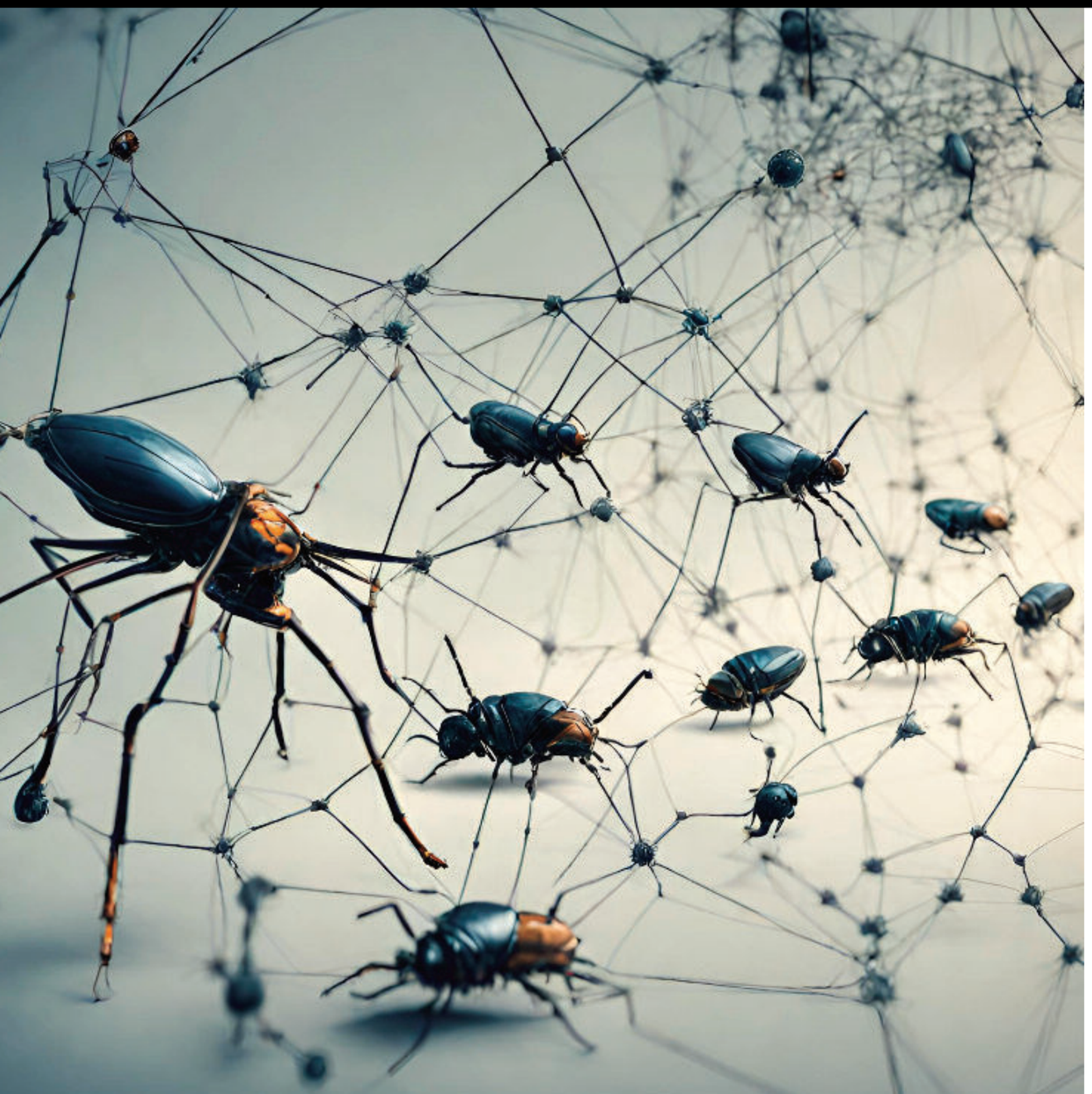
Royal Entomological Society

Volume 48(4) | 2024

Antenna



CONTENTS

Volume 48(4) | 2024

World-leading virus laboratory, The Pirbright Institute, on tackling Bluetongue Virus

World Firefly Day 2024

Evolution of mimicry in *Heliconius* butterflies: historical hypotheses meet modern models

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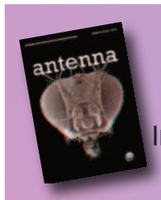

Antenna

Index and online copies

Index

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Cover Picture: AI image generated by James Gilbert (see pages 193–198).

Editorial

It's been an all-action quarter for the RES, as demonstrated by the huge array of *Society News*. On front-line science, we've had the biggest and arguably best Ento ever and some very well-attended Special Interest Groups, including a fascinating and important one on the role of AI in entomology. The successful journals-based monthly online series has continued, and as well as reports on these there are articles flagging two journal special issues, one on biomonitoring and one on forensics. The Society had a meaningful presence at the International Congress of Entomology in Kyoto and will be bidding to host ICE in 2033.

Bluetongue disease of sheep and cattle is on the rise and Jane Phillips interviews scientists at The Pirbright Institute. Fireflies are on the decline and V.P. Uniyal explains what is being done in India to help reverse this. Science often moves forward when there are competing theories to explain a particular phenomenon. Our *Opinion Pieces* section gives the opportunity for one party or the other to put their point of view. Andy Brower explores conflicting theories to explain the evolution of mimicry in *Heliconius* butterflies, his own differing from what is currently considered the mainstream theory. We have invited a response from the other camp.

There is a growing call to give more prominence to the welfare of insects when using them for research. The Society has produced a statement on the issue. We would welcome your views. There is also a growing call to highlight the contributions of pioneering female entomologists. The restoration of the grave of one such, Eleanor Ormerod, is now complete. You can view the result and find out about the Society's award in her honour.

On the outreach front, the relocation to Stratford of our Chelsea Flower Show Garden is complete and we've teamed up with Aardman Animations to produce an insect trail featuring Lloyd of the Flies, our first non-human Society Ambassador. Two books aimed at the public, *Insects* and *Insectarium*, have been published recently with support from the Society. Indeed, the former was written entirely by members. The story of its preparation is recorded herein. We also have a brief report on Insect Week.

Hopefully, this issue has reached you in time for Christmas. The library holds a collection of weird and wonderful old Christmas and new-year cards showing insects, some of which are featured in our librarian's contribution to this issue.

Many thanks to all contributors. Have a good one!

Richard Harrington

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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).

Antenna

Bulletin of the Royal Entomological Society

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Letter from the President

Jane Stout signing the Obligations Book

It's been an exciting first month as president – I was thrilled to be able to meet so many members at Ento24 in Liverpool. The vibe at the meeting was wonderfully positive. I met lots of early career researchers doing fascinating pure and applied insect science; I got to meet the fantastic staff and trustees of RES in real life; and the opportunity to see the *Bees* exhibit at the World Museum in Liverpool was fabulous. Thanks to everyone, especially Amy Everard, for organising such an uplifting meeting.

Another highlight of Ento24 was the outstanding plenaries. The speakers (Michael Samways – Stellenbosch University, Steve Torr – Liverpool School of Tropical Medicine, and Susanne Foitzik – Johannes Gutenberg University Mainz) were impressive and engaging, addressing insect conservation, control of disease vectors and the genetic basis of behaviour, respectively. It was inspiring and overwhelming to appreciate how much work they and their collaborators had accomplished to culminate in the stories they told. The plenaries complemented the excellent oral and poster sessions superbly. Congratulations to Sharon Zytynska, Chris Williams, Chris Jones and Michelle Davis for convening such an impressive scientific programme.

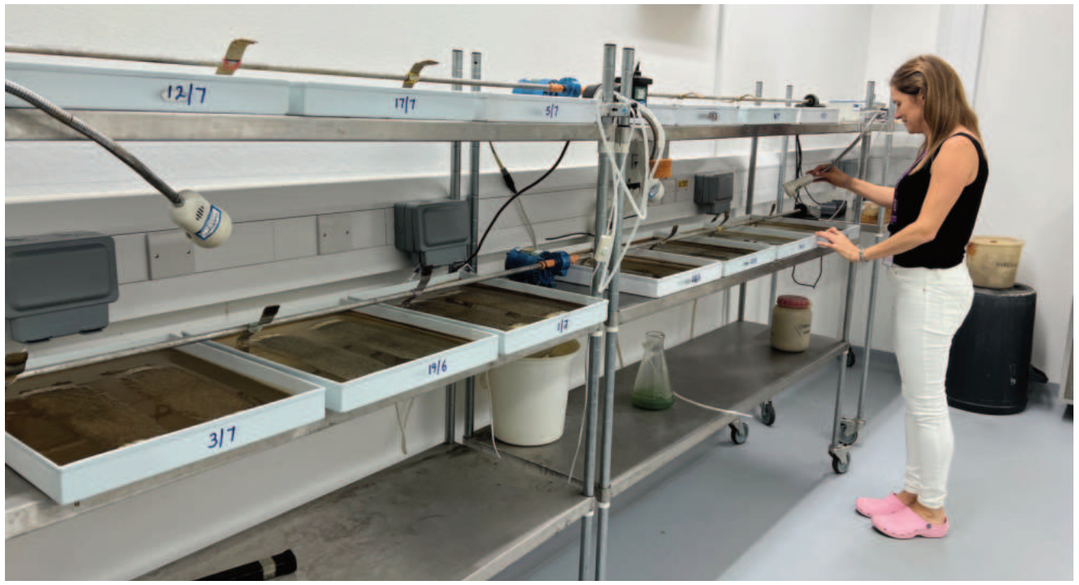
Among the other events during Ento24, I very much enjoyed the *Women in Entomology* session, where we heard about the women who have made their mark in entomological history. Despite women having been admitted to the RES from its foundation in 1833, they have been greatly outnumbered by men in the world of insect science. As a woman, an entomologist who has spent most of her academic life in a Botany department, I was particularly intrigued by the book by Emma Hutchinson in 1879, entitled *Entomology and Botany as pursuits for ladies*. She was certainly onto something. Hopefully, the new RES EDI Committee and forthcoming strategy will mean that not only gender equality, but diversity and inclusion of all forms will be more actively encouraged and supported in the future.

As a Fellow of the Society, I also got to sign the Book of Obligations, under the watchful eye of RES librarian and archivist, Rose Pearson. This impressive book is a piece of history in itself. It is signed by two of the most famous naturalists of all time, Charles Darwin and Alfred Russel Wallace, as well as other, perhaps less entomologically renowned, famous women (Queen Victoria and Queen Elizabeth II). Adding my name to that book along with the other Fellows, was a slightly surreal but special moment.

I came back to the day job in Dublin, reflecting on what insect science is and how to describe the breadth of the subject to my colleagues, family and friends. To me, modern entomology broadly encompasses how to look after insects (conservation, food), how to get rid of problematic insects (pest/vector control) and how insects work (the pure science – taxonomy, behaviour, genetics, ecological interactions). It is heartening to see that the beneficial roles of insects are now given as much scientific airtime as pest management (which wasn't the case when I started out), and that the fascinating and sometimes strange aspects of the insect world, the stories that unfold when you look closely and long enough, continue to be researched and told. Notably, some of these stories are brought together in the wonderful new book, written and edited by RES Members and Fellows, *Insects* (available through the RES website – get it on your gift list this year!). But what Ento24 also reminded me was that problems can't be solved from a single disciplinary perspective. Working with other disciplines, across sectors is key to addressing challenges; entomologists working with engineers, computer scientists, health scientists, artists, planners and psychologists, in research institutions, public bodies and private industry. This is going to be important as we will tackle the Grand Challenges in Entomology.

Finally, like many of you facing into a new academic year, sometimes feeling a bit like a worker ant, focussing on specific tasks, it's important for me to remember and channel the positivity experienced at Ento24. With the knowledge, skills, enthusiasm, sense of wonder, and collaboration that RES members undoubtedly possess, I am optimistic about the future of insect science and I look forward to working with you all over the coming months.

Jane Stout
President
Royal Entomological Society



World-leading virus laboratory, The Pirbright Institute, on tackling Bluetongue Virus

Culicoides midges have become the latest entomological villains to make news headlines. As vectors of bluetongue virus (BTV) in ruminants and camelids, perhaps their portrayal is justified. "Farmers warned to stay alert after Dutch bluetongue outbreak", one headline read. *Culicoides* midges are in the family Ceratopogonidae, commonly known as biting midges. Within the genus, there are over 1,300 species, several of which are potential disease vectors, including of BTV and Schmallenberg virus.

BTV causes a non-contagious viral disease, which is notifiable in the UK, which means it must be reported to the authorities if a case is found or suspected. Clinical signs in sheep can include mouth lesions, lameness, high fever, drooling, swelling of the neck, head and tongue, and sudden death. Symptoms in cattle and deer are less severe but these animals are still involved in disease transmission. While the disease poses no threat to humans, its impact on animal health, along with trade and movement restrictions, means that BTV has a high economic impact on the livestock industry.

The Pirbright Institute in Woking, Surrey, carries out world-leading research into viral diseases of animals. A range of experts work on different aspects of bluetongue virus, with Dr Marion England leading the Vector Ecology research group, Dr Christopher Sanders leading the Veterinary Entomology group and Dr Carrie Batten leading the Non-Vesicular Reference Laboratory, which carries out testing of samples taken from animals suspected to have bluetongue disease in the UK. Additionally, Dr Simon Gubbins, who leads the Transmission Biology group, specialises in modelling bluetongue disease transmission.

Working with DEFRA and the Met Office, the teams analyse wind patterns and temperature to determine the risk of *Culicoides* BTV-infected vectors coming from continental Europe to the UK. They have created mathematical models to predict transmission within and between farms, helping to inform the government on possible mitigation measures. They are also home to the National and World Organisation of Animal Health (WOAH) reference laboratory for BTV. The diagnostic tools used to detect BTV in ruminants, including next generation sequencing technologies, are also developed and used here. Understanding

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Culicoides nubeculosus larva (Photo: The Pirbright Institute).

host–virus–vector interactions is critical. In high-containment animal research facilities, the team studies the clinical presentation, pathology, infection dynamics and immune response in cattle and sheep infected with new BTV strains, using a *Culicoides* infection model that accurately simulates infection in the field.

I visited The Pirbright Institute to meet with Marion to find out more about its critical work in understanding, predicting and preventing BTV transmission. Beeped in, having passed security, we head to the insectary, where all the entomological magic happens. More security door bleeping, and before we can enter the main research areas, we put on overshoes. We enter a room where Marion's colleagues, Rafael and Melanie, are busy working. Melanie is a post doc and works with Marion to run the UK *Culicoides* surveillance scheme. Marion explains more on how the surveillance programme works. "We've currently got 18 traps located on farms and zoos. The sites run these for us on a voluntary basis. They set the trap up and switch it on once a week, empty it, and then post us what they've collected. This surveillance allows us to monitor the abundance and diversity of vectors at different times of the year."

Before entering the insectary, I had been picking Marion's brains on potential genetic control measures. Rafael has recently joined the Institute to work on insect transgenesis and explains some of his work. "I'll be mainly working with mosquitoes to study their genomes and their response to virus infection. You can develop insects with resistance to viruses to find out why some species or individuals are susceptible to different viruses, or you can create insects that can only survive in certain conditions to reduce the populations in the wild. It is possible with some species already, but programmes such as this need to be carefully managed to understand the consequence of modifying them and their populations in the field."

There are also challenges in studying midge colonies, Marion tells me. "The midge species that transmit BTV in Northern Europe can't be colonised in captivity. They don't like to mate in enclosed spaces. However, we have two *Culicoides* species here. One is *Culicoides sonorensis*, a North American species and BTV vector. While it's not native, it is relatively easy to rear, so we use it as our model species for studies to see how the virus replicates inside the midge. The other species is *Culicoides nubeculosus*. It is native to the UK and Northern Europe but doesn't transmit BTV. It is therefore a useful comparison to the vector species, so we can see what the virus is doing in one versus the other to help us understand why some species are able to transmit the virus and others do not. During the vectors' active season, we can also collect our native BTV vectors from the wild, bring them into the laboratory and conduct experiments using them, but having the colonies allows us to work year-round with a guaranteed supply of insects."

Blood-fed (left) and unfed (right) *Culicoides obsoletus* (Photo: The Pirbright Institute).

BTV belongs to the Sedoreoviridae family and is one of 20 known species in the *Orbivirus* genus. There are currently 29 serotypes of BTV, but the recent unfolding events capturing the headlines are centred around BTV-3. "Most of our previous research has been conducted on BTV-1, 4 and 8, and with the emergence of BTV-3, you initially have to assume that the virus will behave in a similar way to those we do understand. As the outbreak progresses, we are able to build up more data on the new serotype and which vector species are involved, and this helps to improve our transmission models and tailor them to the current BTV serotype and strain we are dealing with."

The first five cases of BTV-3 were discovered in The Netherlands on 5th September 2023. By January 2024, nearly 6,000 cases had been reported, and by February 2024, around 5% of the Dutch sheep flock had been lost. On 11th November 2023, BTV-3 was detected in the UK; a single cow on a farm in Kent. The outbreak inevitably spread, leading to heightened concerns across the British farming sector. After a brief winter hiatus, the virus re-emerged on the continent and it is hypothesised that infected midges were blown across the English Channel around mid-August, kick starting the UK's 2024 outbreak. The situation is evolving rapidly, however, and writing this on 20th October 2024, the total number of infected farms is 145 in the UK, 143 of which are in England and two in Wales (the latter due to animal moves that occurred before movement restrictions were put in place). Much of the east of England is now under movement restrictions.

This isn't the first time an outbreak of BTV has impacted the Northern European and UK livestock industry. There were several outbreaks in Europe between 1998 and 2006; however, their distribution was confined to the Mediterranean Basin where the Afro-Asiatic vector, *Culicoides imicola,* is present.

"And then in 2006, we had the first ever BTV outbreak in northern Europe, and this was caused by bluetongue virus serotype 8. It was brought under control largely by vaccination", Marion explains. The first cases were detected near Maastricht in The Netherlands. Subsequently, it spread rapidly across Europe, with cases reported in Belgium, Germany, France and Luxembourg, causing thousands of deaths of ruminant livestock. The first case in the UK was recorded in September 2007, with 125 holdings affected by early 2008. In May 2008, a vaccination programme was launched, and subsequently there were no reported cases of BTV-8 in the UK in 2008, unlike elsewhere in Europe, where vaccination roll out fell behind the wave of new infections.

"Northern Europe became BTV-free from 2013. BTV disappeared for a couple of years before popping up again in France in 2015 and nobody knows quite where it came from. Maybe it was still circulating at very low levels, maybe in the wild deer population," says Marion. "After large numbers of animals in Europe had been vaccinated or exposed, there was no longer a naïve population of livestock. But over time, there is a turnover of animals, and the population is naïve again. So that's one theory. Another theory is that it was from bull semen from an infected animal, frozen during the outbreak and used for artificial insemination after a period on ice."

Marion and the team are trying to anticipate BTV-3's next movements. One of the key questions is whether it can overwinter in the UK. "Overwintering, persistence of the virus in the absence of its vectors, is a phenomenon that we don't understand very well. As far as we know, the midge cannot pass the virus to its offspring. If all the adult midge population dies off in winter and the midge overwinters as larvae, none of the larvae should be infected with BTV. Typically, adults would not survive the winter here. As the temperature lowers as we go into winter, the adult population reduces. *Culicoides* become active from about 4°C, but at higher temperatures like 30°C, they begin to desiccate and die. BTV needs temperatures to reach around 12°C to start replicating, so as temperatures warm, the virus can be transmitted."

I wonder if climate change and our increasingly warm winters have extended the midge season, and even the ability of the virus to be transmitted. These are questions Marion and the team have been investigating. "We had a very mild winter, and the midges took a long time to disappear. We didn't detect activity levels completely stopping until January, which normally we would see around the end of November. The larvae overwinter in the soil and adults emerged a month earlier than usual this year. Normally it's around the second week of April, but this year it was 18th March." This has led the team to wonder if some of the adults survived the cold period from January through to March. While the lifespan of a midge is normally a couple of weeks in the wild, some may live for a couple of months. "Could we have adults that were infected in the previous autumn surviving all the way through and then biting an animal in the spring?" Marion wonders. She is also exploring the possibility of midges moving into animal housing through the winter where it is warmer, and even possibly continuing to bite within the housing.

