereth the idle and fond
conceipts, which many haue writ-
ten anent this subiect.
By
CHAR: BVTLER Magd:

At Oxford,
Printed by Ioseph Barnes. 1609.

Title page of the 1609 edition of *The Feminine Monarchie*.

Contribute to Special Issues in RES journals

The RES journal Editors are keen to see more Special Issues in our journals. These issues are just that – special, covering around one issue a year and seeking high quality submissions from relevant researchers in the field. Special issues in RES journals benefit from additional bespoke promotion and tend to be well read and cited. We have recently published a fantastic Special Issue in *Medical and Veterinary Entomology* and we have a call for abstracts in *Agricultural and Forest Entomology* and a call for papers in *Insect Conservation and Diversity*.

Like most Society journals, the RES journals are a major source of income, without which much of our other fantastic work would not be possible. By publishing with us you're not only giving your work a platform in a high-profile, international, rigorously peer reviewed entomology journal, you're also supporting the entire entomological community.

Medical and Veterinary Entomology

Neglected Bacterial Diseases: a re-emerging field of infectious diseases research

Read our latest Special Issue, highlighting neglected vector borne bacterial pathogens including *Bartonella, Anaplasma, Rickettsia* and *Borrelia* species. Papers include studies on pathogens infecting lice, hard ticks, soft ticks, fleas, bat flies and deer keds.

To find out more about the need for research on these organisms and the pathogens they transmit, please read the editorial.

Editors: Maureen Laroche and Emma Weeks

Read the full Special Issue on the journal website

Agricultural and Forest Entomology

Call for abstracts: Advances in insect biomonitoring for agriculture and forestry

Deadline: 31 July 2023

Editor: Jordan Cuff, Newcastle University

Special Issue Scope

Recent years have seen the emergence and development of various high-resolution methodologies for biomonitoring of insect populations. From high-throughput sequencing of community DNA from replicated traps and airborne nucleotides, through machine-learning-based visual detection, to high-sensitivity bio-acoustic identification of species by their characteristic wingbeat frequencies, the biomonitoring toolbox of the 21st Century shows incredible promise. These novel approaches are broadly applicable to monitoring pests and ecosystem service providers across agriculture and forestry but are in their relative infancy and are only now beginning to be operationalised at landscape scales.

The data and studies arising from these approaches will not only enhance our biomonitoring capacity, but also facilitate highly resolved cutting-edge research at large spatiotemporal scales. While these methods will undoubtedly transform the way in which we monitor agricultural and forest systems, there are many shortcomings and sources of error still emerging. This special issue of *Agricultural and Forest Entomology* will provide a synthesis of the multitude of emergent advanced biomonitoring methods. This special issue will also present an opportunity to critically evaluate these approaches, assess their compatibility and forecast their broader relevance in agriculture and forestry prior to their broad adoption.

Visit the journal website for more information and to submit

Insect Conservation and Diversity

Call for submissions: Insect Diversity and Conservation in Urban Areas

Deadline: 31 August 2023

Editors: Tilly Collins, Imperial College London; Chris Hassall, University of Leeds; Manu Saunders, University of New England

Special Issue Scope

A greater and greater proportion of people live in highly urbanised areas and have limited contact with the natural world. There is now a greater emphasis on, and understanding of, benefits provided by both ornamental and functional urban greenspaces. A critical component to the function of such greenspaces are the insects which inhabit these and coherent syntheses of two major aspects of entomological understanding are needed. Along with these umbrella syntheses, IC&D is seeking submissions of manuscripts for review that fit underneath them and the special issue will thus be fully supported by elements of primary research on these topics.

Theme one: Urban Insect Diversity

This theme will consider papers on how insects thrive in urban zones, for example papers on ecological traits of both pests and beneficial insects. Any submissions reporting primary research on the diversity of insects in urban areas are welcome.

Theme two: People and Insects

This theme will consider papers on interactions between people and insects in the urban environment, including human perception of insects and citizen science work. Quantitative and qualitative methods are welcome.

For more information see the journal website. Presubmission enquiries are encouraged.

Insect Week 2022

Francisca Sconce and Luke Tilley
Royal Entomological Society, UK (fran@royensoc.co.uk)

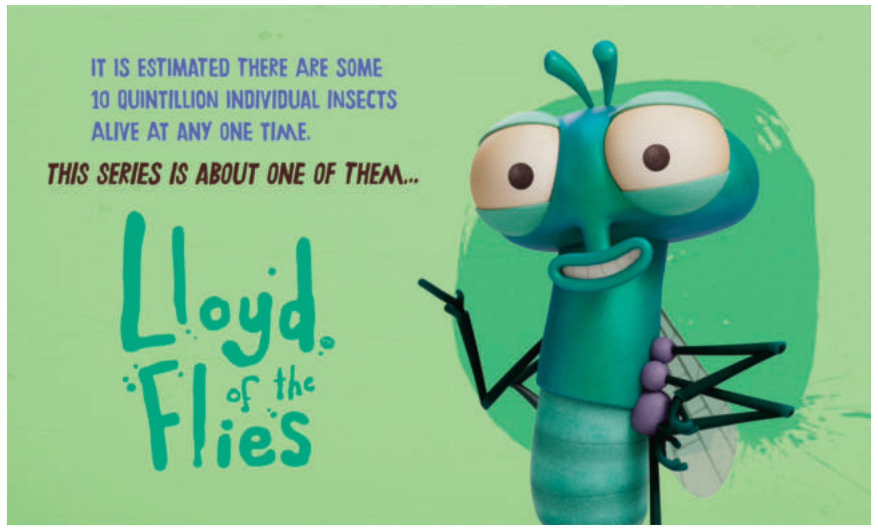
Another successful Insect Week ran from 20th to 26th June 2022. There were activities celebrating all things six-legged during the week, including over 100 events for children, families and adults. These ranged from interactive stands at nature reserves, and art exhibitions, to bug hunts and entomological workshops. The Society ran an online panel event 'Perceptions of Insects: Philias and Phobias', addressing why humans have such differing reactions to insects, where RES trustees Prof. Adam Hart and Prof. Seirian Sumner gave engaging presentations. They were joined by Dr Verity Jones, Dr Liam Hathaway and Dr Franziska Kohlt who gave insights into insects through the lenses of popular culture, literature and psychology. There were plenty of questions from the audience, on our quest to understand what people love and loathe about insects from around the world.

The Society took part in the Big Bang Fair 2022 at the NEC, Birmingham from 22nd to 24th June. The exhibit, supported by Harper Adams University and RES Outreach Committee members, promoted study pathways and careers in entomology, as well as letting the audience know how incredible and vital insects are. With a total event audience of over 23,000, we gave away thousands of resources to eager children, parents and teachers.

To mark the week, Writers Rebel created a short film *Almost Invisible Angels*, by ecological writer Jay Griffiths and artist-activist Gaby Solly, and voiced by actor Sir Mark Rylance. Filmed at Tintern Abbey, the film celebrates 'the tiny creatures on which human life depends'. Elsewhere in the week, Aardman Animations released the trailer for their series *Lloyd of the Flies*, a comedy series for 7 to 11 year olds about a housefly called Lloyd B Fly, which later premiered on CITV in September 2022 in the UK. RES staff, trustees and Outreach Committee members contributed short videos on the theme of 'how do you feel about insects?', mindful that the language of emotions and feelings, instead of facts, can be more engaging for the wider public increasing their understanding of insects and entomologists.

The *Insect Odyssey* art exhibition opened at Salisbury Museum, with visual responses and interpretations of contemporary artists and makers to historical entomological publications. The exhibition was curated by Dr Elisabeth Darby, Prudence Maltby and Dr Michael Darby, supported by the RES Goodman Award. During the week we launched a a new art competition for children, led by Dominique Vassie (see https://www.insectweek.org/art-and-photography/). The ever-popular annual Insect Week Photography Competition was also launched.

A challenge badge for youth groups, 'Incredible Insects', was launched just before the week, created by Outreach Committee member Dr Hayley Jones, of the RHS and Surrey West Girl Guiding (SWGG). To achieve the badge, young people take part in four activities related to insects, such as a bug hunt, a quiz, creating a habitat for invertebrates and making insect art. On the SWGG website the challenge pack is free to download, and the material badge can be purchased.



The third issue of INSTAR Magazine launched in the week, edited by Dominique Vassie, with a diverse range of contributors. Aimed at young entomologists aged 7 years old and above, the new issue included a guide to insect mouths, what happens inside a butterfly's chrysalis, and an insect larvae quiz.

Thank you to all who contributed to Insect Week, including RES Outreach Committee and RES staff, in particular Bianca Saccone, RES Digital Media Officer.

Big Bang Fair 2022

Claire Hoarau (above) and Eugenia Fezza (below) with young people.

Miles Binnie, Ross George, Remy Dimmock and Dominique Vassie.

Luke Tilley with young people.