So how does the transmission cycle work? Marion explains: "Newly emerged adult midges are uninfected because BTV can't be passed from their parents, so they need to bite an infected animal. They need two blood meals to cause an infection, acquiring BTV on the first and passing it on during the second. The period between blood meals is dependent on how quickly they digest their blood meal, how quickly they make and lay their eggs and how soon they want to feed again. All these factors are dependent on temperature, so the process shortens and lengthens in time depending on how warm it is. It could be a week between blood meals, it could be two weeks. If the midge has bitten a BTV-infected animal, the virus can replicate within the midge

Stomoxys calcitrans larva and *Stomoxys calcitrans* male and female genitalia (Photo: The Pirbright Institute).

and then move to the salivary glands where it is then passed to the next animal that the midge bites. The process of replication within the midges is called the extrinsic incubation period, and the rate of virus replication within the midge is also dependent on ambient temperature. Occasionally, the virus may be transmitted by other means, such as transplacental transmission, whereby animals that have been infected when they're pregnant pass the virus to their offspring which are then born in the spring. This is another potential mechanism for the virus to overwinter." Based on the behaviour of other serotypes of BTV, scientists believe animals can be viraemic for up to 60 days. If this is the case with BTV-3, then the virus could overwinter in the ruminant host.

Chris Sanders' group conducts research within Pirbright's high containment laboratories to understand how the virus behaves once it infects a midge or an animal. During my visit, Chris was undertaking a second *in vivo* study on BTV-3 in the animal isolation unit. By using midges from the colony to infect sheep and cattle, they can replicate a natural infection and study its behaviour, rather than inoculating the animal using a needle. "There are factors in the midge saliva that can help kickstart the infection in the ruminant by facilitating virus transmission. If you just inoculate the animal with a needle, you're missing out the interaction that happens between the host, the virus and the vector," explains Marion. "Chris takes a midge from the colony and inoculates it with the virus into its thorax using a fine glass needle. Not all the midges survive this, but enough do and the virus replicates inside the midge. We then put these infected midges into little pots that have gauze over the top and allow these midges to feed on the animal."

The first study exposed five sheep to BTV-3-infected midges, and all five exposed sheep contracted BTV-3. One showed no clinical signs and the other four became sick, although one of them rallied after treatment. "The sheep were the same breed, and sourced from the same place, so it demonstrates the variation in individual response to the infection. The variation in clinical presentation can be down to virus strain, breed and species, but even within a breed you get significant variation. Today, Chris is carrying out the same study on cattle, looking at what the clinical presentation is like, how long the animals are viraemic for and, importantly, whether the infected animals can reinfect midges. So, we are also feeding uninfected midges on an infected animal and studying the efficiency of virus transmission to vectors. With BTV-8, only a small proportion of midges fed BTV would have been able to transmit the virus. So, if you feed 100 midges on an infected cow, only one might become infectious with BTV. This is due to the many factors stopping the virus replicating within the midge. It has to break out of the midge's midgut, successfully replicate to infectious levels and migrate to the salivary glands; and 99 times out of 100, it's not successful. But there are billions of midges, so that still results in millions of infected midges."

Armed with the background story of their research and context, we head to the lab. The *Culicoides* Reference Laboratory surveillance work started in 2006 in response to the initial BTV incursion, but the *Culicoides* research colonies were started way back in the 1950s. "This is all from 18th April in Chester", says Marion as she shows me a sample of midges. "Normally, this would be when we're just beginning to see them emerge, but there was a lot of adult activity by April of this year."

When they receive the samples, they pick out individual midges under the microscope to identify them to species level, before putting them into a solution of 70% ethanol, allowing them to be stored for many years. Marion pulls out a recent haul of midges, picks one out and places it under the microscope. "These are British *Culicoides*, and we identify them for the most part by their wing patterns. There are about 50 species in the UK, and six of them are vectors of BTV. 90% of what we catch on farms are those six species."

I wonder if it's possible to test them for BTV. "In theory we can, but you may need to test thousands before you find one that is positive. It doesn't work as an early warning tool, as you would likely see disease in animals before you would be able to detect it in the vectors. Also, if vector samples are negative for virus, it does not mean that the virus is not circulating, just that you collected a sample that wasn't infected. These ones are from Dover, collected on 1st April. You've got two species there. Both are vectors. The little ones on the left are *Culicoides obsoletus*. They're our most numerous ones. The big one on the right is *Culicoides pulicaris*." Marion points out the site of Chris' injection into the thorax, and I contemplate what an act of precision this must be. She then zooms in. "We sex them and identify them to species level, and we try to age them. Before the females have taken a blood meal, they have an empty abdomen and it's clear and white. The two on the left have nothing in their abdomens. They're only a day or two old. They haven't had a blood meal yet. They would go and find a host and take a blood meal, so when we see that under the microscope, we see a fat abdomen full of blood. We wouldn't test blood-fed ones for BTV because you might just pick up the virus that's in the blood meal. It doesn't necessarily say that the vector is infective, just that it's fed on something that was infected. You need to be able to show that the virus has moved from the mid-gut, replicated and gone to the mouthparts. The speed of virus replication within the midge is dependent on temperature. It's about 5 days at 20°C. I would just test their heads, because that tells you if the virus has migrated to the mouthparts." We return our focus to the microscope. "Here you can see the blood-fed ones. After they've had a blood meal, they digest it and then develop eggs. You can see inside their abdomen, it's chock full of little eggs, so we know they're a little bit older. They will then oviposit. What's then left inside the abdomen is a red-brown pigmentation, which you can see on that one on the right, so she's had eggs and would be looking for her next blood meal. If she was infected by the first blood meal, and the virus had disseminated, she would be ready to pass the virus on through a second blood meal. She's the one we're most interested in."

Marion decides now is a good time to introduce me to their colonies. We walk down the corridor and enter a temperature-controlled room where the research colony of *C. sonorensis* is kept. There is a series of pans filled with a small amount of liquid, and some wadding, and in them the larvae are wriggling around. "When we set up a new pan, we take some of the old water and put it in the new pan because there's a bacterial culture in there. They are fed every couple of days; they get a spoonful of ground up grass meal, and some of nutrient broth." We leave this room, travel down the corridor and take a right. "This is *Culicoides nubeculosus*, our native species that isn't a vector. Both colonies are on a 16 h:8 h light:dark cycle. Every Monday, Wednesday and Friday, a technician feeds them, collects eggs and sets up a new pan, throws away the old pan, and everything moves along one. We collect the pupae by flooding the pans so all the pupae float to the top and then we vacuum them off the surface with a pump. Adults emerge from the pupae inside pots. We usually just keep a few pots of adults to get enough eggs to keep the colony going. These get blood fed using an artificial feeding system called a Hemotek. They feed through an artificial membrane covering a small well that gets filled with horse blood and heated to 37°C. Trying to rear *Culicoides* species in a sustainable way can be challenging. UK vector species won't mate in these pots. A lot also won't feed through an artificial feeding system, but this species seems to be happy to."

Further down the hallway, we peer into a room where a PhD student is studying the flight dynamics of *Culicoides*. Cameras are pointing at a flight arena collecting data to compare flight behaviour of infected and uninfected midges. "A midge flying through the air is like us trying to walk through treacle; it's very thick for something so tiny. There's evidence from other systems that a virus changes the behaviour of the vector. The virus may manipulate its host for its own benefit. So here, we are studying whether BTV infection changes the way that *Culicoides* fly."

Marion shows me various other research colonies, including stable flies, a potential vector of lumpy skin disease virus. An escapee led to a healthy arm slap from Marion to dispatch it. She assured me the slap was less painful than the bite. I'll have to take her word for it. It's only now that Marion reveals that today is her birthday!

Marion and her group plan to begin work using environmental DNA to detect the presence of *Culicoides* larvae in soil. There is also work planned to investigate the ecological role of midges, in particular the potential pollination role of *Culicoides*. "It's important that we understand what they're doing on farms other than biting animals. They spend 90% of their time not feeding on their host, so what are they doing? Understanding where they are, either in the soil as larvae or as adults perhaps frequenting a specific plant, would enable the development of methods to better control them. The males need nectar, as they don't blood feed, so if we could limit the nectar source, that might have a knock-on effect on population size."

There is currently no treatment for BTV and vaccinations are serotype-specific. Given the severity of the situation, the Secretary of State approved the emergency use of vaccines in England. Three vaccines have been used across Europe and are available under licence with priority given to those in high-risk areas.

The work of the researchers at The Pirbright Institute will play a critical role in monitoring and mitigating the impact of BTV in the years to come.

Firefly flashes and field observation.

World Firefly Day 2024

Illuminating India: The Nationwide Firefly Conservation Initiative

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Introduction
Fireflies, or lightning bugs, hold a special position in a country where biodiversity is as rich and varied as its culture. These enchanting beetles from the family Lampyridae, known for their bioluminescence, play a crucial role in the ecosystem. They are not just a summer's delight but also excellent bio-indicators of a healthy environment. Their larvae contribute to natural pest control by feasting on garden pests like snails and slugs. The adults are pollinators and a food source for other animals. Despite their ecological importance, researchers have largely neglected fireflies, resulting in a conservation status that remains data deficient.

Several key factors contribute to the decline of firefly populations. Urbanisation, deforestation, and agricultural expansion destroy or fragment their natural habitats. This alteration or diminution of wetlands, meadows and woodlands impacts their breeding and feeding grounds. Artificial light disrupts fireflies' mating rituals, as excessive lighting interferes with their bioluminescent signals. Chemical pollutants and pesticides harm fireflies directly or destroy the insects they feed on, reducing food availability and contaminating water sources where fireflies lay their eggs. In some areas, the collection of fireflies for the pet trade or scientific research causes local population declines if not managed sustainably.

Strategies for Firefly Conservation
Conservation efforts are essential to address these issues. Protecting natural habitats, reducing light pollution, and using fewer chemicals are steps that can help mitigate their decline. By raising awareness and supporting local conservation initiatives, we can ensure the future of firefly populations and maintain the ecological balance which they help sustain. There are over 2,200 species of firefly worldwide, but in India only about 50 have been documented so far. There is a significant gap in our understanding of their diversity and ecology. To help bridge this gap and to instil a valuable sense of responsibility, a citizen science initiative was launched across the country.

Communication of citizen science through social media.

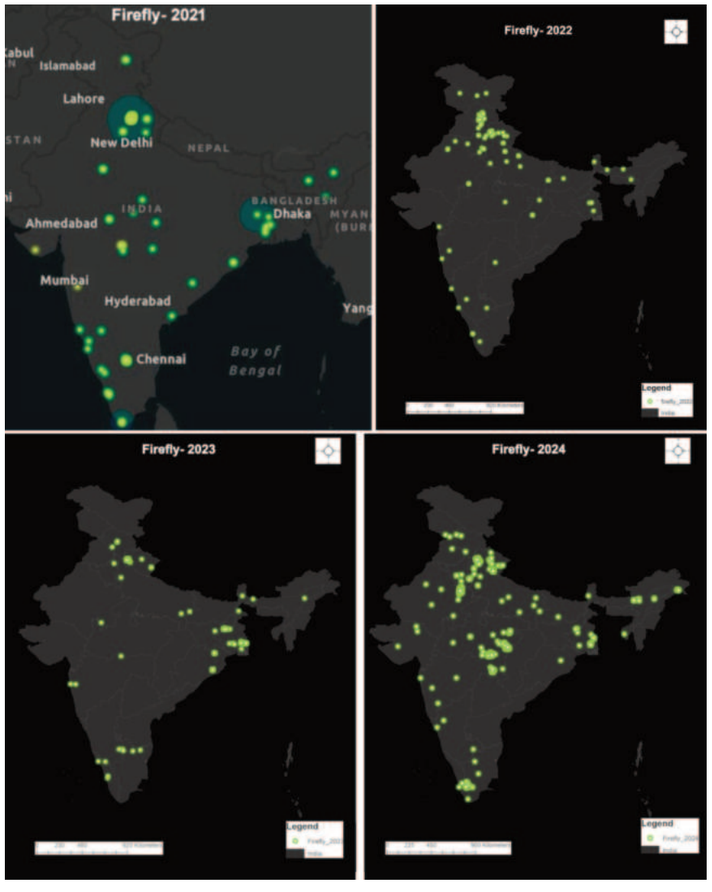
Citizen Science Initiative
Fireflies are magnificent creatures whose collective flashes create a mesmerising recreational environment. To highlight their significance, the organisation *Fireflyers International Network* designated the first weekend of July as *World Firefly Days*. We launched a nationwide firefly survey in July 2021 to support firefly conservation and raise awareness in India through a Rufford Foundation small grant for firefly study in Doon Valley. Thus, in 2021, a ground-breaking citizen science project was launched to document firefly occurrences across India. This is now an annual event.

To enhance survey participation, we designed an eye-catching cover page and prepared a questionnaire to collect essential information on fireflies. We generated a link to the questionnaire using ArcGIS Survey 123. We circulated this link through the official websites and Instagram handles of the Wildlife Institute of India and Graphic Era University. Additionally, we leveraged personal contacts to increase involvement. We guided participants to go out at around 8–9 pm, look for fireflies, make an approximate count and provide information on nearby anthropogenic pressures to identify potential drivers behind the decline of firefly populations.

Over the past four years (2021–2024), public participation has grown steadily. We have provided educational programmes, workshops and community events, offering platforms for people to learn about fireflies and contribute to their preservation.

Highlights from Firefly Surveys
Firefly surveys have played a pivotal role in engaging

Abscondita perplexa.



Indian Firefly Survey Responses 2021-2024.

Firefly larva feeding on snail.

communities across the country, aiding in the documentation. The first survey in 2021 involved just 76 citizen scientists. In 2022, 170 from 19 states took part, and 93 participants from 14 states in 2023. The response grew remarkably in 2024 with 350 participants from 20 states. Over the years, approximately 26,000 firefly sightings have been documented, revealing a significant participation from states including Uttarakhand, Madhya Pradesh, Maharashtra, Kerala, Rajasthan and West Bengal. This widespread involvement not only highlights the distribution of fireflies across diverse regions but also fosters a deeper appreciation and understanding of these luminous insects. Such widespread involvement indicates a collective recognition of the ecological importance of fireflies. Their presence serves as a strong indicator of environmental health, making their conservation crucial. By involving citizens in these surveys, we not only gather valuable data but also promote a sense of stewardship towards the environment. The firefly survey has thus become more than just a data collection exercise; it is a movement that educates and inspires people.

Future Directions: Ensuring the Glow Continues

The success of the firefly survey sets the stage for future projects aimed at strengthening conservation planning for fireflies. By continuing to engage communities and expand research efforts, we can ensure that the glow of fireflies continues to illuminate our nights, signalling a healthy environment for generations to come.

The celebration of World Firefly Day in India exemplifies the power of collaborative efforts in biodiversity conservation. Through the combined efforts of various organisations and enthusiastic citizen scientists, we are not only safeguarding these magical beetles but also nurturing a culture of environmental stewardship.

Field visit.

OPINION PIECE

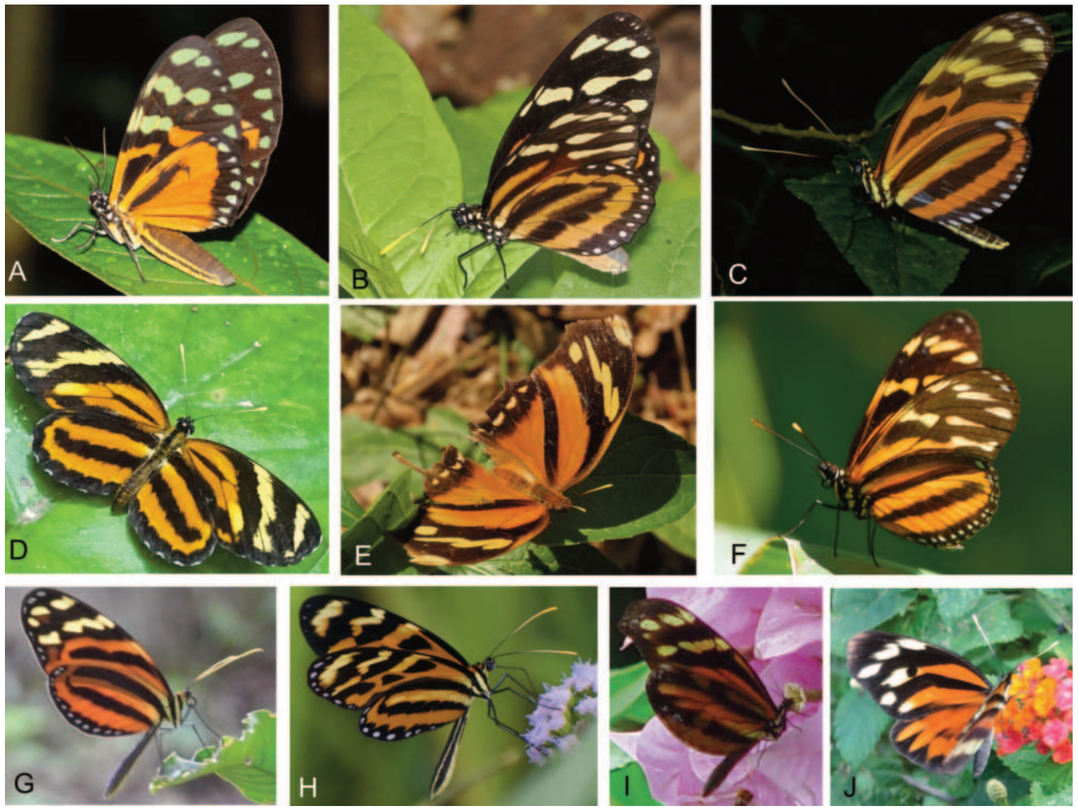


Figure 1. The occurrence of mimicry is widespread in Lepidoptera. All images licensed Creative Commons share alike.
A) *Chetone angulosa* (Erebidae: Pericopina) (photo by GuyBroome, www.inaturalist.org/observations/145506112);
B) *Lycorea halia* (Nymphalidae: Danaini) (photo by Phil Benstead, www.inaturalist.org/observations/214745543);
C) *Heliconius ismenuis* (Nymphalidae: Heliconiinae) (photo by Josue Ramos Galdamez, www.inaturalist.org/observations/189539726);
D) *Melinaea lilis* (Nymphalidae: Ithomiini) (photo by Neptalí Ramírez Marcial, www.inaturalist.org/observations/14487842);
E) *Consul fabius* (Nymphalidae: Charaxinae) (photo by Oliver Komar, www.inaturalist.org/observations/207714091);
F) *Eueides isabella* (Nymphalidae: Heliconiinae) (photo by Carlos Arturo Marín Medina, www.inaturalist.org/observations/19146634);
G) *Eresia eunice* (Nymphalidae: Melitaeini) (photo by Neil Husher, www.inaturalist.org/observations/152054266);
H) *Mechanitis isthmia* (Nymphalidae: Ithomiini) (photo by Asher Perla, www.inaturalist.org/observations/123783832);
I) *Dismorphia amphione* (Pieridae: Dismorphinae) (photo by Jeff Chapman, www.inaturalist.org/observations/9485150);
J) *Perrhybris pyrrha* (Pieridae: Pierinae) (photo by laurauthar, www.inaturalist.org/observations/148532557)

Evolution of mimicry in *Heliconius* butterflies: historical hypotheses meet modern models

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Introduction

Traditionally, evolutionary biologists have explained mimicry in butterflies by evolutionary convergence towards a common aposematic wing pattern that advertises to experienced visual predators that the butterflies bearing it are distasteful or otherwise unpalatable. During the past 20 years, researchers have elucidated an additional mechanism to explain mimetic resemblance among Neotropical *Heliconius* butterflies: hybridisation between species belonging to different mimicry complexes, allowing introgression of wing pattern alleles and the resultant swap of mimetic allegiances. This essay describes these adaptive mechanisms and compares and contrasts them as explanations for the evolution of mimicry in this paradigmatic group of butterflies.

OPINION PIECE

Evolution of mimicry

Over 160 years ago, Henry Walter Bates (1862) published his classic paper describing the advantage palatable butterfly species gain from resembling unpalatable species, thus deceiving avian predators: the adaptive phenomenon subsequently referred to as Batesian mimicry. A few years later, Fritz Müller (1879) extended Bates's theory by mathematically describing the safety in numbers which unpalatable butterflies achieve by sharing a common wing pattern – an instance of positive numerically-dependent selection. Although widely accepted as a confirmation of Darwin's (1859) theory of natural selection, almost a century would elapse before Jane Van Zandt Brower (1958a, b) corroborated the efficacy of Batesian mimicry with controlled experiments.

In Batesian mimicry, palatable mimics deceive potential predators, while in Müllerian mimicry, unpalatable mimics honestly advertise their distastefulness (of course, there may be intermediate cases – not all aposematic butterflies are equally noxious (Brower *et al*., 1968)). Müllerian mimetic *Heliconius* butterflies are warningly-coloured and distasteful to vertebrate predators (Brower *et al*., 1963), due to cyanogenic glucosides that they derive from their passifloraceous larval hostplants (Davis & Nahrstedt, 1987).

In the standard scenario, mimicry evolves because predators learn to avoid a common, distinctively coloured and chemically defended species – the 'model'. Less common or less well-defended species that predators may mistake for the model are selected to converge on the model's colour pattern by more intense predation on variants that look less like the model. In Batesian systems, convergence of palatable mimics is costly to the model, because attacking the mimics can disrupt the predators' memory of the aposematic signal (thus, Bates' observation that palatable mimics are scarcer than the models). By contrast, a Müllerian mimicry complex exerts an evolutionary 'gravitational pull' on all its members, selecting for phenotypes that conform to the common pattern, with predators weeding out oddballs. Of course, a single lepidopteran mimicry ring may contain both Müllerian and Batesian mimics (*cf*. Beccaloni, 1997), often representing different genera or families of butterflies, and even some moths (Fig. 1). Their common aposematic raiment is clearly explained by adaptive convergence.

Patterns of *Heliconius* diversity

In Amazonia, up to ten species of *Heliconius* converge on a common Müllerian mimetic phenotype. At the same time, multiple contrasting mimicry rings coexist among different sympatric *Heliconius* species. Further, as Bates (1862) first noted, mimetic complexes vary their colour patterns geographically. Since Bates, the bewildering diversity and relationships of *Heliconius* have been taxonomically revised and phylogenised repeatedly (Riffarth, 1901; Eltringham, 1916; Emsley, 1965; Brown, 1981; Brower, 1994a; Beltrán *et al*., 2007; Kozak *et al*., 2015; Brower & Garzon-Orduña, 2017). The genus contains fewer than 50 species, but more than 350 phenotypically distinct intraspecific varieties (Lamas & Jiggins, 2017). Many of these are allopatric, distinctly different-looking geographical races or subspecies. *Heliconius* systematists disagree on circumscriptions of some species, but generally employ some version of the Biological Species Concept (Mayr, 1940), which relies on the potential to interbreed, rather than on appearance, to delineate species boundaries. This concept is preferred because differentiated races of the same species freely hybridise when they come into contact. Despite this interbreeding, conspecific races maintain wing pattern differences without blending into one another, due to strong selection by local predators against both migrants crossing the hybrid zone, and non-mimetic hybrid phenotypes (Mallet & Barton, 1989).

Many geographically varying mimicry rings are explained by convergence of wing patterns between different species of *Heliconius*, perhaps most famously between *H. erato* and *H. melpomene* (Sheppard *et al*., 1985). Evidence from hybrid zones shows that once established, hybridising races persist despite the lack of mating barriers. But how does a new, different-looking race arise? To explain the paradox of *Heliconius* intraspecific geographical variation despite strong selection for phenotypic uniformity, Brown *et al*. (1974) proposed the Pleistocene Refugium Hypothesis (Haffer, 1969): perhaps isolated local populations diverged during periods of rainforest contraction between 2 million and 20 thousand years ago. Molecular clock estimates have corroborated the temporal consistency of *Heliconius* intraspecific divergences during the Pleistocene (Brower, 1994b, 1996a; Quek *et al*., 2010; Arias *et al*., 2014; Garzón-Orduña *et al*., 2014; Hoyal Cuthill *et al*., 2015).

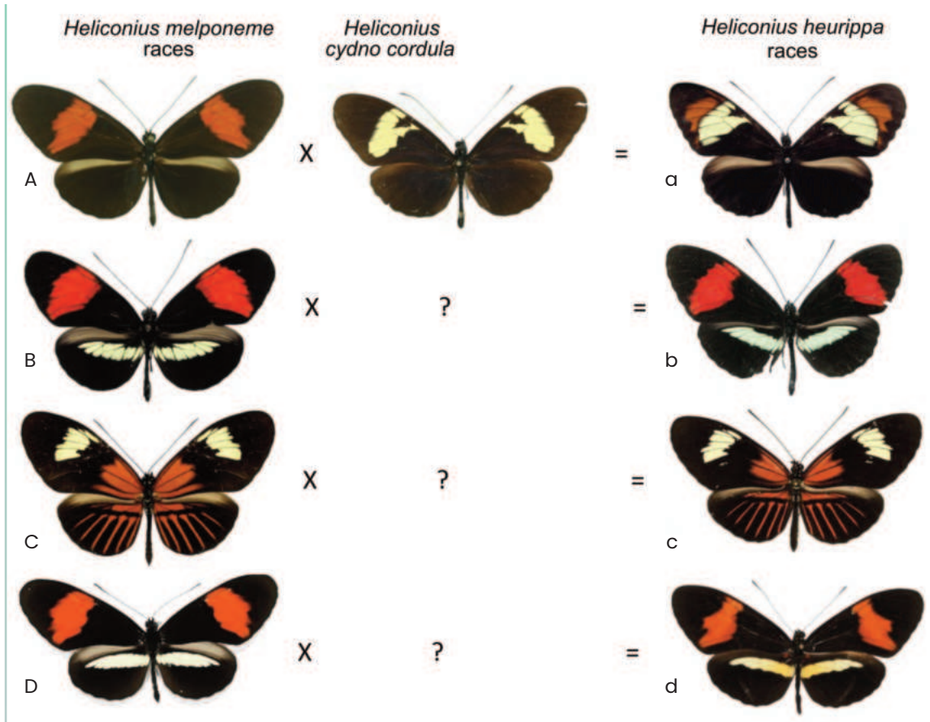

Figure 2. Putative races participating in homoploid hybridisation and the resulting new species. According to Mávarez *et al.* (2006) *H. heurippa* was formed by hybridisation between *H. melpomene melpomene* and *H. cydno cordula*. *H. melpomene* races: A= *melpomene*, B = *mocoa*, C = *malleti*, D = *amaryllis*. *H. heurippa* races: a = *heurippa*, b = *tristero*, c = *florencia*, d = *thelxinoe*. There is no nearby *H. cydno* for B, C or D to hybridise with to produce b, c or d. Images in Figs. 2, 3 and 4 courtesy of Michel Cast (used with permission).

A new paradigm: hybrid origins of *Heliconius* species?

Mávarez *et al*. (2006) proposed that the nonmimetic species *H. heurippa* (Fig. 2) was formed by hybridisation between *H. melpomene melpomene* and *H. cydno cordula*. Their genetic and breeding experiments suggested that *H. heurippa* is phenotypically intermediate between these 'parental' forms. Note that *melpomene* x *cydno* F1 hybrids look more like *H. melpomene melpomene* than *H. heurippa* does, so if this scenario is correct, proto-*H. heurippa* hybrids defied the gravity of Müllerian mimicry by evolving away from the common model. Subsequent genomic evidence showed that *H. heurippa* belongs to the *H. cydno* group (Arias *et al*., 2014). This fact led *Heliconius* researchers to propose a model of 'islands of divergence' (*e.g*., Nadeau *et al*., 2012) in which only gene regions encoding colour patterns introgress across species boundaries, while the remainder of the genome remains unadulterated. Subsequently, *H. heurippa* has been described as a *melpomene* x *timareta* hybrid (Nadeau *et al*., 2013), or a northeastern race of *H. timareta* with introgressed wing pattern elements from *H. melpomene* (Arias *et al*., 2014). Given nearby conspecific races with red or yellow forewing bands (Fig. 3), *H. heurippa* is now most parsimoniously viewed as a geographical race originating from intraspecific, not interspecific, gene flow.

Mallet *et al*. (2007) published a list of putative hybrid *Heliconius* specimens to support the argument that "the species boundary is a continuum" and to provide an empirical foundation for the existence of interspecific hybridisation. Brower (2018) offered alternative interpretations of many of those specimens that undermined the "continuum" narrative. Mallet (2019) responded but disputed the identity of only three of the putative hybrids in detail. Regardless of whose interpretations are correct, the overarching criticism remains that the occurrence of hybrid *Heliconius* specimens does not *de facto* imply a viable conduit for interspecific gene flow: many such hybrids are sterile (Rosser *et al*., 2019), and those that are not may have low mating success with their parental forms (Kronforst *et al*., 2007; Brower, 2011; Merrill *et al*., 2011).

As described above, phenotypically different conspecific *Heliconius* races freely interbreed in hybrid zones, but these zones persist because predators weed out hybrid offspring exhibiting nonmimetic phenotypes (the same selective mechanism thought to drive the evolution of mimicry in the first place). By contrast, sympatric *Heliconius* species are effectively reproductively isolated from one another by visual and/or pheromonal signals (Darragh *et al*., 2017; Garzón-Orduña and Brower, 2017; Mérot *et al*., 2017). For homoploid hybrid speciation to occur in *Heliconius*, species with different visual and pheromonal mating cues must interbreed, and their hybrid offspring must survive (despite potentially exhibiting odd, nonmimetic phenotypes) and reproduce over multiple generations, without being numerically swamped out by their parental forms. Successfully navigating this gauntlet of selective challenges is quite unlikely (Brower, 2011).

Nevertheless, despite a partial retraction (Mávarez *et al*., 2021), *H. heurippa* continues to be touted as a hybrid species, and the *Heliconius* homoploid hybrid speciation story has become a standard explanation for other *Heliconius* species, including ones like *H. hermathena* (Jiggins *et al*., 2008), for which one of the purported parental species is remotely allopatric (at least that hypothesis has now been rejected – Massardo *et al*., 2020). This narrative now functions as an *a priori* framework for interpreting the evidence, rather than a hypothesis to be tested by it. In the remainder of this essay, we turn our spotlight on two recent high-profile articles invoking hybrid speciation in *Heliconius*: Rossi *et al*. (2024), and Rosser *et al*. (2024).

Hiding in plain sight

In the mid-1800s, W.C. Hewitson described two distinctive, imperfectly mimetic *Heliconius*: *H. heurippa*, from Colombia (1854), and *H. timareta*, from Ecuador (1867) (*H. timareta* is locally polymorphic, with one of its forms mimicking *H. melpomene malleti*). Genomic data show that these taxa unequivocally belong within the *H. cydno* species complex (composed of *H. cydno* races, *H. pachinus*, *H. heurippa* and *H. timareta*), which is sister to *H. melpomene*. Because *H. heurippa* nests phylogenetically among other races of '*H. timareta*' (Mérot *et al*., 2013; Arias *et al*., 2017; Jiggins, 2017), the correct senior specific epithet for all taxa called '*H. timareta*' is *heurippa* (Brower, 2018). This nomenclature is employed henceforth.

While *H. heurippa heurippa* and *H. heurippa timareta* have been known for more than a century, among the most remarkable recent *Heliconius* discoveries is the recognition of a series of geographical races of *H. heurippa* along the eastern side of the northern Andes (red dots in Fig. 3) that are virtually identical to sympatric *H. erato* and *H. melpomene* forms. Brower's (1996b) discovery of *H. heurippa tristero* triggered a cascade of new finds: *H. heurippa timoratus* Lamas, 1997; *H. heurippa florencia* Giraldo *et al*., 2008; *H. heurippa thelxinoe* Lamas & Mérot, 2013; and the nonmimetic *H. heurippa linaresi* Arias & Lamas, 2016. Additional undescribed races likely exist (Brower, 2013, 2018).

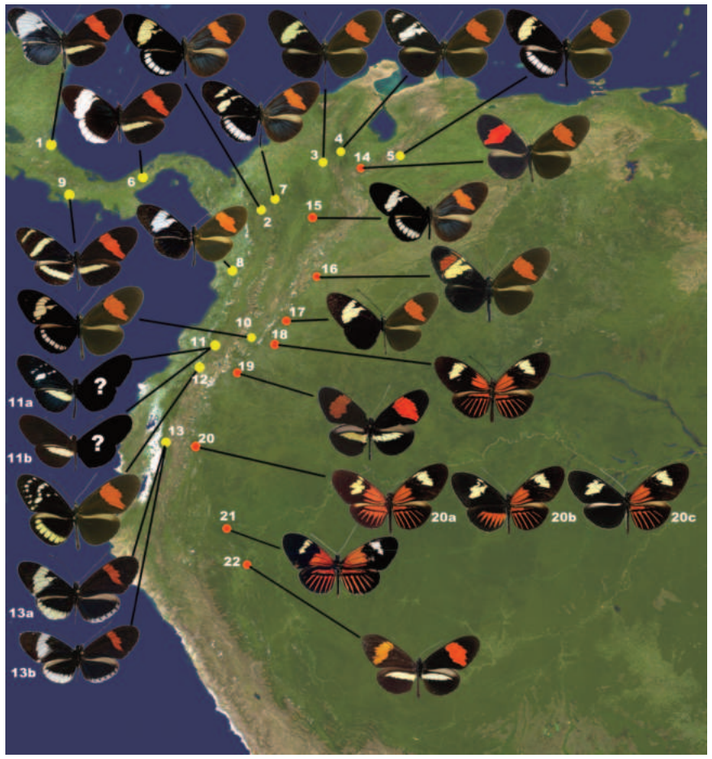

Figure 3. South America map featuring the parallel distributions of *H. melpomene* and *H. heurippa* races.
1. *H. cydno galanthus* / *H. melpomene rosina*; 2. *H. cydno cydno* / *H. melpomene martinae*; 3. *H. cydno cordula* / *H. melpomene melpomene*; 4. *H. cydno gadouae* / *H. melpomene melpomene*; 5. *H. cydno barinasensis* / *H. melpomene melpomene*; 6. *H. cyno chioneus* / *H. melpomene rosina*; 7. *H. cydno cydnides* / *H. melpomene martinae* ; 8. *H. cydno zelinde* / *H. melpomene vulcanus*; 9. *H. pachinus* / *H. melpomene rosina*; 10. *H. cydno lisethae* / *H. melpomene martinae*; 11a, b. *H. cydno weymeri* / no corresponding *melpomene*; 12. *H. cydno hermogenes* / *H. melpomene martinae*; 13a, b. *H. cydno alithea* / *H. melpomene cythera*; 14. unnamed *H. heurippa* cognate / *H. melpomene melpomene*; 15. *H. cydno wanningeri* / *H. melpomene martinae*; 16. *H. heurippa heurippa* / *H. melpomene melpomene*; 17. *H. heurippa linaresi* / *H. melpomene melpomene*; 18. *H. heurippa florencia* / *H. melpomene malleti*; 19. *H. heurippa tristero* / *H. melpomene mocoa*; 20. *H. heurippa timareta* (locally polymorphic) / *H. melpomene malleti*; 21. *H. heurippa timoratus* / *H. melpomene ecuadorensis*; 22. *H. heurippa thelxinoe* / *H. melpomene amaryllis*.

As mentioned above, *H. erato* and *H. melpomene* exhibit parallel mimetic geographical variation, from Central America along both sides of the Andes and across Amazonia to Atlantic coastal Brazil. The Andes produced a vicariant split between cis- and trans-Andean races in both species in the lower Pleistocene (Brower, 1996a; Nadeau *et al*., 2013). *Heliconius cydno*'s geographical races have traditionally been viewed as occurring mostly west of the Andes, where they are black and white/yellow, and mimic *H. sapho* and relatives. However, genomic and breeding experiments show that those races, plus the seven *H. heurippa* races now known from east of the Andes, represent a single, polytypic biological species with a spatially and temporally equivalent radiation and to those seen in *H. erato* and *H. melpomene* (Fig. 3).

Rossi *et al*. (2024) asserted, based on skewed residual homoplasy values (f_d of Martin *et al*., 2014) along a 20kb sliding window of the sequence of chromosome 18 (see below), that the wing patterns of *H. heurippa tristero* and *H. heurippa thelxinoe* were introgressed via hybridisation from *H. melpomene mocoa* and *H. melpomene amaryllis*, respectively, while neglecting to consider potential alternative explanations: the equally remarkable convergence between *H. melpomene* and *H. erato* races has occurred at least a dozen times without hybridisation between those two species.

Given that wing pattern alleles evidently do not penetrate across intraspecific *Heliconius* hybrid zones where interbreeding is common, it would be quite remarkable for wing pattern alleles to defy selection for both mate preference and mimicry, and slip across a species boundary even once. But given the premise of Rossi *et al*.'s introgression scenario (that ancestral *H. heurippa* forms did not resemble sympatric *H. melpomene*), explaining the current phenotypic diversity of *H. heurippa* races requires at least three, and perhaps five or six independent introgression events between sympatric *H. melpomene* and proto-*heurippa* ancestors – multiplying the implausibility of the introgression scenario. Although we do not yet understand how mimetic parallelisms occur at the molecular level, the same mechanisms that allow mimicry between *H. erato* and *H. melpomene* can in principle parsimoniously account for convergences between *H. heurippa* and *H. melpomene*, too.

Correlates and causes

Heliconius elevatus, an Amazonian member of the 'silvaniform group' (mainly orange, yellow and black *Heliconius* species mimicking ithomiine butterflies; Figs. 1, 4), is closely related to *H. pardalinus*, with which 99% of its genome is 'homogenised' (Rosser *et al*., 2024). Rosser *et al*. argued that *H. elevatus* gained the remaining 1%, including its red dennis-ray wing pattern alleles, via introgressive hybridisation from *H. melpomene*, around 200,000 years ago. Brower (1996a) inferred that all the phenotypically diverse Amazonian races of *H. melpomene* also diverged within the last 200,000 years, and further, that the ancestral pattern of *H. melpomene* was the 'postman' and not the dennis-ray phenotype. Although age estimates for *H. melpomene* intraspecific diversification vary (Quek *et al*., 2010; Hoyal Cuthill & Charlston, 2012, 2015; Arias *et al*., 2014), there is agreement that the dennis-ray pattern is derived. Thus, *H. melpomene* races were evolving the dennis-ray pattern at about the same time as *H. elevatus*, and just like the *H. heurippa* example, the introgression explanation begs the question of how *H. melpomene* got its wing pattern. Indeed, Hines *et al*. (2011) suggested that *H. melpomene* acquired the dennis-ray pattern by introgressive hybridisation from *H. elevatus*!

Figure 4. South America map featuring the parallel distributions of selected *H. melpomene*, *H. pardalinus* and *H. elevatus* races.
SE Colombia: *H. elevatus elevatus, H. pardalinus orteguaza, H. melpomene malleti*
middle Amazon: *H. elevatus tumutumari, H. pardalinus radiosus, H. melpomene meriana*
Mato Grosso: *H. elevatus schmassmanni, H. pardalinus maeon, H. melpomene madeira*
Lowland Bolivia: *H. elevatus perchlora, H. pardalinus ariadne, H. melpomene penelope.*

Scrutiny of Rosser *et al*.'s Fig, 1c and Suppl. Fig. 2 shows that for 97% of the genome windows, Amazonian *H. pardalinus* and *H. elevatus* races are more closely related to one another than they are to either *H. pardalinus sergestus* from the Huallaga Valley in Peru, or *H. elevatus bari/tumatumari* from the Guianas (where *H. pardalinus* does not occur). Thus, it may be an oversimplification to say that *H. melpomene* hybridised with ancestral '*H. pardalinus*' to yield *H. elevatus,* because the various races of *H. pardalinus* do not constitute a single entity.

Implausibly, Rosser *et al*.'s Fig. 1e implies that introgression occurred between distantly allopatric populations of *H. pardalinus* and *H. melpomene* to produce the Guianan *H. elevatus bari*.

There are multiple, convergent phenotypes between different geographical races of *H. elevatus* and *H. melpomene*, one of the most striking being the Amazonian forms that lack the red rays on the hindwing (Fig. 4). If introgression and not mimetic convergence caused the similarity between *H. elevatus* and *H. melpomene*, then as in *H. heurippa*, there must have been multiple, independent introgression events that produced these different races.