Gary Needham and others on the team.

insect WEEK

20 to 26 JUNE 2022

2022 Photography Competition

Here are the beautiful winning entries from the Insect Week 2022 Photography Competition. We received over 700 entries from 34 countries across six continents. This year the competition was judged by Dr Tim Cockerill (Head Judge and Senior Lecturer, Falmouth University), Ashleigh Whiffin (Pelham-Clinton Entomology Genetic Collection Curator, National Museums Scotland) and Lucia Chmurová (Important Invertebrate Areas Officer, Buglife). Tim said, "The quality overall was really high, it was a tough one this year, there were some incredible entries and fascinating insects!"

The overall winner was *It takes two*, an image of a mating pair of Golden-tabbed Robber Flies, *Eutolmus rufibarbis,* by Pete Burford in the United Kingdom.

The Under 18 category winner was *Fresh Out Of The Shower*, an image of a Blue-tailed Damselfly, *Ischnura elegans,* in Sweden by Gustav Parenmark (aged 16).

Many congratulations and well done to the runner-ups, and the highly and specially commended.

The 2023 competition will open on 19th June 2023; we look forward to your entries.

Specially Commended (adult): Ashy Mining Bee *Andrena cineraria* (f) on an old dandelion head. Stacked image. Rory Lewis (UK)

1st (adult): It takes two.
Eutolmus rufibarbis.
Pete Burford (UK)

2nd (adult): Hummingbird Hawk-moth.
Macroglossum stellatarum.
Marc Brouwer (Netherlands)

Specially Commended (adult):
Dozing Demoiselle. *Calopteryx splendens* (f).
Bailey Carswell-Morris (UK)

Specially Commended (adult):
Twin-lobed Deerfly *Chrysops relictus* (m).
Marc Brouwer (Netherlands)

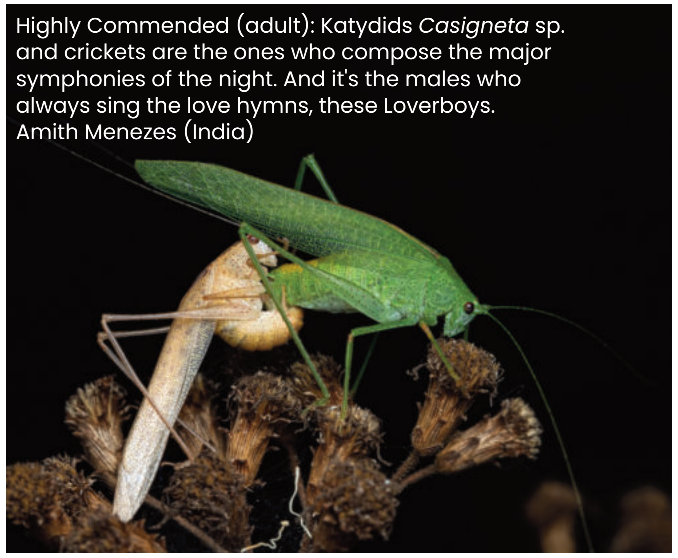
Specially Commended (adult):
Low angle shot of a *Saga hellenica.*
Panagiotis Dalagiorgos (Greece)

Specially Commended (adult): Freshly-hatched Owlfly larvae, family Ascalaphidae. The larvae are voracious predators in leaf litter and on tree.
Amith Kiran Menezes (India)

Specially Commended (adult): Dune Robber Fly *Philonicus albiceps* eating a Sulphur Beetle *Cteniopus sulphureus*. Jamie Spensley (UK)

Highly Commended (adult): Beewolf *Philanthus triangulum* with Honey Bee prey. Stacked image. Rory Lewis (UK)

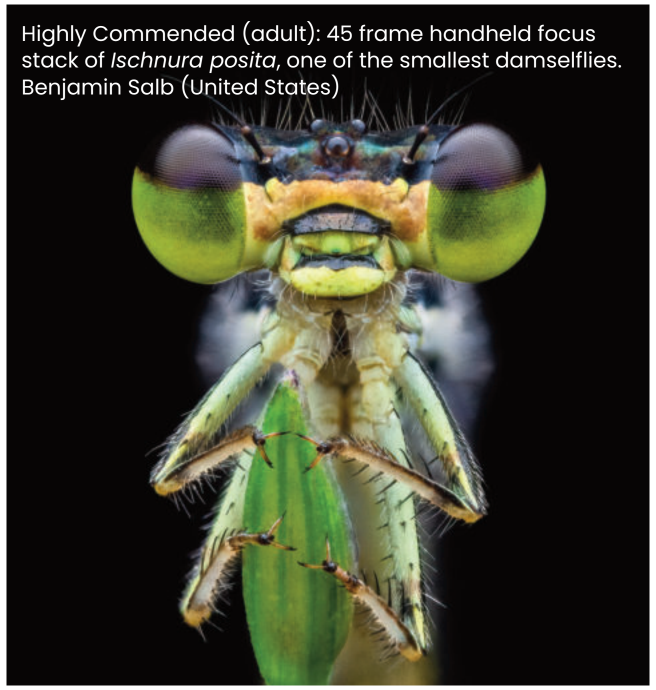
Highly Commended. Male Orange-tip *Anthocharis cardamines*, backlit by the afternoon sun. Sarah Perkins (UK)