Signatures of introgression

If the *Heliconius* hybrid speciation narrative were correct, then, given the vastness of genomic data sets, the evidence pointing to interspecific introgression of wing pattern alleles ought to be overwhelming. We would expect trans-specific genomic regions assimilated into a genome as a result of hybridisation and crossing over during meiosis to yield observable mismatched chromosomal regions, rather than single nucleotide polymorphisms (SNPs) scattered across the genome. However, instead of detailed inference of chromosomal homology, two types of genomic similarity measures are generally invoked as evidence of introgression: relatively low levels of genetic divergence at certain chromosomal regions between hypothetically hybridising species (or high levels of divergence between sister taxa), and gene trees based on short genome segments that are incongruent with the 'main' species tree. Unfortunately, the statistics used to measure these patterns, such as f_d, assume selective neutrality and are sensitive to population-genetic factors such as historical population size (Durand *et al*., 2011). They assume evolutionary neutrality and are confounded by natural selection, which either by increasing numbers of substitutions (directional selection) or by eliminating variability (purifying selection) can alter pairwise divergence, branch lengths, or branching patterns in gene trees.

Unsurprisingly, gene trees from chromosomal regions containing wing pattern genes frequently differ from the 'species tree' background, but is this because the wing pattern-controlling alleles introgressed, or because they are under selection? Or is it simply pareidolia (distilling seemingly significant patterns from large samples of random data)? Evidence that is consistent with a hypothesis does not necessarily refute alternative hypotheses, and science does not proceed by 'confirming' one's preferred theory. We know from finer-scale analyses of individual genes that homoplastic nucleotide sites abound within every gene that has been so far examined (Brower & Garzón-Orduña, 2017), and a parsimonious explanation for homoplasy is simply evolutionary noise. Instead of analyses of

sliding windows of thousands of base pairs or SNPs, finer scale analyses of sequences with assessment of the functional roles of the detected polymorphisms are needed to find actual homologues that would support one hypothesis over another.

Mimicry is non-homologous convergent evolution. We don't understand how mimetic convergence evolves at the molecular developmental level, but the phenomenon occurs nevertheless, between *Heliconius* species, among nymphalid tribes, and even among lepidopteran families (Fig. 1), which are almost certainly not engaging in introgressive hybridisation. It is therefore parsimonious to hypothesise that whatever mechanism accounts for convergence between a *Heliconius* butterfly and an ithomiine or a pericopine arctiine can in principle also account for convergence between *Heliconius* species.

If interspecific introgression is an important adaptive mechanism responsible for shared wing patterns among *Heliconius* species, then why does it not result in phenotypic homogeneity of wing patterns within *Heliconius* species, as well? The persistence of hybrid zones in *H. erato* and *H. melpomene*, and the demonstrated selective disadvantage borne by intraspecific hybrid offspring (Mallet & Barton, 1989) show that wing pattern genes do not flow, even when there are no reproductive barriers to hybridisation.

Theories of hybrid speciation and pattern sharing via introgression entail that shared wing patterns among *Heliconius* species are not convergent, but truly homologous. If that is true, then there should be genomic smoking guns that preclude alternative explanations, not circumstantial evidence consistent with a preferred hypothesis. The burden of proof rests upon those who invoke additional mechanisms that seem biologically onerous, given the selective constraints discussed earlier. Mimicry is remarkable, but one unlikely phenomenon is still less unlikely than two unlikely phenomena.

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Featured Insect

The pigmy water boatman, *Micronecta scholtzi*

Pigmy water boatmen are tiny bugs of the Micronectidae family. They can be found in European freshwater ponds, lakes and slow flowing rivers. They received a lot of attention 13 years ago when scientists discovered that they have the loudest call compared to their size (Sueur *et al.*, 2011), of all animals. Pigmy water boatmen made the Guinness Book of Records as having the "loudest penis". Yes, you read that right! In these species, only the males produce sounds and the current consensus for the sound production mechanism is that the males rub a striated part of their genitalia against an opening of their abdomen.

They are so loud that they can be heard from outside the water if you get close enough to the pond. It sounds a bit like a very faint cicada (Fig. 1). The fact that they are so loud is surprising because there is a strong relationship between a species' size and its loudness, such that bigger animals are able to produce louder sounds. *Micronecta scholtzi* produce much louder signals than expected. How do they manage to emit such loud sounds with such a small body size? Like many aquatic insects, pigmy water boatmen have a bubble under their elytra that allows them to breathe. The resonant properties of this bubble may explain why the sound is so loud (Reid *et al.*, 2018). Researchers are trying to use this ability to bio-inspire new miniature earpieces.

Males signal more in open water than in vegetation, as in open water their signal might propagate more easily and thus be heard better. The activity of males tends to be maximal at night with a peak around 5:00 am. Even though they are very loud, they can be disturbed by human sounds. When human noise is present, pigmy water boatmen increase their signalling effort: they are more active and remain active for longer (Desjonquères *et al.*, 2020).

It appears that all species in the genus *Micronecta* are quite loud. What led to the evolution of such loud signals? Although behavioural studies are still largely lacking, we know that males produce these sounds in a reproductive context. Indeed, females of two Australian species in the same genus spent more time close to a loudspeaker playing conspecific sounds than heterospecific sounds, showing that females distinguish between males of their own species versus another (King, 1999). Moreover, in male-female trials, females moved towards males that produced sounds. This suggests that males are using sounds to attract females. The particular sound features that females like are currently unknown, but I would bet that they prefer the loudest males. So, there is still lots to learn about these tiny yet loud insects.

Camille Desjonquères
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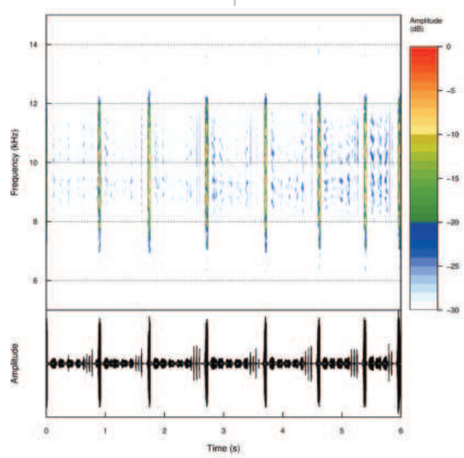


Figure 1. Spectrogram of *Micronecta scholtzi* call.

Insects in the News

July to September 2024

Richard Harrington
with the help of material
provided by
Jesamine Bartlett, Stuart
Reynolds and Hugh Loxdale

Although you will be reading this around Christmas, this insect news comes from peak summer in the northern hemisphere, and we've been spoilt for choice. Insect declines have been very much to the fore. Whereas stories at this time often feature 'plagues of wasps' and ask how we can keep them away from our picnics, this year the press was bemoaning their absence. *Apple News* picked up on the importance of wasps in pollination and pest control, claiming that their services are worth $417 billion per year and that the venom of one species might help cure liver cancer. Pest controller James Tennent told *The Daily Telegraph*: "The numbers are so low, it's unbelievable. Some days we sit there waiting for the phone to ring". Thomas Ings of Anglia Ruskin University reckons they'll be back. He told the BBC: "When there are more wasps in one year there tends to be fewer the next". Our very own vice president was reported by *The Guardian* as being "thrilled" that people were worrying about low wasp numbers. Other groups that usually come in for stick are mosquitoes and midges, but *Apple News* ran with "No mosquitoes – no chocolate or smoked trout". Alex Dittrich (Nottingham Trent University) in *The Conversation* leapt to the defence of midges as vital decomposers and pollinators.

Butterfly Conservation reported exceptionally low numbers in their annual Big Butterfly Count. We have a "butterfly emergency". The season was late, but the dates of the survey were as usual, and I was telling people not to worry. I was wrong. The late summer rush of nymphalids never came. Jeremy Clarkson noticed, too. "Something is afoot", he said to *The Daily Telegraph*. In the UK, the blame was put fairly and squarely on the wettest spring since 1986. Tony Juniper, chairman of Natural England, also blamed the drought of 2022 which led to a dearth of larval foodplants from which some species have not yet recovered. He added that there was a noticeable knock-on effect on bird and bat populations. A headline in *The Independent* read: "Rise in number of 'starving' bats". This doesn't quite square with some stories about moths. Jan Miller wrote in *The Guardian*: "While butterflies seem to be struggling, the cooler and wetter season can be good for moths", claiming that moths tend to be more polyphagous, and hence more adaptable, than butterflies. Is that true? According to its environment editor, Helena Horton, moths are "not just for fuddy-duddies – interest is booming as species struggle". As often seems to be the case, environmental changes result in fewer species we want, and more of those we don't want. "Moths wreak unprecedented destruction on orchard", reported the BBC, referring to Apple Ermine Moth (*Yponomeuta malinellus*). The Somerset Cider and Brandy Company warned of shortages. The Guardian's Helena Horton (again – she seems particularly good at getting insects into the news) reported on Rentokil's use of parasitic wasps (*Trichogramma* spp) to control moths in museums, heritage sites and homes. She also wrote an article suggesting that washing-up liquids may be contributing to insect declines, and another reporting Chinese research showing that streetlights cause leaves to become so tough that insects can't eat them.

In some much-needed good news, the BBC reported that Cornwall County Council has partnered with the University of Exeter and engineering firm Cormac to create 78 ha of pollinator-friendly spaces, leading to a "two-fold increase" in flower visits by insects, especially solitary bees and wasps. Cormac's Melissa Ralph said the project showed how Cornwall could "reverse" a decline in insects.

A poor summer for butterflies.

More good news from the BBC, or bad news depending on how you look at it: an Italian father and son were fined the equivalent of £150,000 for smuggling hundreds of endemic insects out of a safari park in Sri Lanka.

There is a nice article on firefly (Lampyridae) conservation in India on pages 168-170. According to Sandi Schwartz of the American publication *Lawn and Garden*, they are disappearing there, too, for a range of human-induced reasons. One in three North American firefly species may be at risk of extinction. The Bethany Beach Firefly (*Photuris bethaniensis*) in Delaware, for example, is threatened by housing development. Another firefly story involved orb-weaving spiders (*Araneus ventricosus*) manipulating the flashes of captured male fireflies (*Abscondita terminalis*) to imitate the flashes of females and lure more males into their webs.

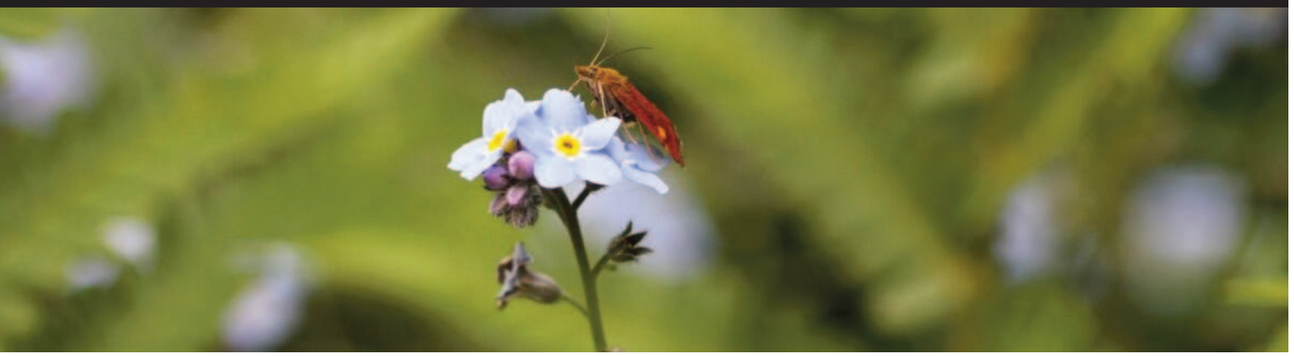
Insects sometimes make the news because of their rarity. The Dark Crimson Underwing moth (*Catocala sponsa*) was reported as being threatened by a plan for a Cambridgeshire busway. That was Helena, again, in *The Guardian*. Patrick Barkham, also writing for *The Guardian*, reported an appearance of the Norfolk Snout moth (*Nothris verbascella*), a species thought to have become extinct in Britain in 1971, in a village near Norwich. BBC News Somerset reported the first appearance of the Lesser Silver Diving Beetle (*Hydrochara caraboides*) at a nature reserve in Glastonbury. A beetle *Limulodes paradoxus* that hadn't been seen alive since 1933 was found by biology students at the University of Louisville, Kentucky, whilst in Kansas, Missouri, the U.S. Fish and Wildlife Service announced that it would seek protection for the Regal Fritillary butterfly (*Speyeria idalia*).

Various threats posed by pest and disease outbreaks affecting humans, livestock, plants and insects also made the news. An ant species (*Lasius emarginatus*) from Europe invaded Manhattan a decade ago and has spread at a rate of about a mile a year to reach New Jersey and Long Island. *The Daily Telegraph* reported that a night curfew was imposed on parks in Plymouth, Massachusetts, following confirmation of a human case of the deadly mosquito-borne disease Eastern Equine Encephalitis. *The Guardian* reported the first known human deaths from Oropouche virus, transmitted by mosquitoes and midges, in Brazil. It also reported a programme organised by a laboratory in Valencia to release sterilised male Asian Tiger Mosquitoes (*Aedes albopictus*) to fight dengue fever in Europe. *The Guardian* reported the first appearance of the invasive Red Dwarf Honey Bee (*Apis florea*) in Europe (Malta), raising fears of impacts on native bees. Meanwhile, *The Daily Telegraph* reported the worst outbreak of American Foulbrood ('apian anthrax') in ten years in Yorkshire. It can apparently only be controlled by destroying infected colonies. Bluetongue, a fatal disease of ruminants, especially sheep, transmitted by *Culicoides* midges, has been widely reported as surging this year. There is a timely article on this by Jane Phillips on pages 163-167. The Norwegian News Agency reported that there have never been as many cases of tick-borne Lyme borreliosis as in the first half of 2024. A total of 175 cases was reported from January to June to the Norwegian Institute of Public Health, which said that temperature, humidity and short-sleeved clothing could be responsible.

In Derbyshire, a "plague" of flies was reported in the village of Willington to BBC Derby, after some lax 'fly-control' measures at a local poultry farm resulted in a rapid escalation in insects. This was not the only 'fly-pocalypse' story of the summer. The BBC reported that, in Leicester Forest East, residents felt trapped in their homes by a fly invasion that followed a fire at a recycling centre. "I'm swatting continuously. I dread cooking a meal and we can't have any doors or windows open. The children cannot play, we cannot sit in the garden, our summer has just been ruined." said one disgruntled resident.

Perhaps the most astonishing story that I saw this quarter in the popular press came from *The New York Times* and reported work from the University of Würzburg in Germany showing that Florida Carpenter Ants (*Camponotus floridanus*) amputate nest mates' legs after serious femur injuries sustained during fights with ants from other nests. They clean the wound to prevent infection and thereby save lives. Injuries to the lower leg cannot, apparently, be successfully treated in the same way.

There's not much news herein from the southern hemisphere. As insects in the north hunker down for the winter, yours will be enjoying the good times, so please send in any reports you see in the popular media.



Mint Moth (*Pyrausta aurata*). Photo: Fabian Harrison.

News from Council

Council Meetings and AGM
Council (chaired by outgoing president, Jane Hill) met on 17th July and 9th September 2024 and the AGM (chaired by new president, Jane Stout) was held on 10th September with a record attendance. All meetings were in hybrid format, the first in London following a workshop linked to planning the Society's 2025–2028 strategy, and the others in Liverpool during Ento24. Outgoing vice president Rebecca Farley-Brown was thanked as well as outgoing trustees, Lynn Dicks and Adam Hart, and new trustees, Mike Bonsall and Hayley Jones, welcomed. Seirian Sumner was announced as the new vice president.

CEO's Reports
Simon Ward, CEO, updated trustees on the relocation of the Chelsea Flower Show Garden, which is now open at Stratford Cross alongside a *Lloyd of the Flies* insect trail in collaboration with Aardman Animations. Simon reported on other grants, partnerships and business developments, including the progression of a major grant from the EU Life Fund to see the conservation science team continue their work in Denmark until 2029. Insect Week was a success, with the photographic competition from last year's also receiving much publicity. Michael Samways' book, *Conservation of Dragonflies* (CABI) was published on 11th June with support from the Society. *Insects* (DK), to which many RES members contributed, was published on 5th September. *Insectarium* (Bonnier Books), to which the RES also contributed, is to be published on 26th September. Simon also reported on progress with our Handbooks series and our journals, for which the numbers of papers submitted and published have increased substantially this year. Simon gave an account of the Society's activities at ICE in Kyoto. The meeting was very successful for the Society, but May Berenbaum was unable to give the Wigglesworth Lecture because of illness. She will be invited to present it at a later date. The Society will be bidding to host ICE 2033. Simon thanked Events Manager, Amy Everard, who will be leaving at the end of October. He welcomed Jayne Whiffin as the new Managing Editor.

A visit to the Chelsea Flower Show Garden, which is now open at Stratford Cross.

Jane Hill under a display of butterflies at Broadgate Shops, Liverpool Street Station.

Head Office Relocation
Plans for the sale of The Mansion House are proceeding well and a purchase brief for a new head office has been agreed.

Employment Policies
Updated employment policies covering family leave, flexible working and leave arrangements were approved. These reflect changes to legislation.

RES Byelaws and Regulations
Some minor changes to the byelaws and regulations were agreed at Council and approved at the AGM. These reflect current working practices.

Ethical Treatment of Insects
A statement of the Society's position on the ethical treatment of insects, developed by our Science, Policy and Society Committee in collaboration with the Insect Welfare Research Society, was approved. The key messages are that there is still little known about insect sentience and no scientific consensus. Therefore, it is important that there is further research in this area and that, in the meantime, insects used for research should be kept to the minimum level possible, be 'ethically killed', and replaced or repurposed where possible. This statement has been written partly due to the increasing consideration of the ethical treatment of insects by Animal Welfare and Ethical Review Bodies at various research institutions. Jessica Stokes will be starting with the Society on 16th September to work on a project on the ethical treatment of insects.

Higher Education Bursaries
Higher Education bursary funding to both Harper Adams University and Reading University for the 2024–2025 academic year was approved. These two universities were the only applicants meeting the Society's criteria for this award.

Appointment of Honorary Fellows
The process for the appointment of Honorary Fellows was discussed and will be finalised following further work by the Membership Committee. All members will have the opportunity to nominate Honorary Fellows.

Membership Figures
Membership figures were presented. It was agreed that reported membership figures will include all those who are less than a year in subscription arrears. Although membership is at a record high, membership income is not yet at budget partly due to growth in categories that produce less income, and the number in arrears is currently up. Various mitigation strategies are coming into play, including improved automated reminders, organisational membership and focussing on underrepresented groups.

Matters for Information
The Director of Finance, Steven Lee, gave updates on the Society's investment portfolio and management accounts. Reports were received from the Finance Committee, Outreach Committee, Education & Training Committee, Science, Policy & Society Committee, EDI Committee, Membership Committee, Publications Committee and Health & Safety Group.

Cultivating Curiosity: The RES Insect Garden's new home and exciting future

Luke Tilley

Photo: Tammy Marlar

Over the summer of 2024, the RES trustees and staff team were delighted to plan, deliver and announce the opening of the award-winning RES Insect Garden (Chelsea Flower Show 2023) in its new location at Stratford Cross, East London. This marks an exciting new chapter for this impactful and long-term engagement project.

The relocation follows its success at Chelsea, where it was praised for its innovative design and planting, its ability to provide food and habitats for insects, and using sustainable approaches that are resilient to climate change. At the show itself and through extensive media coverage in the UK and around the world, it brought strong messages to millions of people about the importance of insects and their study in our gardens, ecosystems and lives. Thanks to the generous support of Project Giving Back, Lendlease, SHIFT (London Legacy Development Corporation) and individual donors through the Big Give Appeal, the RES Insect Garden is now fully open to the public in an innovative and diverse area of the city.

The relocation of the garden to Stratford Cross, a gateway to a new cultural quarter in London, will provide years of opportunity for public engagement, scientific discovery, and insect science education. Thousands of visitors, residents and workers will pass by this garden every day, each with the chance to interact with a beautifully designed space that highlights the critical role insects play in our urban landscapes. The compound eye-inspired laboratory is vibrant and unique, which draws attention from afar. The laboratory not only adds a striking visual element to the urban landscape but also serves as a functional space for studying insects with small groups.

A garden for all

The RES Insect Garden is more than just a collection of plants – it's an outdoor teaching laboratory, a space full of ideas for insect habitats and an example of how even small urban spaces can be transformed into havens for insects. Designed by renowned garden designer Tom Massey, the garden demonstrates how simple, practical steps can support insect biodiversity. Featuring habitats made from dead wood, stones and leaf litter, the garden is a visual and functional reminder that everyone can contribute to insect conservation, whether they tend a garden themselves, a balcony, or even a single window box. The lighting design of the garden minimises impact on insects by using low-intensity red lights.

Tom Massey emphasised the importance of this move to Stratford Cross: "The vast majority of the UK's population live in urban areas, so we must consider brownfield sites as important for biodiversity as more rural locations. Stratford Cross is a fantastic example of how it's possible to deliver a sustainably built environment that prioritises benefits for both people and nature. It is great to see the garden come to life in its permanent home as a platform for the RES to raise awareness of insects and their importance in the global environment."

As entomologists around the globe know, insects are often overlooked, which means that more opportunities are needed to engage with people and increase the visibility of the fascinating insects around us. The RES Insect Garden will now serve as a long-term resource for education, research, and community engagement, inspiring visitors to understand the impact that insects have on the natural world around them and learn more about the measures that can help provide habitats to boost populations of hundreds of species.

Launching with Lloyd of the Flies

One of the most exciting aspects of the garden's relocation is the augmented reality (AR) trail, developed in partnership with Aardman Animations, creators of the popular children's series Lloyd of the Flies. Lloyd, a mischievous housefly, has been named the first-ever non-human Ambassador of the Royal Entomological Society, and his Bug Hunt trail is sure to be enjoyed by families visiting the garden.

Using Aardman's AR app, children and families can help Lloyd find his insect friends and return them to the bug hotel in the garden. Along the way, visitors will learn fascinating facts about insects and see the world through an insect's eyes, bringing a sense of fun and discovery to the garden experience.

Photo: Tammy Marlar

Matthew Walker, creator and director of Lloyd of the Flies, said: "We created Lloyd of the Flies to bring the fascinating world of insects to children in a fun and accessible way, so the partnership with the Royal Entomological Society and the team at Lendlease is a perfect way to celebrate Lloyd's appeal. Having spoken to Lloyd himself ahead of the big Bug Hunt launch at Stratford Cross, I can confirm that he can't wait to explore the RES Insect Garden for himself and introduce his friends to the fantastic habitats and sources of food for insects that it offers!"

The Bug Hunt trail not only offers a playful experience for younger visitors but also serves as an important tool for raising awareness about insect conservation. By engaging children and families in a creative, interactive way, the trail and Lloyd's new role as an RES Ambassador promote curiosity about the insect world.

Educational opportunities in 2025 and beyond

The RES Insect Garden will become a focal point for educational initiatives designed to engage both children and adults. In partnership with the Field Studies Council, the RES is set to launch a dedicated education programme in early 2025, offering children the opportunity to explore and learn about insects in a hands-on environment. These sessions will help ignite an early interest in entomology and provide a practical introduction to science and nature in an urban context. The garden and lab are also suitable for teaching students studying A-level Biology and the new Natural History GCSE. It is hoped that the garden will grow to have at least 140 dedicated entomological teaching sessions per year to school children by 2029.

For adults, the garden and the RES team will also support an educational programme developed in collaboration with Newham Borough Council, focusing on urban biodiversity and the role insects play in cities, homes and green spaces.

Simon Ward, CEO of the Royal Entomological Society, sees the garden's relocation as a major milestone for the Society's mission: "We are passionate about inspiring the next generation of insect scientists – whose fascination with insects often starts in childhood. Our huge thanks go to Lendlease, SHIFT and Project Giving Back for helping bring the RES Insect Garden to East London as a permanent urban haven for insects and insect science."

In addition to its public engagement and education roles, the RES Insect Garden will serve as a platform for scientific research. Working with local universities, its central location and innovative design make it an ideal site for studying how urban green spaces can support insect biodiversity.

A bright future for the garden

As the garden settles into its new home, the RES looks forward to expanding its role engaging people in the study and science of insects. The Stratford Cross location, with its high footfall and proximity to world-class cultural and academic institutions, ensures that the RES Insect Garden will reach a wide audience. Whether through the Bug Hunt trail, schools educational programme, or its role as an outdoor laboratory, the garden will continue to play a flagship role promoting the appreciation of insects and entomology.

We invite RES members and the public to visit and explore the garden, and to follow the progress of this wonderful new urban space for insects over the years to come.

For more information, visit www.royensoc.co.uk/the-res-garden/.

Photo: Tammy Marlar

Launch of the organisational membership scheme to support our community

We are delighted to have launched our organisational membership scheme this summer. The scheme provides opportunities for partners to engage with us on a regular, impactful level whilst also giving colleagues access to a range of benefits including discounted individual membership options and complimentary tickets for our Special Interest Groups and our main Ento conference.
Organisations will also be able to showcase their membership by requesting a bespoke membership logo for PR and marketing purposes to show their support for one of the world's largest entomological societies.

Through the organisational membership scheme, partner organisations will be able to consult with us on our ongoing work and strategic programmes, supporting global cutting-edge research and championing insect science across all sectors and career stages. We are looking forward to working with organisational members on joint projects and wider training and education initiatives.
Please take a look at https://www.royensoc.co.uk/organisational-membership/ to view our different membership levels and benefits for your organisation and colleagues.

To join our organisational membership scheme and for any questions please contact Anne Weinhold, Business Development and Fundraising Manager anne@royensoc.co.uk.

RES Statement on the Ethical Treatment of Insects

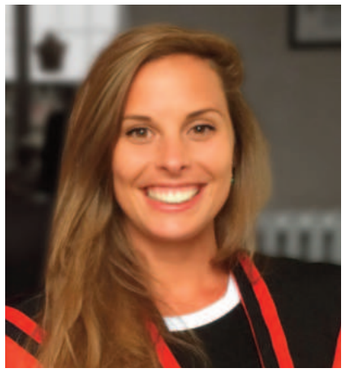
The Royal Entomological Society has been working with the Insect Welfare Research Society (IWRS) to produce resources for researchers and the Animal Welfare Ethical Review Body network (AWERB) to support its statement on the ethical treatment of insects. This statement was published in October 2024, and we have a new team member working on ethics, Dr Jessica Stokes, funded in partnership with the IWRS. The statement with links and a media summary can also be found in the policy section of our website: www.royensoc.co.uk/policy.

The Royal Entomological Society is committed to supporting and maintaining the highest ethical standards in research. When animals that may be sentient are involved in research, these standards include considering their welfare. However, there is no scientific consensus on whether insects are sentient. More research is needed on this topic.

With significant uncertainty about an animal's sentience, precedent suggests adopting research practices that minimise the risk of unnecessary harm. These practices can be informed by existing tools for risk mitigation. Such tools can support entomologists interested in harm minimisation in their research or insect management. Considering welfare can also advance other scientific objectives, such as promoting reproducibility, transparency and research quality.

Where insects are ethically killed for research purposes, researchers should consider repurposing the specimens to maximise their use. This could include contributing to museum collections, supporting further research and study or creating educational resources.

Given the significant differences between insects and the animals for which these tools were developed, it is crucial that entomologists adapt these risk mitigation and welfare assessment tools to their specific contexts and needs. Other scientific societies have begun this work, such as The Animal Behaviour Society and the Insect Welfare Research Society. Both these organisations have provided preliminary resources for use at the discretion of lead investigators, management professionals or educators while still pursuing their professional objectives.



The RES supports the entomological community in conducting ethical research by developing practical resources available to its membership. The RES also encourages the development of further resources to ensure that our practices remain aligned with the highest standards of scientific integrity and ethical responsibility.

Eleanor Ormerod

Richard Harrington

Take a look at *Antenna* 45(4) 202–204, and you will find a profile of Eleanor Anne Ormerod FRES (1828–1901), a pioneer of agricultural entomology, who lived in St Albans, Hertfordshire. The article includes a photograph of her grave, which the Society pledged to restore, in the Hatfield Road Cemetery. Unfortunately, there were major delays to the project which were beyond the Society's control, but the work has now been completed by stonemasons A.C. Stoneworks. The Society is grateful to Maggie Johnston, former Deputy Librarian at Rothamsted Research, who alerted us to the state of the grave.

The Society now has an award in Eleanor Ormerod's name for the application and practice of entomology. The Eleanor Ormerod Award for Application and Practice recognises individuals or teams who have made outstanding contributions to applied entomology across fields such as agriculture, horticulture, public health, veterinary and medical entomology, and insect farming. This new award celebrates those who have translated insect science into practical solutions that address real-world challenges.

By honouring the legacy of Eleanor Ormerod, the Society continues to promote the application of insect science in ways that positively impact society, just as Ormerod did with her work on agricultural pest management during the 19th century. The Eleanor Ormerod Award acknowledges this spirit of innovation, recognising those who exemplify excellence in applied entomology.

Nominations for the Eleanor Ormerod Award are now open until 1st February 2025. The award is open to individuals or teams, and nominations can be submitted through the Royal Entomological Society's website at www.royensoc.co.uk/awards.

If you know someone who has made a significant impact in the practical application of insect science, we encourage you to submit a nomination and help us recognise their contribution.

Postscript
Whilst visiting Eleanor's grave, I spotted an unusual name amongst the headstones in the First World War section, Private T. W. Tortoishell. Although not spelt quite like the butterflies, I thought it nice to give him a brief mention. Private Thomas Walker Tortoishell served with the 3rd Australian Pioneers and died on 8th June 1917. I've not been able to find out how and where he died.

Journals and Library

Treasures from the RES Library and Archive

Rose Pearson
RES Librarian and Archivist

The RES Archive contains one particularly festive box, inside which is a selection of unusual Christmas and New Year's cards, sent by some very creative entomologists.

Frank Nelson Pierce, born in Liverpool to a tobacconist father in 1862, was elected to the RES in 1891 and is best known for his series of books on the genitalia of lepidoptera. However, every Christmas from 1902 to 1940 he sent home-made entomologically themed cards to friends and family. Forty-five of these cards are featured in the RES Archive and reveal a surreal sense of humour. Several of the cards feature entomologists on the hunt for Lepidoptera, and sometimes the reverse; one card features a very hungry caterpillar catching an unfortunate lepidopterist and consuming him whole, with a lucky butterfly fluttering free of his discarded net (Fig. 1).

Continuing the theme of invertebrates fighting back against vertebrates, another card features a beetle with four tiny boxing gloves squaring up to a duck (Fig. 2).

Some of the cards showcase the artist's professional speciality: Lepidoptera genitalia. Several cards from the 1930s simply feature festively coloured diagrams of the subject (Fig. 3). One card from 1909, when aviation was something of a novelty, features an entomologist reacting in shock to a plane with some unusual appendages (Fig. 4). If any keen-eyed lepidopterists are able to identify the species, we would be fascinated to hear.

Pierce was a Fellow of the Society for over fifty years, and we will explore his life in more depth in a future issue, as well as looking at some of the more sombre cards he sent during the two world wars.

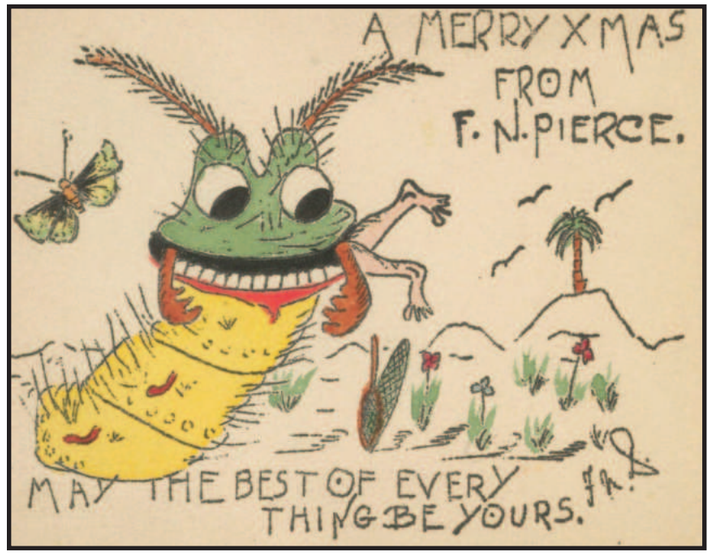


Fig. 1: Card by Frank Nelson Pierce.

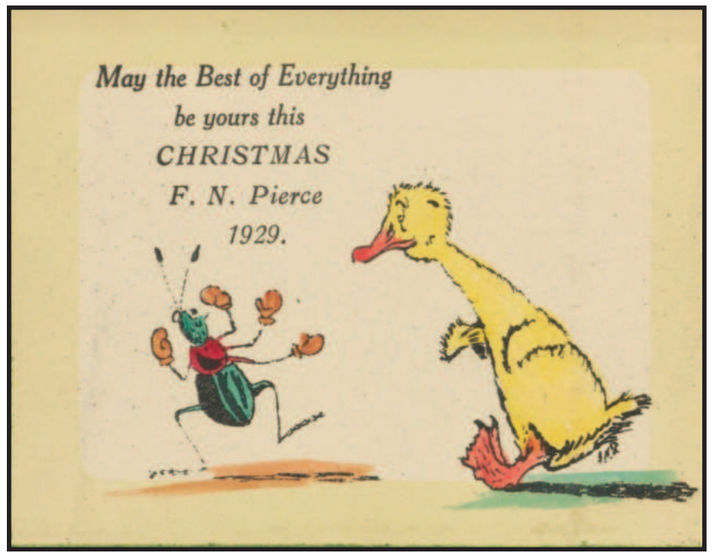


Fig. 2: Card by Frank Nelson Pierce.

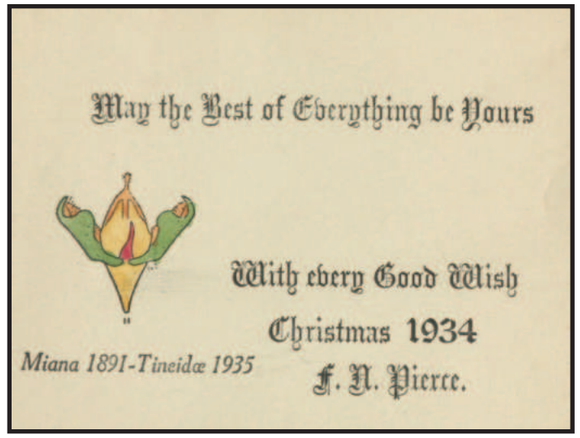


Fig. 3: Card by Frank Nelson Pierce.

Fig. 4: Card by Frank Nelson Pierce.

Issue 48(2) featured examples of illustrations printed from real butterflies, a process known as lepidochromy, where the wings are placed between two sheets of paper, and pressure is applied through a press, producing an image of the wings with the antennae and body drawn in later with ink. Another example of this uncommon (and no longer acceptable) art, featuring a Heath Fritillary butterfly (*Melitaea athalia*) is a New Year's Card (Fig. 5) sent in 1908 by Robert Maxwell Prideaux, of Sevenoaks, Kent, to 'Dr and the misses Chapman'. Prideaux joined the Society in the same year, and was a member for over thirty years, serving on Council in 1917. In a 1908 article in *The Entomologist*, he discusses a trip to Berisal, Switzerland, where he recorded a number of butterfly species, including the one featured on this card. Thomas Algernon Chapman was a Scottish physician and Vice President of the Society for several terms between 1900 and 1917. Following his death in 1921 'the misses Chapman', his sisters Emily and Laura, donated £500 to the Society in his memory.

The final New Year's card (Fig. 6) from 1903 features a photograph of an Orange-tip butterfly labelled as *Euchloe cardamines*, now known as *Anthocharis cardamines,* sitting on a sugar lump. The sender, Hugh Main, was an enthusiastic insect photographer, speaking on the subject at several RES meetings, and providing photographs for publications such as Evelyn Cheesman's 1924 book for children *Everyday doings of insects.* He was elected a Special Life Fellow of the Society in 1945. The recipient, Henry Jerome Turner, was a schoolmaster, who edited *The Entomologist's Record and Journal of Variation* from 1911–1950. From 1921–1929, he served as the Honorary Librarian of the Society, overseeing its move to Queen's Gate, as well as donating a number of volumes from his own library to the Society's collections. In 1948 he was made a Special Life Fellow of the RES.

These and other examples of entomological art can be viewed in our Library and Archive in St Albans. Email library@royensoc.co.uk or call 01727 899387 to make an appointment.

Wishing you a merry Christmas and a happy new year!

Fig. 5: Card by Robert Maxwell Prideaux.

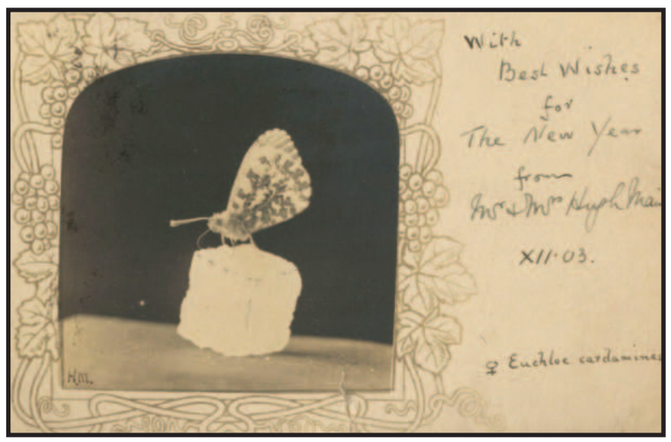


Fig. 6: Card by Hugh Main.

Insects: behind the scenes of the new RES book

By Lucy Timmins, Bloom PR

Published by DK with the RES on 5th September, the stunning new hardcover book, *Insects – Discover the Science and Secrets Behind the World of Insects,* aims to captivate and educate readers about the pivotal role that insects play in our lives. Edited by two past presidents of the Society and one of our trustees, with engagement from some 200 RES members including around 90 contributors, this book sheds light on the intricate science of insects while addressing the pressing global concern around the decline of insect populations.

In a recent interview, one of the editors, past president Jane Hill, shared her insights on why this is an opportune moment to publish such an important work. "There's a widespread recognition that we should be worried about insect decline," she noted. "With increased media focus and policy outreach regarding this issue, the time has never been better to create a book targeting a general audience."

Insects stands out not only for its beautiful illustrations and engaging content but for its accessible writing. The book aims to demystify complex entomological terminology, making the importance of these creatures relatable to everyone from curious children to insect enthusiasts. Jane explains, "You don't need any prior knowledge about insects and we're sure that anyone who dips into its pages will find something fascinating or fun."

The creation of *Insects* is a testament to collaborative entomological expertise. Jane explained her role in bringing this project to life, recounting the genesis of the idea with the RES Director of Publishing, Emilie Aimé. Their discussions began with DK at the RHS Chelsea Flower Show in 2023. "After providing members with a list of proposed topics and inviting volunteers to contribute, we received over 250 offers. This provided the opportunity to choose from an incredibly diverse group of contributing authors with rich knowledge to share."

The book demonstrates the remarkable diversity of expertise within the Royal Entomological Society's 2,300 global members including many early-career researchers. Jane emphasised the uniqueness of this approach, stating, "I don't think DK has ever created a book of this kind in such a wide-reaching, collaborative way before." To ensure the book maintained a cohesive voice, three editors were appointed: Jane herself, along with former RES president Helen Roy and RES trustee Allan Watt. The result is a rich tapestry of insights and perspectives from leading entomologists, making *Insects* a truly collective endeavour that taps into the depth of knowledge within the RES community.

The project also emphasises inclusivity, achieving a remarkable 50/50 gender balance of contributing authors and, in doing so, addresses the gender disparity in entomology. Jane notes that while the gender balance at the undergraduate level is nearly even, fewer women pursue careers in academia, leading to a skewed senior membership. Through its outreach efforts, the RES aims to ignite curiosity in insect science among underrepresented groups, including women and people from diverse backgrounds. The contributors to *Insects* reflect this commitment to inclusivity, ensuring that the world of entomology is open to everyone.

Insects is a book that will rekindle our collective curiosity about the tiny creatures that play such a critical role in the health of our planet. Although many people are fascinated by insects in childhood, that sense of wonder may diminish, hindered by societal or gendered norms that might deem such a specific interest in nature "less cool." The book aims to bridge this gap by reminding readers of the marvels of the insect world and encouraging adults to revisit their early curiosity. Jane explains "One of the goals was to help the public understand both the beauty of insects but also their critical role in our ecosystems and food systems." While some may retain a cultural fear or squeamishness about insects, understanding their ecological significance may help shift perceptions.