Highly Commended (adult): Katydids *Casigneta* sp. and crickets are the ones who compose the major symphonies of the night. And it's the males who always sing the love hymns, these Loverboys. Amith Menezes (India)

Highly Commended (adult): This ant lion *Euroleon nostras* was found late night after a rain storm. Dennis Teichert (Germany)

Highly Commended (adult): Pink Grasshopper *Pseudochorthippus parallelus* with genetic mutation known as erythrism, which causes a reddish discolouration. Beverley Brouwer (Netherlands)



Highly Commended (adult): 45 frame handheld focus stack of *Ischnura posita*, one of the smallest damselflies. Benjamin Salb (United States)

INSECT WEEK

Highly Commended (adult): Incoming! *Bombus terrestris*. Raymond J. Cannon (UK)

Highly Commended (adult): Backlit shot of a *Mantis religiosa* next to a mushroom. Panagiotis Dalagiorgos (Greece)

Specially Commended (under 18): Tug of war. *Formica rufa* and *Orthetrum cancellatum* (f). Gustav Parenmark (Sweden)

Highly Commended (adult): 51 shot handheld focus stack of a living Six-spotted Tiger Beetle *Cicindela sexguttata*. Benjamin Salb (United States)

Highly Commended (adult): Some ant species are key predators of soil dwelling pests. *Aphaenogaster iberica* depredates on fruit fly pupae in the ground of citrus orchards. Ángel Plata (Spain)

Specially Commended (under 18): Sleeping Beauty. Gustav Parenmark (Sweden)

INSECT WEEK


1st (under 18): Fresh out of the shower. *Ischnura elegans.*
Gustav Parenmark (Sweden)


Specially Commended (under 18):
Red Mason Bee *Osmia bicornis* (m).
Will Scarratt (UK)

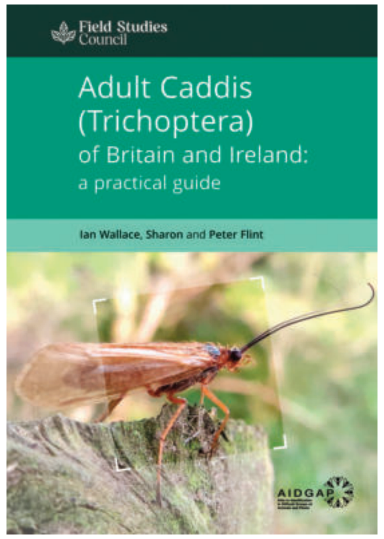

2nd (under 18): New Zealand Praying Mantis
Orthodera novaezealandiae.
Rosa Dunbar (New Zealand)


Specially Commended (under 18):
Two become one. *Pieris rapae* (f top; m below).
Jamie Smart (UK)

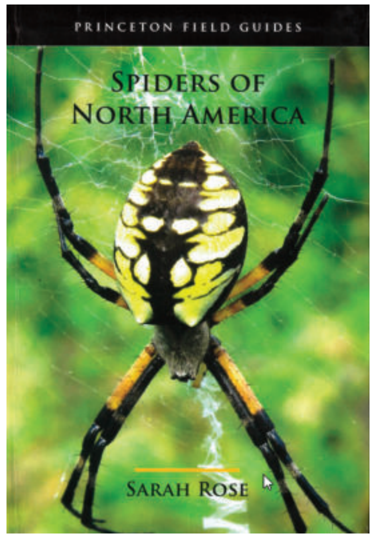
Royal Entomological Society Antenna Reviews