Jane Hill.

Insects highlights the essential role of entomologists through chapter headings that cover key research processes: Classify, Record, Conserve – crafted in an accessible way to broaden the reader's understanding of the study of insect science and the complex relationships between insects and their habitats. Readers will come to recognise not only the staggering diversity of insects, but also how entomology can shape innovations in technology, medicine and environmental conservation. The chapter 'Celebrate' illustrates how insects enrich our cultural lives, inspiring art, folklore and literature throughout history. The book not only advocates for the protection and appreciation of insects, but also describes their profound influence on humanity's creativity and ingenuity.

The book also tackles the increasing concern around insect declines and the impacts of habitat changes, invasive species and climate change. It includes a section that outlines the advantages of community science and the valuable contributions that people can make to monitor insect populations and assess whether changes reflect a temporary fluctuation, or a long-term trend. Jane hopes that with reports of reduced butterfly populations and ecosystem collapse *Insects* may inspire readers to participate in community science initiatives such as The Big Butterfly Count and iNaturalist, which "all help to build a longer-term picture about insect populations."

Insects is a treasure trove of astonishing facts that show the incredible diversity and extraordinary adaptations of insects found across the planet from freshwater habitats to arid deserts. Their remarkable resilience in extreme conditions is seen throughout the book. Jane highlights a few of her favourite examples, such as the Fog-basking Beetle (*Onymacris unguicularis*) which has evolved a unique cuticle allowing it to capture and store droplets of water from fog blankets over the desert at night, which is used for hydration during the day. In extreme cold, insects have developed survival strategies by developing chemicals in their haemolymph (blood equivalent) that function as a natural antifreeze. The Emerald Ash Borer beetle (*Agrilus planipennis*) remains unfrozen at temperatures as low as -30°C, with reports of survival as low as -50°C. Even more astonishing, Malt Fly (*Chymomyza costata*) larvae can endure immersion in liquid helium at a frigid -262°C!

The book also addresses the stigma surrounding wasps, often regarded merely as "picnic pests." RES trustee Seirian Sumner provided expertise on the vital contributions wasps – in their many and varied guises - make to ecosystems, including pollination and pest control. This enlightening exploration of the insect world encourages a deeper appreciation for their essential roles in our environment.

Jane's personal favourite, the Speckled Wood butterfly (*Pararge aegeria*), has been the subject of significant research due to its remarkable response to climate change. As temperatures rise, this butterfly is expanding its range throughout the UK, providing a visible indicator of climate progression that can be observed in real time. It emerges as a compelling symbol of ecological adaptability and resilience in a changing climate. "I hope these astounding facts will ignite a sense of wonder in readers and show just how integral insects are to our planet's natural habitats and ecosystems."

Insects is not just a celebration of entomology; it is a call to arms for readers to appreciate the remarkable complexities of these creatures. Jane encourages everyone to contribute to insect conservation and conversation, "whether it be through gardening, supporting eco-friendly policies, or by simply learning more."

This book is a wonderful resource, making scientific research accessible and enjoyable for all, regardless of prior knowledge. The authors engage a broad audience, striking a perfect balance between complexity and enjoyment. With its emphasis on our interconnected fates, it urges readers to actively participate in the safeguarding of our planet's incredible insect life. *Insects* is an essential addition to your bookshelf and will delight and enlighten all who explore its pages.

Many thanks to all RES contributors for spreading the word.

Insects is available from all good bookshops. UK-based members can find a discount code for bookshop.org in the member area of the RES website

The welcome return of forensic entomology to the journal *Medical and Veterinary Entomology*

Zanthé Kotze, Daniel Martín-Vega, Lisa Reimer and Emma N.I. Weeks

Lisa Reimer and Emma Weeks are co-Editors-in-Chief of our journal *Medical and Veterinary Entomology* (MVE). Zanthé Kotzé and Daniel Martín-Vega are Associate Editors, both covering the topic of forensic entomology. In April 2023 we published a virtual issue collecting together published papers on forensic entomology to celebrate opening the scope to include papers on this topic again after many years. Following a call for papers, we plan to publish a new special issue on novel approaches and advances in forensic entomology in early 2025. Here Lisa and Emma find out more about Zanthé and Daniel and ask for their take on reintroducing forensic entomology to MVE.

What kind of research do you do?
Zanthé: My focus started with an interest in physiology and environmental effects on larval development of necrophagous species but has shifted to encompass decomposition ecology as a whole, considering multi-kingdom and multi-species interactions before, during, and after arthropod colonisation of carrion. Of particular interest to me within the decomposition of carrion, is the chemical ecology and the volatile emissions that result in the patterns of decomposition and attraction to ephemeral resources such as carrion.
Daniel: My research has been focused on different biological aspects of insects of forensic, medical and veterinary importance, including for example their temporal and spatial distribution or their carrion colonisation patterns. Recently, I have been particularly interested in morphological studies with a developmental and functional anatomy perspective, using novel imaging techniques like micro-computed tomography.

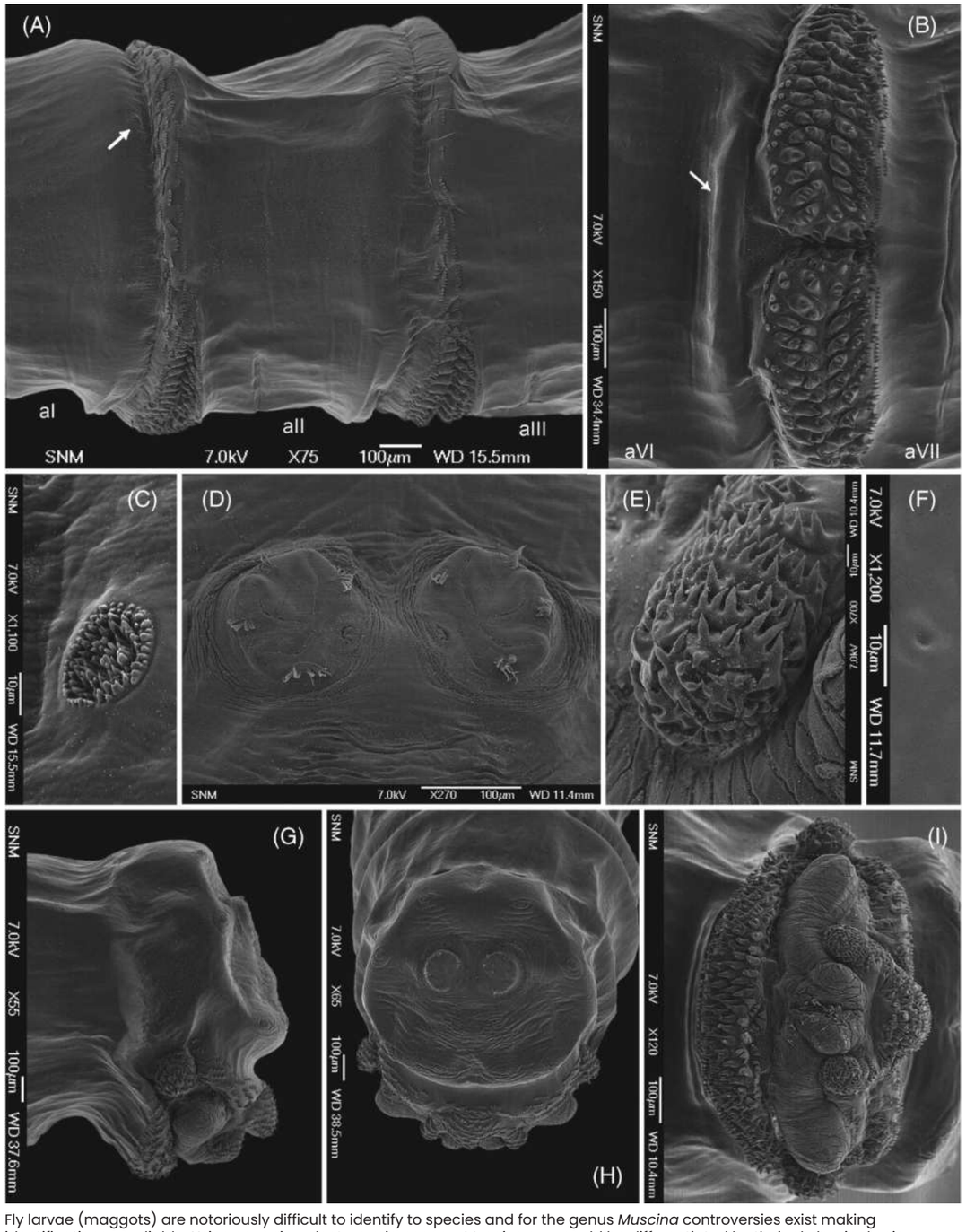
What is the topic of the virtual special issue?
Zanthé: The virtual special issue highlights papers with a focus on forensic entomology, including ecological and distributional patterns of insects of forensic importance, as well as those discussing aspects of chemical ecology and development of carrion insects, and those providing morphological and/or molecular tools for reliable species identification.

What type of papers are included in the virtual special issue?
Daniel: The papers we selected for the virtual issue are older papers that have previously been published in MVE that relate to forensic entomology. These papers have proven to be long-term references for forensic entomology researchers and practitioners and have been selected as a baseline to highlight the types of papers we hope to see more of in the future.

What is the importance of this virtual special issue and the topic?
Zanthé and Daniel**:** Within the last two decades there has been a dramatic increase in research dedicated to insects of medical, veterinary and forensic importance. Some of the species associated with myiasis are also those commonly found on carrion, thus allowing the investigation and analysis of these insects in a medical capacity. Not only insects associated with carrion, but other insects of medical relevance like lice can provide valuable information in legal investigations, as shown by Eremeeva *et al.* (2024). Forensic entomology is not limited to human cases and can also be used to investigate cases where poaching is suspected, as demonstrated by Pienaar and Dadour (2024) on the use of forensic entomology in rhino poaching cases in South Africa. Forensic entomology provides a robust and valuable tool for legal and criminal investigations, but needs a solid and reliable base of high-quality experimental research. Like in any other scientific discipline, novel approaches and methodological advances such as those outlined by Thümmel *et al.* (2024) and McTaggart *et al.* (2024) have the potential to strengthen and increase the accuracy of entomological analyses in forensic casework.

What is your editor's choice paper from the virtual special issue?
Zanthé: My choice would be Fouche *et al.* (2023). This study is unique in that it investigated the cues involved in interspecific communication between necrophagous species using headspace analysis, an area which is understudied. The authors found indicator compounds that could explain larval regulation and interactions in carrion by *Lucilia sericata* and *Calliphora vomitoria*. Identifying compounds unique to each species and common in both will allow a broadening of the understanding of interspecific relationships of necrophagous species co-inhabiting carrion resources.
Daniel: My choice would be the study of Grzywacz *et al.* (2015) on the larval morphology of *Muscina*. It provides thorough descriptions combining different microscope techniques, as well as a straightforward key for the reliable identification of species. Larval specimens of necrophagous flies are among the most frequently collected entomological evidence in forensic investigations, and they can also be of medical and veterinary importance as agents of myiasis. Hence, reliable larval identification tools are crucial for researchers and practitioners, so

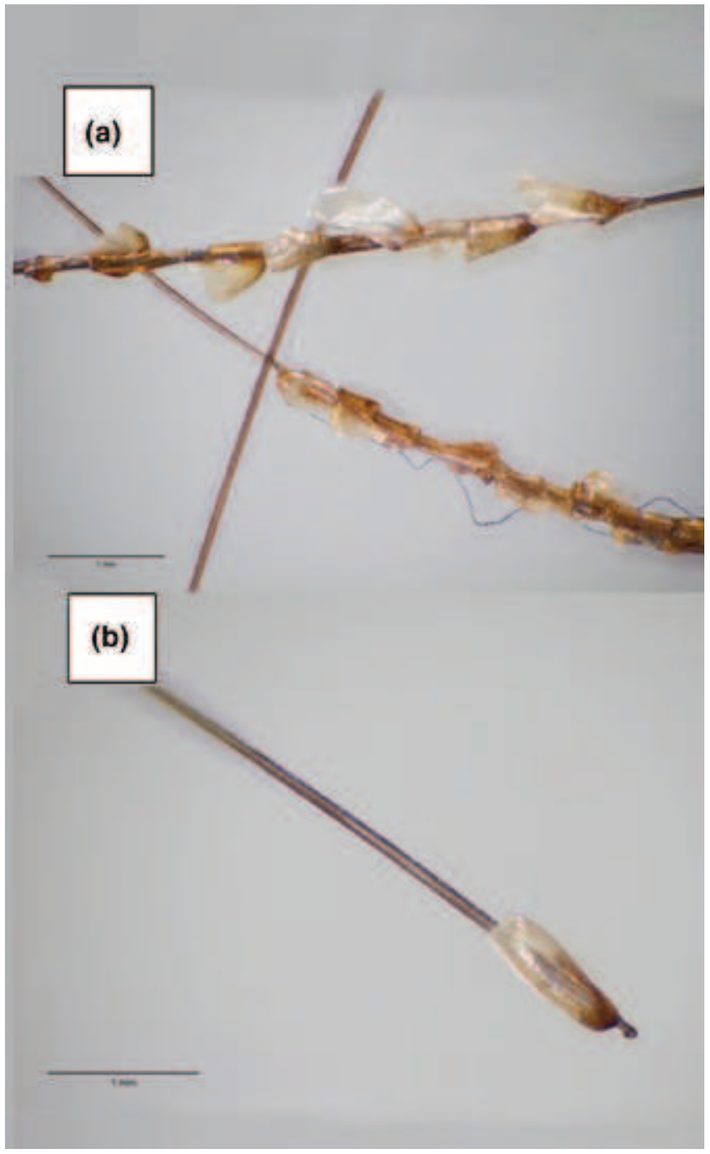
PUBLICATIONS



Fly larvae (maggots) are notoriously difficult to identify to species and for the genus *Muscina* controversies exist making identifications unreliable. Using scanning electron microscopy, *Muscina* spp. could be differentiated by their abdominal spines (indicated by the arrow). Image adapted from Grzywacz *et al.* (2015).

this type of paper represents a basic reference that will be used anytime in the future.

How is MVE hoping to publish more of this research?
Zanthé: Forensic entomology is nowadays a dynamic and well-established scientific discipline involving multiple topics that need to be investigated. Case reports and more technical studies certainly provide a valuable source of information, but they are more suitable for publication in specialised journals in forensic sciences and technologies. On the other hand, given its specific scope and strong publication history, MVE can contribute to the advancement and development of forensic entomology with baseline and high-quality papers



From Erermeeva *et al.* (2024) The position of the nits (lice eggs) can be used to determine how long a person has been infested with head lice. The authors discovered that the person had been infested with headlice for at least 166 days prior to death.

on the biology of forensically relevant arthropods.

What sort of papers are you most interested in receiving?
Daniel: We are hoping to receive papers that include novel approaches to identification, evolution, and development of species, as well as modeling techniques. MVE is a journal of the Royal Entomological Society, so we are interested in manuscripts that cover biological aspects of insects and other arthropods of forensic relevance.

Are there any papers that MVE would be unlikely to publish on this topic?
Daniel: MVE is unlikely to accept papers that are geographically limited in their application, for example, papers reflecting successional studies in a specific area. Similarly, species checklists and faunistic inventories of arthropods associated with cadavers will not be considered. Case and technical reports will not be considered either.

What does the future hold for forensic papers in MVE?
Zanthé and Daniel: We are preparing a special issue of MVE which includes high quality papers that show the potential of novel approaches to the use of insects as reliable forensic indicators. This special issue will contain eight full length original articles on topics including medical forensics, wildlife forensics, novel identification techniques, physiology, toxicology and chemical ecology. We encourage *Antenna* readers to look out for an announcement early in 2025 when this special issue will be released.

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Meetings

Electronics & Computing and Data Special Interest Groups Meeting Artificial Intelligence (AI) in Entomology

3rd July 2024, Syngenta Jealott's Hill and Online

Convenors: Mark O'Neill, James Gilbert, Rob Lind

Report by Richard Harrington

It is clear that AI will have a profound impact on many aspects of our lives, and it is timely to consider how it is already being used in entomology and what the future might hold. Syngenta, as one of the world's leading life sciences companies, was an appropriate host for the meeting. The Jealott's Hill International Research Centre is home to 1,000 employees, many of whom are entomologists. Jim Reay, Head of CPD Capability Development, welcomed delegates and outlined Syngenta's portfolio, highlighting areas where AI can help, such as designing safe and effective new chemistry technologies and modelling pest outbreaks. Jim said that the company is very keen on collaborations and stressed that good people are more vital than technology.

Let me start by defining 'deep learning', a term that came up repeatedly. It is a method in AI that teaches computers to process data in a way that is inspired by the human brain. Deep learning models can recognise complex patterns in pictures, text, sounds and other data to produce accurate insights and predictions.

Rob Lind (Syngenta) and Mark O'Neill (Tumbling Dice) set the scene, speaking about the rise of AI in insect science. Rob pointed out that artificial neural networks (ANNs), which are the basis of much AI, could be bioinspired in that insect brain networks are similarly highly structured in layers, using 'skip connections' to feed the output of one layer as the input to the next layers. 'Data is king' is Rob's mantra – 'good data in, good model out'. Data on which models are trained can be real or synthetic, and Rob warned of potential risks from models training on AI-generated data, as this could lead to echo chambers (going round in meaningless circles). Biotic neural networks have the advantages of insight, reasoning, theory of mind, sentience and subjectivity. Abiotic neural networks have the advantages of data retention, data analysis, imitation and objectivity. Partnerships between the two are synergistic. Rob outlined the evolution of AI from

Fig. 1. System for attracting and photographing moths (credit Grace Skinner).

Fig. 2. DIY Camera trap (credit Maximilian Sittinger).

rule-based algorithms through predictive AI to generative AI, potentially leading to multimodal artificial general intelligence.

Mark discussed these points in relation to optimising biodiversity identification in the field, key issues being power efficiency, computational efficiency, data bandwidth and the extraction of relevant patterns from an ocean of irrelevant ones. The solution, he said, is computationally efficient, low power machine learning. He showed an example of drone footage used to count and identify four species of dragonfly using a novel approach that is both fast and efficient but does not involve mainstream machine learning. Intelligent motion detectors extract relevant patterns using heuristics. The extracted patterns are then broken down into a set of sub-images (shards), which are correlated with a pre-labelled training dataset using a hybrid pixel-pattern/network-connectivity correlator to identify them. Around 95% of the classifiable material was correctly identified to species, outclass rejection (of patterns which are not in the training set) was excellent and errors of omission were acceptable given the noise in the data. Overall, it compares very favourably with deep learning approaches needing more computational resources and hence power.

The theme of monitoring movement was continued by Joris Mattheijssens (Ghent University, Belgium) and Bo Li (Syngenta). Joris is studying insect pollination of the Kiwiberry ("like a small but tastier Kiwifruit"). Timelapse cameras monitored one male and one female plant, and insects were detected on the images using a chain of deep learning and computer vision techniques. He found that Western Honeybees (*Apis mellifera*) only visit female flowers whereas bumblebees (not separated to species) visit both sexes and are more active than *A. mellifera*, so are much more useful. Pre-anthesis pollination was detected, which can be problematic in female flowers because it causes scars to form on the fruits, although it is useful in male flowers as it prolongs the overlap of flowering periods. Bo is studying the activity of fruit flies (*Drosophila* spp.) using a video-based multi-object tracking system (DELIA) as a model system to assess the potency of insecticides in terms of symptoms and mortality. The hope is that this can improve on manual assessment, which is time-consuming, subjective and cannot follow the activity of individual flies. The evaluation metrics showed promising results for all the tracking methods used, although further development is necessary to recognise if an individual insect is moribund.

There is a great demand for monitoring data. Toke Thomas Høye (Aarhus University, Denmark) described how deep learning models can help in the development of a globally-standardised monitoring system using insect camera traps. He outlined some of the challenges, such as the need to understand how resources change in time in order to choose a suitable camera position. The EU MAMBO project (https://www.mambo-project.eu/) uses standardised flower-bed communities for pollinator monitoring. An open access dataset shows visitation rates for individual insects to individual flowers. Visits to earlier-opening flowers tend to be shorter. The project also involves automated image-based monitoring of moths and other insects attracted to globally standardised UV light sources. These data can be used for understanding seasonal dynamics and day-to-day variation without killing insects or going into the field, and have huge potential in studies of phenology, functional ecology, species interactions and ecological monitoring. Important steps are being taken towards global standards for image-based autonomous monitoring of insects (AMI). Currently, 70 AMI traps are running in EU countries. Building on the Aarhus design, UKCEH and partners have engineered a resilient, reliable and scalable system which uses UV lighting and a high-resolution camera to attract and photograph moths. The images are put into a machine learning

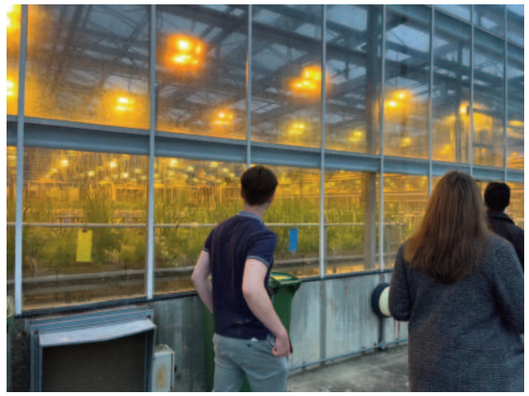


Fig. 3. Site tour (credit James Gilbert).

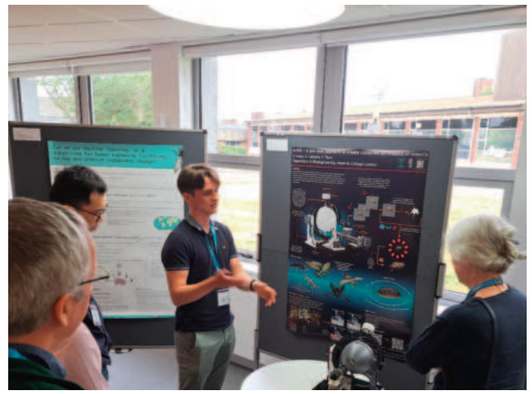


Fig. 4. Oscar Healey, Imperial College.

pipeline to detect, track and classify individuals to provide information on species presence, relative abundance and trends over time. Grace Skinner (UKCEH) described this system (Fig. 1) and pointed out that the traps can be left out for months at a time and can be used for monitoring the effects of extreme weather events, tracking within-night activity patterns and assessing the impact of agri-environment schemes on moth diversity and abundance.

How can collaboration between humans and machines, or augmented intelligence (AuI) improve insect identification? This was the question raised by Song-Quan Ong (Aarhus University, Denmark and Universiti Malaysia Sabah, Malaysia). Currently, we are at a semi-autonomous stage which requires human taxonomists. To identify insects caught on sticky traps, Song-Quan demonstrated an AuI pipeline consisting of two annotation stages, a deep learning model to locate all insects on the trap, followed by a hierarchical file system that allows taxonomists to classify the insect image files and organise their taxonomy into folders with the help of a pre-trained deep learning model that pre-annotates the insects prior to review. An augmented one-step model could perform similarly to (or better than) humans given a larger amount of high-quality training data.

Maximilian Sittinger (German Centre for Integrative Biodiversity Research, Halle-Jena-Leipzig) described a DIY camera trap (Fig. 2) for pollinator monitoring based on low-cost, off-the-shelf hardware components and open-source Python software. It can be operated by a solar panel. It is being used in the SEPPI (Standardised European Monitoring of Plant–Pollinator Interactions) project (https://seppi-pollinate.weebly.com/) to record potential pollinators and study their interactions. Currently there are 58 camera traps in eight countries, and it is hoped that the automated method will capture spatial trends in pollinator diversity, composition, visitation rate and network structure.

During an extended lunch break, there was the opportunity to view posters and go on a site tour (Fig. 3). Grab your sandwiches. The tour was guided by Gary Needham and Iain McGonigal and demonstrated how Syngenta is using imaging systems and AI, together with automation, to screen for new ways to control insects.

Nine posters were presented. Caitlin O'Farrell (University of Portsmouth) is using AI to map and predict taphonomic change and insect activity during decomposition, in order to predict the post-mortem interval, and is exploring whether these methods can replace the need for human studies. Oscar Healy (Imperial College London) (Fig. 4) is developing an open-source, low-cost photogrammetry platform to create coloured 3D models of insects for application in research, education, outreach, conservation and animation. Maria Anastasiada (Cranfield University) is combining computer vision and deep learning methods for automated detection and tracking of insect pollinators in Thailand. Vasileios Vasileiadis (Syngenta) is using a low-cost, solar-powered sensor that draws on AI and machine learning algorithms to quantify and identify bees at genus level autonomously. Zsófia Varga-Szilay (ELTE Eötvös University, Hungary) is detecting Buff-tailed Bumblebees (*Bombus terrestris*) on three plant species in the Azores using computer vision-based deep learning methods as part of an effort to unravel differences in their foraging behaviour. Tim Lukins (Forest Research) is developing a lab-based machine-learning classification system based on a convolution neural network (CNN) to identify and classify soil fauna, whilst filtering out spurious detection. CNN is a deep learning architecture used in image processing. Gregoire Noel (University of Liège, Belgium) is using CNN to identify and count insects from high-resolution pictures of collections, initially from 80 lepidopteran and coleopteran families from Africa. Gytis Bernotas (University of West England) is using CNNs to distinguish the sexes of the Yellow Mealworm beetle (*Tenebrio molitor*), which is only possible from differences in gap sizes between the visible abdominal tergites and is important in breeding programmes for farming the insects as animal feed. Mukilan Deivarajan Suresh (Newcastle University) is exploring the potential of deep learning and image-based recognition in advancing biomonitoring, especially of pest and beneficial insects in an agricultural context.

Okay, lunch boxes away please. Presentations so far have

Fig. 5. Azores native forest (credit Sébastien Lhoumeau).

discussed how AI can help the study of insects. With Barbara Webb (University of Edinburgh), the boot was on the other foot as she spoke about how insects can inspire AI. Her group's aim is to understand the mechanisms underlying insect behaviour and to test that understanding by building the mechanisms embodying their hypotheses as mathematical models, computer code or actual machines, and show the relevance of insect capabilities to AI. Ant navigation was used as an example. Desert ants navigate in complex, cluttered terrain over distances of up to 1 km by path navigation (dead reckoning) and visual memory. Ants were tracked with GPS and hand-held downward cameras and LiDAR used to reconstruct what they were seeing. Naïve ants on their first exit from the nest make a foraging excursion then follow a direct route home. After that they take a direct route out and back. Ants which are then experimentally displaced back to the food can, after a short search, find their way back to the nest along the route they have only twice seen, thus demonstrating accurate visual memory. Visual memory must involve pattern recognition, and the ants must associate the views they experience with their progress towards food or their nest. There is much to learn about how memory is organised in the insect brain and such understanding may lead to low-cost, low-computation solutions for navigation and other tasks relevant to AI such as intelligent robotics.

Although from the University of Southern Queensland, Australia, Derek Long was present in person to speak about an AI-powered, smart phone-based app for monitoring Silverleaf Whitefly (*Bemisia tabaci*) (SLW), a major pest of cotton, in an attempt to replace labour-intensive methods of assessing the need for control. 1,600 annotated images were used in algorithm development, and nymph identification using lens-magnified images in the field was 89% accurate. This method allows assessment of parasitism and hence the scoring of the nymphs as viable or unviable. For non-magnified images, identification is in two stages, a one-shot object detection followed by zooming in for classification, which was 75% accurate. This method is quicker but cannot detect parasitism. The biggest challenge is building trust in the system with the industry. The first version has been released and the next step is commercialisation for widespread deployment, hopefully resulting in reduced chemical control.

Detection of insects in the soil cannot be done with cameras. Karthik Ashok (Baker Consultants Ltd) is developing a neural network-based system to detect the acoustic stridulation signals of wireworms (larvae of click beetles) using off-the-shelf microphones, recorders and TensorFlow-based models. Mesocosms (colonies in pots) involving two genera of wireworms (*Agriotes* and *Athous*), which are pests of potato, were used in development of the prototype. The plan is to use the technology in early-warning detection and species assessment across the UK.

Understanding mosquito behaviour is crucial to developing monitoring tools. Khaled Mostafa Hussein and Mohamed Hany Abdelfatah (October University for Modern Sciences and Arts, Egypt) tracked the movement of three mosquito species using computer vision. Six videos each tracked six mosquitoes in a laboratory setting. The trajectory of each mosquito was extracted, and deep learning successfully classified the different directional movement patterns. Heatmaps were used to quantify activity levels, and this made it possible to distinguish the sexes accurately.

Mosquitoes such as *Culex quinquefasciatus* can fly in complete darkness without crashing into anything. Richard Bomphrey (Royal Veterinary College) wants to know how they do this, and whether such understanding can be applied to aircraft. Using an eight-camera system operating at 10,000 frames per second, he has built up a high-resolution picture of mosquito wing deformation and identified the forces generated. The mosquitoes are equipped with pressure mechanoreceptors. As they approach a barrier, pressure waves activate the sensors and lead to an avoidance reaction. The acoustic profile of the pressure waves tells them their orientation. Richard has applied this technology via a CNN to quadcopters and shown that it works in preventing them from colliding with objects. Richard has been studying dragonflies in a similar way and has mapped in detail the sensilla on the wings which detect strain and airflow. By filming in a wind tunnel and simultaneously looking at which neurons are spiking, he is building a picture of the flight control mechanism which, again, has potential for application in aircraft systems.

A very different application of AI and computer vision led Jack Hollister (University of Southampton and Natural History Museum London) to the astonishing conclusion that 20% of the Museum's British and Irish Lepidoptera are potentially wrongly labelled for one reason or another, not necessarily the fault of the original labeller as the nomenclature may have changed or there are issues with their online portal. He pointed out that

MEETINGS

Fig. 6. *Pseudophloeophagus tenax borgesi*, which is endemic to the Azores archipelago (credit Sébastien Lhoumeau).

Fig. 7. SLAM (Sea Land Air Malaise) trap (credit Sébastien Lhoumeau).

Fig. 8. The panel (credit James Gilbert).

it is important not to let the AI see the labels. Another unusual use of AI is in the reporting of extreme aversion to insects (entomophobia). Moshe Gish (University of Haifa, Israel) was surprised at the skewing of the aversion frequency curve to the most extreme categorisation when Japanese citizens were asked to rate their level of fear and disgust in response to various images of insects, and the finding that there was no correlation between the aversion score and the use of insecticides in homes. He recognised that the questioning needed to be more nuanced and developed a Computerised Adaptive Test using ChatGPT to do this, which resulted in the most extreme category being broken down into smaller units. If a subject gave an extreme score in response to a picture or question, the next picture or question was milder, and *vice versa*. This resulted in a more objective scoring system than one involving self-recording. Interestingly, only women were tested as it has been shown that men tend not to admit fear!

To manage biodiversity conservation, it is important to be able to predict likely outcomes in response to the many agents of change. Sébastien Lhoumeau (University of the Azores, Portugal) is developing a recurrent neural network (RNN) to forecast arthropod community composition within the native forest (Figs 5, 6, 7) of Terceira in the Azores. RNNs are suited to analysing temporal and sequential data. The dataset used to train the RNN model consisted of arthropod species abundance records from a long-term environmental monitoring project. The RNN was able to capture complex dynamics and generate accurate forecasts for the next sampling period, thus demonstrating its potential in early detection of potential shifts in community structure and the identification of critical conservation areas.

Following the presentations, Rob Lind, Mark O'Neill, Barbara Webb and Richard Bomphrey led a lively panel (Fig. 8) discussion which highlighted the incredible speed of progression in the use of AI in entomology. It was agreed that we are at the dawn of something big, and that another meeting in two or three years would probably involve very different conversations. For example, quantum computing may take possibilities to a new level. AI will be an essential player in solving major issues such as climate change and biodiversity loss. The importance of sharing code and data to make it possible for people to build on each other's systems was highlighted. The continued importance of human taxonomic expertise was emphasised, and it was suggested that it would be useful if AI systems could question taxonomists so as to close the feedback loop. However, with 20% of the Natural History Museum's British butterflies being wrongly identified, the concept of human experts was called into question by some and defended vigorously by others. AI and humans make different sorts of mistakes and hence synergy is essential. There was concern over how we can be sure that AI is being correctly used and not hallucinating, and how we can referee AI-generated papers.

Thus ended a truly fascinating and consequential day. James Gilbert summed up and greatly pleased your pedantic *Antenna* editor by re-emphasising that that data ARE king! Well said, that man. Many thanks to the convenors, presenters, coauthors and RES staff. A future meeting on this theme beckons.

Aphid Special Interest Group Meeting

18th July 2024 Online

Convenors: Joe Roberts and Tom Pope (Harper Adams University)

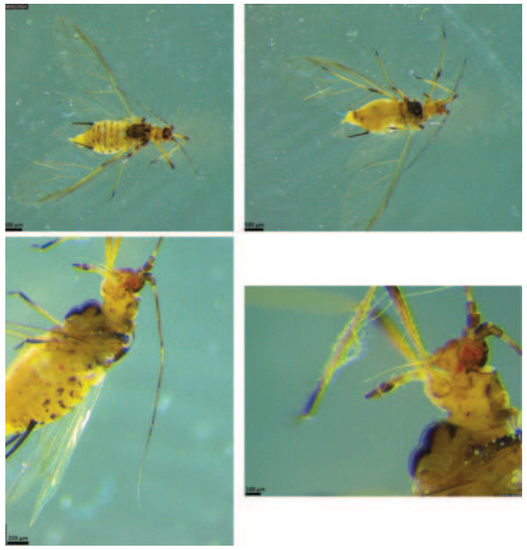
Report by Richard Harrington

I'm not biased, but aphids rank amongst the most biologically fascinating and economically important groups of insects. It is thus not surprising that 75 people attended the Aphid SIG to listen to a diverse set of online presentations.

The first four talks focussed on the role of aphids as virus vectors. James Bell (Keele University, UK) reported work from his Rothamsted days to identify beet yellows virus in sugar beet as early as possible. He found that the virus could be detected by molecular methods (RT-LAMP) three to four days after inoculation, and that a multispectral camera could detect the virus a week after inoculation, beating the human eye by a week. Cameras in drones can track rate of spread under field conditions but the analysis pipeline needs to be optimised to deliver automated assessment, potentially by using artificial intelligence. Martin Luquet (Université de Pau et des Pays de l'Adour, France) is investigating how early flight activity and flight season length of the main aphid vector, Peach–Potato Aphid (*Myzus persicae*), and its abundance, can be predicted using models based on suction-trap data. Whilst winter temperature is the best predictor, land-use data (especially the area of potential aphid reservoirs such as oilseed rape) can improve predictions, and Martin claims a 30% error reduction compared to previous models. Better aphid and virus prediction and detection could help with the deployment of alternative control strategies to insecticides in the face of multiple resistance mechanisms in *M. persicae*.

Representative strong BYDV symptoms three weeks post challenging (Lawrence Bramham).

Barley yellow dwarf virus (BYDV) can cause major yield losses in cereals. Lawrence Bramham (Rothamsted Research, UK) is looking at the possibility of transferring genes conferring resistance to the aphid vectors from the ancestral diploid wheat relative *Triticum monococcum* (line MDR049) to modern hexaploid wheat. Improved knowledge of BYDV strain impacts is also essential, hence strain variation in the UK is being explored with new and improved diagnostics. Alex Borg (Rothamsted Research) is investigating secondary metabolite-based resistance to aphids in *T. monococcum*. Twenty-one volatile organic chemicals in MDR049 were found to induce an aphid-density dependent reduced attraction to English Grain Aphid (*Sitobion avenae*). Transcriptomic analysis showed MDR049 to react to aphid feeding through differentially expressed genes (DEGs), suggesting that the molecular mechanisms required to detect aphid feeding and mount a defence response are present. In MDR037, no aphid-induced DEGs were found, possibly explaining its susceptibility to aphid feeding. Jack Perry (Teagasc, Ireland and Harper Adams University, UK) has been monitoring aphid vectors of BYDV using in-field counts, yellow water pan-traps and suction-traps. He has also assayed for



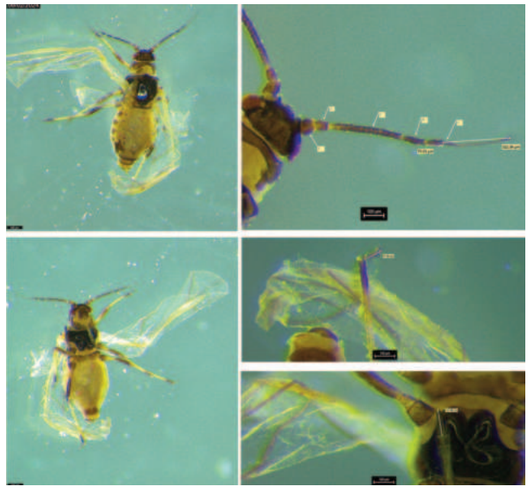
Sitobion fragariae (Copyright Virgile Ballandras)

BYDV in Bird Cherry–Oat Aphid (*Rhopalosiphum padi*), finding 37% of aphids to be carrying virus. Such monitoring should help to develop control programmes in the face of challenges posed by reduced insecticide availability, insecticide resistance and climate change. Meanwhile, Md Munir Mostafiz (Teagasc) has been quantifying life-history traits of *S. avenae* on winter barley to predict population development, which would help to rationalise IPM programmes. In future work he will look at whether crop infection with BYDV-MAV and BYDV-PAV affects population growth and study the aphid on winter barley.

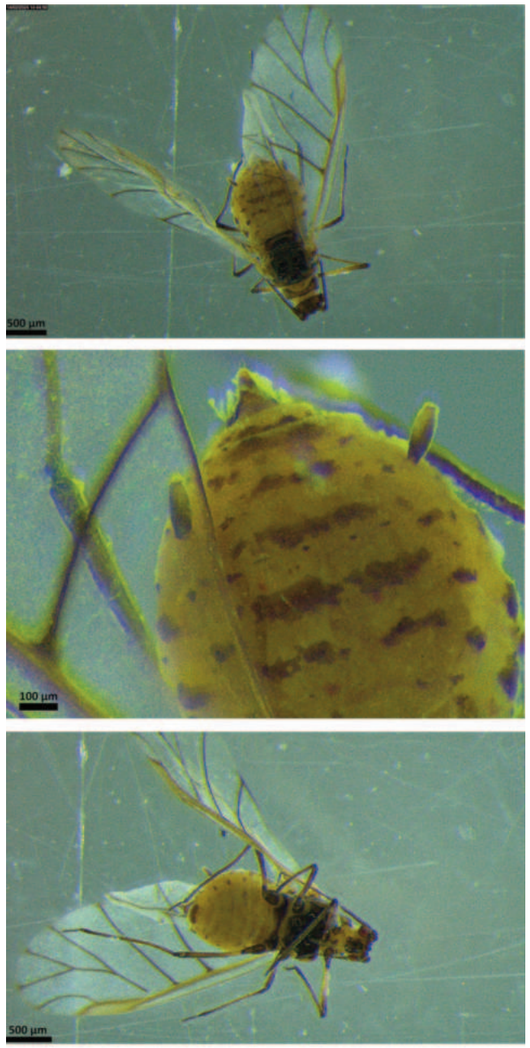
Russian Wheat Aphid (*Diuraphis noxia*) was first recorded in Australia in 2016 and has spread to all the country's grain-growing regions. Ayesha Warnasooriya (Murdoch University, Australia) is monitoring the aphid's status and working to understand its biology and behaviour to develop sustainable pest management strategies.

John Owen (Harper Adams University) is developing a push–pull system involving olfactory and visual cues for sustainable management of aphids in potatoes. Aphids are pushed away by repellents or masking agents and pulled to areas where they can be controlled or do no harm. He presented a vision of the use of dyed plants to hide crops from aphids.

Mariska Beekman (Wageningen University, Netherlands) is doing battle with *M. persicae* in sweet pepper greenhouses, trying to reduce reliance on chemical control. Often in 'conventional' glasshouses using chemical insecticides, only a single clone of *M. persicae* is found, whereas there is much more diversity in 'organic' greenhouses not using insecticides. Recently, there has been a new clone on the block which appears to be resistant to the few remaining insecticides available. It has become the dominant clone in conventional greenhouses but has not appeared in organic greenhouses, suggesting that it is at a selective disadvantage in the absence of insecticides.