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

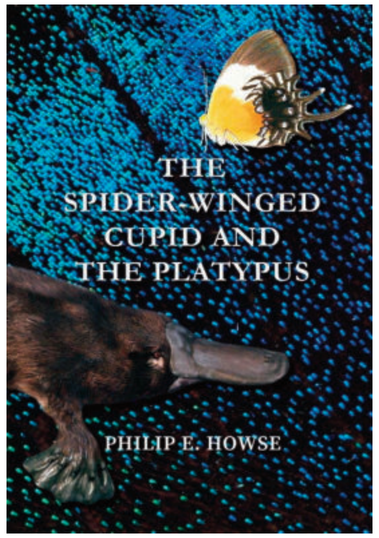
The following reviews have been added to the *Antenna* website:
https://www.royensoc.co.uk/publications/book-reviews/



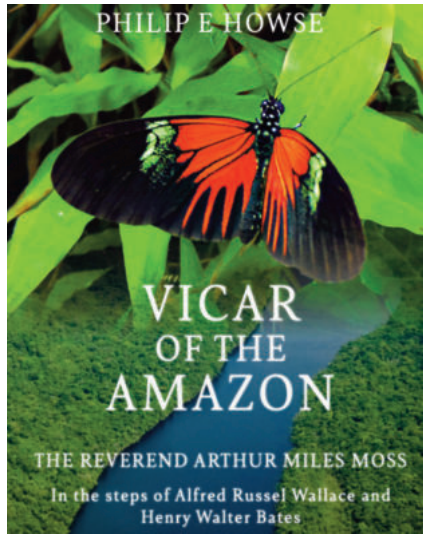
Adult Caddis of Britain and Ireland: a practical guide
Ian Wallace, Sharon Flint and Peter Flint
Published by Field Studies Council
ISBN 9781908819758
Reviewed by Craig Macadam



Spiders of North America
Sarah Rose
Published by Princeton University Press
ISBN 9780691175614
Reviewed by Geoff Oxford



The Spider-winged Cupid and the Platypus
Philip E. Howse
Published by Butterflies and Amazonia Publishers
ISBN 9781739885632
Reviewed by Hugh D. Loxdale



Vicar of the Amazon – The Reverend Arthur Miles Moss: In the footsteps of Alfred Russel Wallace and Henry Walter Bates
Philip E. Howse
Published by Butterflies and Amazonia Publishers
ISBN 9781739885601
Reviewed by Hugh D. Loxdale

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).

June 2023

Wed 7 — 7 June
Online talk – Angharad Gatehouse (virtual event)

Sat 17 — 17 June
Joint BSBI and RES Daneway Meeting

Mon 19 — 19 June – 25 June
Insect Week 2023

July 2023

Wed 5 — 5 July
Online talk – Sam Cook (virtual event)

Thu 6 — 6 July
Rearing Special Insect Group

September 2023

Tue 5 — 5 September – 7 September
Ento23

October 2023

Wed 4 — 4 October
Online talk – Martin Kaltenpoth (virtual event)

Mon 16 — 16 October – 20 October
XII European Congress of Entomology (ECE) 2023 (external event)

November 2023

Wed 1 — 1 November
Online talk – Una Fitzpatrick (virtual event)

Wed 8 — 8 November
Orthoptera Special Interest Group

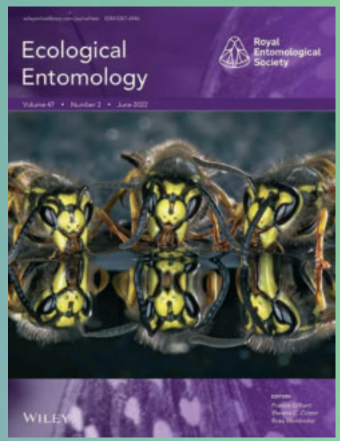
For full details on all RES meetings please visit www.royensoc.co.uk/events

RES Publications

Publishing in RES Journals supports the Society's work – submit today!

bit.ly/RESJournals

Agricultural and Forest Entomology
Impact Factor: 2.13
@AFEntomology



Ecological Entomology
Impact Factor: 2.23
@Ecol_Ent

Systematic Entomology
Impact Factor: 4.84
@Systematic_Ent

Insect Conservation and Diversity
Impact Factor: 4.27
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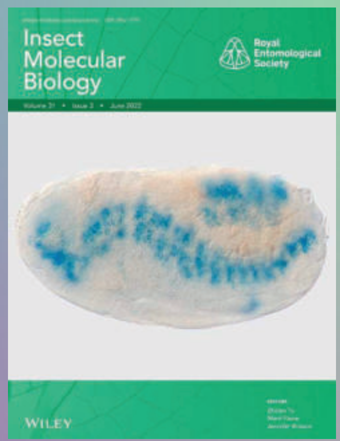

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