Rhopalosiphum insertum (Copyright Virgile Ballandras)



Brevicoryne brassicae (Copyright Virgile Ballandras)

Parasitoids are vital friends in the fight against pest aphids. A genotype of Potato Aphid (*Macrosiphum euphorbiae*) has been found that is resistant to parasitism by *Aphidius ervi*, and Laura Martinez-Chavez (Harper Adams University) is concerned that this could threaten biological control in strawberries. She has characterised clones of the aphid in terms of their genotype and facultative endosymbiont complement and performed assays showing large differences in parasitism rates between clones. She is examining the role of aphid genetic variation in aphid–parasitoid interactions to inform on the likely effectiveness of *A. ervi* in controlling *M. euphorbiae* on strawberries. So far, she has found no significant effect of aphid genotype on parasitism success.

Where peach is found, *M. persicae* can complete a sexual cycle. Raphaël Lugan (Avignon Université and PSH, INRAE, Avignon, France) reports that three peach varieties carry a resistance gene which prevents aphids settling. He is studying the molecular basis of this antixenosis. The departure of aphids coincided with the activation of multiple plant immune mechanisms. The plant apices stopped growing because of a collapse in compounds essential to plant growth which are also vital in aphid nutrition. Matteo Gravino (John Innes Centre, UK), also working with *M. persicae*, found that Mp10, a chemosensory protein in aphid saliva, acts as a local anaesthetic to suppress immunity triggered by plant pattern recognition receptors (PTI). He discovered that Mp10 interacts with plant AMSH, a deubiquitinating enzyme which cleaves ubiquitin from proteins, thus destabilising cell membranes, which could explain the Mp10-mediated PTI suppression.

Jay Goldberg (John Innes Centre) is trying to understand the genetic basis underlying the extraordinary polyphagy shown by *M. persicae*. Dealing with a wide range of plant defence chemicals is a problem for generalists, and this is where transcriptomal plasticity comes into play, with differential gene expression (DGE) occurring in a host plant-dependent and time-dependent manner. Jay found over 500 genes with time-dependent expression profiles, many of them likely having metabolic functions.

The Sugarcane Aphid (*Melanaphis sacchari*) is an important vector of sugarcane yellow leaf virus (SCYLV) but does not cause direct feeding damage. The closely related Sorghum Aphid (*Melanaphis sorghi*) causes direct feeding damage to sorghum. Ricardo Pimenta (Universidade Estadual de Campinas, Brazil) has found that *M. sorghi* can transmit SCYLV to sugarcane and is concerned that the virus might worsen direct aphid feeding damage. He found that SCYLV suppresses sugarcane's defence responses to its vector. He has identified potential key regulators of the response of sugarcane to *M. sorghi* and these could be targets for future molecular studies, potentially leading to methods for preventing crop damage.

Virgile Ballandras (Maynooth University and Teagasc, Ireland) is developing non-destructive DNA metabarcoding techniques for the identification of aphids in bulk samples, optimising the process to ensure that key features are preserved so that morphological identification remains possible. Initial work has involved designing primers based on 10 to 15 individuals of each of 20 species.

It's not often that I come across an aphid I've not heard of. Until now, though, the Apricot Aphid (*Myzus mumecola*) has passed me by. It arrived in Italy in 2016 and has spread to neighbouring countries. The secondary host is unknown, and Marta Chignola (Free University of Boze-Bolzano, Italy) wants to find it and unravel other aspects of the aphid's biology, as Italy is the largest producer of apricots in Europe and needs to defend the crop against this new pest. Molecular techniques have identified two clusters, one from east Asia, which is related to *M. persicae*, and one from Europe and Japan, which is related to the Cannabis Aphid (*Phorodon cannabis*).

IPM has not reached its full potential. We are siloed and there is no holistic approach. We need to understand synergisms and antagonisms. So say Dave Chandler (Warwick University, UK) and Andy Gladman (ADAS Horticulture, UK) who are developing an IPM strategy for aphid control (*M. persicae* and Cabbage Aphid, *Brevicoryne brassicae*) on brassica crops combining partial (multigene; durable) host plant resistance and biologically-based controls, especially entomopathogenic fungi (EPF) and parasitoids, the idea being that partial resistance will slow down aphid development, giving biocontrol agents a better chance of keeping the population under control. They have screened brassicas for partial resistance based on population development and documented gene expression responses in resistant and susceptible lines. The EPF *Beauvaria bassiana* is generally not good at controlling aphid nymphs because of the lag between inoculation and germination, giving aphids time to moult and shed spores. Control of adults is more successful, but targeting adults gives them time to reproduce. Screening ten fungal isolates found one that caused appreciable mortality in first instar nymphs, as it germinates more quickly. Resistant cabbages were found to slow aphid development such that there was 60% survival from the fungus on susceptible plants and 30% on the partially resistant plants. Plants attacked by aphids upregulate cis-jasmone production, which increases parasitoid activity in certain brassica genotypes. It can also reduce aphid landing. Thus, there is clear potential to produce plants that enhance biocontrol. In similar vein, Mst Atikunnaher (University of Warwick) is combining host plant resistance and companion cropping to attract parasitoids in a conservation biocontrol programme for Carrot-Willow Aphid (*Cavariella aegopodii*). Millie Small (BugBiome) is also interested in manipulating the symbiotic relationship between microbes (bacteria, fungi and viruses) and crops. Microbes

naturally produce metabolites that can control insects and by understanding what insects respond to, Millie is hoping to design effective biological deterrents. Using trials in outdoor tents, she is looking at aphid settling behaviour and will compare the microbiomes of attractive and unattractive leaves.

Can an understanding of insect learning be used to improve the efficiency of parasitoids as biological control agents? Nikoletta Foskolou (Harper Adams University) is characterising chemical cues associated with host-searching behaviour and determining the abilities of commercially available parasitoids to learn these cues through conditioning. She will evaluate the impact of improved learning on biological control efficacy under semi-field conditions. With warmer winters, parasitoids are becoming increasingly winter active, as are bees. With limited nectar sources in winter, could this lead to competition between parasitoids and bees? Daisy Scott (University of Bristol, UK) has started lab cage experiments with the Buff-tailed Bumblebee (*Bombus terrestris*) and the parasitoid *A. ervi* to find out whether presence of the bee affects the parasitisation rate of *S. avenae*.

I often find the European Earwig (*Forficula auricularia*), crawling over the apples on my tree. They appear to be doing mild damage, but Hayden Tempest (Harper Adams University and NIAB EMR, UK) says that they do an excellent job of controlling Woolly Apple Aphid (*Eriosoma lanigerum*). He surveyed ten trees in each of twenty orchards in three repeat surveys, recording earwigs and noting ground cover, other aphid species present and soil type, as well as doing gut analysis to see what the earwigs had been eating. In a model of earwig presence/absence the only fixed effects were survey date and orchard. Earwigs were present in Braeburn and Gala varieties but not Spartan.

Finally, aphids aren't all bad. Like any other insect they have ecosystem roles and only become a problem through our own actions such as growing monoculture crops and relying too much on insecticides. Alice Casiraghi (Natural History Museum of Barcelona, Spain) wants to use the services of non-pest species to draw in reservoirs of biocontrol agents that may move into agroecosystems. She is investigating Mediterranean shrubs and weeds and their insect communities that might provide a continuous conservation biocontrol service in arid agricultural landscapes of Spain.

Many thanks to Joe and Tom for organising such a stimulating meeting, to all speakers and their co-authors, to all who listened in and came up with excellent questions, and to the RES team. Discussions are afoot concerning extending the SIG to include other hemipteran vectors of plant viruses. An in-person meeting will be planned for 2025.

Monthly Online Meetings

Insect Molecular Biology

10th July 2024

Insect Epigenetics: Challenges and Dilemmas

Talk by Professor Ryszard Maleszka (Australian National University, Canberra)

Report by Chris Williams

Recent online talks have been linked to the Society's journals and this was the turn of *Insect Molecular Biology*. Epigenetics is the study of how the environment influences gene expression to enable plasticity of phenotype in a fixed genotype. Ryszard first pointed out that although it is a hot topic, the type of research now described as 'epigenetics' has been around since the 1930s.

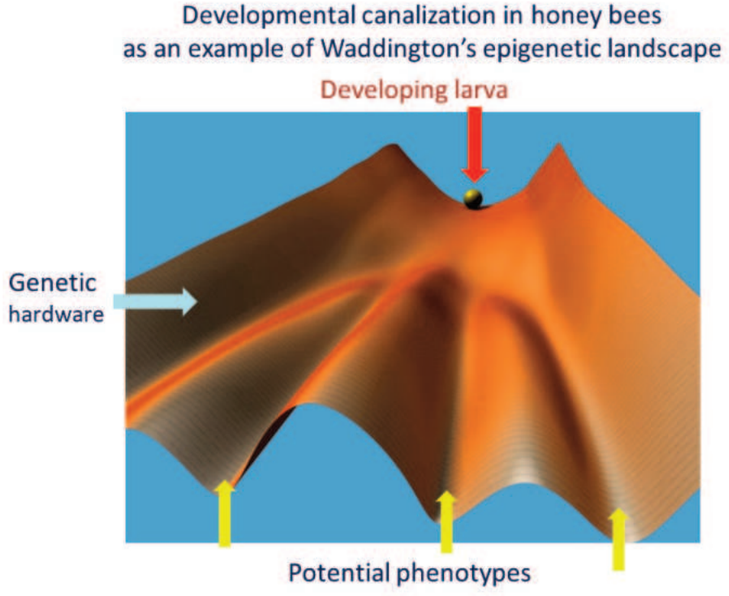
After considering the many and varied types of epigenetic gene regulation, Ryszard moved to the group that he is most famous for, honey bees. He noted that caste differentiation between queen and worker bees is a totally epigenetic phenomenon. He illustrated this nicely with a ball rolling down a hill into potential valleys (phenotypes). This model, shown below, illustrates the concept of genetic hardware and environmental effects on the genotype leading to two distinct phenotypes (worker and queen). This epigenetic control is dynamic and various instructional vectors keep the ball in the correct valley through time.

Next, Ryszard took a step back to consider epigenetics throughout the tree of life. He noted that a key piece of the epigenetic toolkit is the enzyme group, DNA methyltransferases. Although these enzymes have been key to epigenetic reprogramming in mammals, there is no DNA methylation in the model organisms used for epigenetic studies, the fruit fly *Drosophila melanogaster* and the nematode *Caenorhabditis elegans*. This is probably why, at the end of the lecture, when asked what the ideal insect model would be to investigate epigenetics, Ryszard said, without hesitation: "any of the Hymenoptera".

There followed a survey of genes DNMT1 and DNMT3 across Hymenoptera and the incidence of PWWP (a group of 70 amino acids with a core of Pro-Trp-Trp-Pro) duplication that is unique to Hymenoptera. Ryszard showed the results of an elegant experiment in which honey bees were treated with DNMT3 RNAi. The proportion of queens emerging was significantly higher in the treated group compared to the controls. Ryszard went on to describe the important work of Paul Hurd's lab (Queen Mary University of London) on post-translational modification of histone proteins. Going back to the ball rolling down the valleys model, Paul's work has shown extensive genome-wide differences in histone H3 modifications at 96 hours of larval development, which is the point at which the ball is in a particular valley and cannot jump across.

Ryszard ended his talk with a whistle-stop tour of future challenges. Regarding technology, he emphasised the role of single cell sequencing and ultra-deep amplicon sequencing, which hold promise for investigating many reads for just a single or a few genes. On a cautionary note, Ryszard mentioned that insect brains and other tissues have many different cell types and epigenetic modification at one cell type might not be the same across others.

The final story concerned the Bogong moth (*Agrotis infusa*).



This species undertakes vast migrations across Australia by night. It has been shown that it possesses a geomagnetic compass sense, but this only tells the moth where it is going, not where it should go. Since the moths cannot learn the direction in which to go since they develop as larvae before migrating, this information must be inherited epigenetically.

Ecological Entomology

9th October 2024

Pollinators and Pollination: Influence of Policies and Practices

Talk by Professor Jane Stout (Trinity College Dublin)

Report by Richard Harrington

It was a delight to welcome more than 70 listeners to a talk by our new president, who introduces herself on page 162 of this issue. The meeting was chaired by Shannon Murphy, one of the editors of *Ecological Entomology*.

After an introduction involving pollination facts and figures, Jane listed some drivers of pollinator declines as habitat loss, decline in wildflowers, pests and diseases, invasive organisms, climate change and pesticides. Bees are exposed to pesticides via nectar and pollen, but an interesting twist to this story is that *Rhododendron ponticum*, an invasive plant in Britain and Ireland, has naturally occurring toxins in its nectar which can kill bees and cause cardiovascular and gastrointestinal problems in humans if eaten in large quantities.

The EU Natural Restoration Law includes: "reversing the decline of pollinator populations by 2030, and achieving an increasing trend for pollinator populations, with a methodology for regular monitoring of pollinators". The All-Ireland Pollinator Initiative is chasing this goal. You can read about it in *Antenna* 48(1) page 34 following Una Fitzpatrick's online talk on the subject. Despite the many actions undertaken so far, bumblebees are still declining by 3% per year in Ireland and it is not yet clear which actions are supporting pollinators best.

In summary, Jane emphasised that diversity is crucial – it's not all about bees, collaboration between various stakeholders is essential, and we need more entomologists, pollination ecologists – and appreciation, love even, of pollinators.

The Q&A session encompassed the inclusion of rare pollinators and animals other than bees in the All-Ireland Pollinator Initiative and the relative importance of different taxa. There was further discussion on the *Rhododendron* issue. An interesting final question was: "are stories or facts the best way to communicate the importance of pollinators to the public", to which the almost inevitable answer was: "stories based on facts". I would never have guessed that 'Hawkeye' from *Mash* would feature but, apparently, he has had a lifelong interest in science and founded the Alan Alda Centre for communicating science. What a chap! The meeting closed with everybody feeling the love.

Ento24

Liverpool, 10th – 12th September 2024

This was our biggest and most spectacular Ento yet. In the city of The Beatles, though, it's perhaps the Beach Boys' *Good Vibrations* that best sums up the conference. Read all about it from the point of view of the convenors, speakers and delegates.

Convenors' Report

Chris D. Williams (Liverpool John Moores University), **Sharon Zytynska** (University of Liverpool), **Chris Jones** (Liverpool School of Tropical Medicine) and **Michelle Davis** (Edge Hill University)

It was with some trepidation that we accepted the invitation to convene such a prestigious event as Ento24 in Liverpool. However, the support we received from the RES, and particularly Amy Everard, made the whole experience enjoyable and seamless. Plenty of people thanked us for organising the event but all of the nitty gritty was taken care of by Amy, leaving the convenor team to the task of selecting talks and posters. We also received excellent input from Meetings Chair Richard Harrington and Director of Communications and Engagement Luke Tilley, and during the conference the student helpers were a real asset to the smooth running of the sessions.

At our first meeting we decided on plenary speakers and general conference themes. We included themes that related to our interests: Biocontrol and Conservation and Diversity (Chris Williams), Vector Biology (Chris Jones), Host–Microbiome Interactions (Sharon Zytynska) and Pollinators and Genetics & Genomics (Michelle Davis). We also wanted to align our sessions with the Grand Challenges initiative, hence the inclusion of Taxonomy and Diversity, and Monitoring and Controlling Pests.

Overall, the conference was a huge success attracting a record number of delegates, 250 in person and 63 online. The plenaries were all excellent and are available on the RES YouTube channel. Professor Michael Samways kicked things off with a visually stunning and philosophical outlook on the conservation of insects in South Africa. His talk stimulated much discussion and was very timely given the RES and CABI publication of Michael's groundbreaking tome Conservation of Dragonflies. The following morning, we welcomed Professor Steve Torr, from the Liverpool School of Tropical Medicine. Steve's career in researching the ecology of tsetse flies for improved control of African sleeping sickness has had a massive influence in bringing the number of cases down in Africa and, as a result, his team was awarded the Queen's Anniversary Prize in 2023. At the end of the conference, Professor Susanne Foitzik gave a tour de force presentation on the chemical ecology, genetics, behaviour and host manipulation by a cestode parasite in various ant species.

Ento24 convenors Chris Williams, Sharon Zytynska, Chris Jones and Michelle Davis.

Audience applauding at Ento24.

Lunch times and coffee breaks were excellent opportunities to meet with old and new friends. The Annual General Meeting was extremely well attended, where Jane Stout formally took over the role as president of the Society from Jane Hill. At the end of the first day the president's wine reception provided an opportunity to engage with poster presenters. The posters were of an incredibly high standard and as judges we had a very difficult task to pick the winner, Daniel Turk (University of York), runner-up Andrea Ceribelli (University of Liverpool) and online poster winner Maria C. Tocora (University of Toronto, Canada). In the evening of the first day, Liam Crowley hosted his annual EntOlympics for student members. This is always a fun event, and we thank Liam.

The second day began bright and early with a fun run led by Simon Ward to nearby Everton Valley with great views overlooking the city. Prior to the sessions on Day 2, there was a *Women in Entomology* informal mixer. Parallel workshops included an eclectic mix of interesting subjects from *Getting funded*, where Luke Tilley was on hand to give tips on how to acquire small grants. Other workshops included *Public engagement through comics and games*, delivered by Liam Crowley, who has designed an entomological card game. This is a novel and effective means of public engagement. An emerging subject, which has recently come to the fore at the RES is that of *Insect welfare in research and education*. Meghan Barrett and Bob Fischer explored this topic in their workshop. Finally, Gia Aradottir led a workshop on *Research impact and innovation*. With impact case studies an important part of the Research Excellence Framework (REF), it has never been more important to translate research into real world policy benefits. About 60 delegates attended the final early morning session on the *Grand Challenges of Entomology*, which was run by Simon Ward and Luke Tilley.

All the sessions of the conference were well attended, and the speakers were excellent, as were the chairs, who kept everything to time. Alongside other academics, we had the exciting job of nominating a winner of the student talks. From the many excellent and high-scoring talks, we were unable to pick just one winner and therefore this year we announced two speakers for the prize. Well done to Elsie Isiye of South East Technological University (Ireland) and Ida Cecilie Jensen (Aarhus University, Denmark).

Next Year Ento25 will be at the University of Strathclyde (Glasgow) and we hope to see you all there!


Jane Hill presenting Jane Stout with President's Medal. (Photo Richard Harrington)

President Jane Stout and past president Jane Hill.


President's wine reception.

Interviews with our Plenary Speakers

Michael Samways
(Stellenbosch University)

How would you summarise your work and research interests?
It all began when I was a toddler watching a grasshopper in the long grass in the back garden of my rural home in the Chilterns. Back then, it intrigued me why it is that insect populations are able to maintain themselves year in year out when they live for such a short time. And why did different butterflies have characteristic flight patterns yet seemingly flap along in a bizarre way? Later on, while doing thesis field work on bush cricket (*Platycleis*) song behaviour in southern France, I got to know each individual as each night passed. Each had slightly different song features and responsiveness to being approached. Not only that, but because of what we now call landscape fragmentation, and as a result of induced close proximity, it was clear that the adults were being forced into tiny areas of preferred habitat causing *P. intermedia* to modify its song in response to the song of *P. affinis* and *P. falx* in their now adjacent habitats. This concerned me: how are they going to survive in the long term when we continue to take away their preferred habitats? At the time, I had a copy of the very first *Red Book* (1969), with lots of wonderful pictures of threatened birds and mammals, but not one insect was mentioned. That was that, and so I decided to devote my life to saving insects!

Was this your first time at an Ento meeting, or are you a repeat attendee, and how did you find it?
I was fortunate as a research student to be able to attend Royal Entomological Society meetings at its earlier home in South Kensington. There I met so many wonderful senior entomologists who were such an inspiration in all aspects of the subject. It was at an RES meeting where I gave my first talk to an outside audience, and where I received so much encouragement. I have now been a FRES for 50 years, and that says it all!

What do you think the key benefits are of attending these kinds of conferences?
To learn, listen, and interact with a set of people with a like passion. Entomology is such a diverse field that there is always some exciting news from some quarter of the topic. Entomologists are the most engaging of all people I have interacted with professionally. Over the years, one also develops good, solid friendships which makes life so much richer and fulfilling. When asked in social circles what sort of work I do, the answer is simple: "Oh, I don't actually 'work', but I have the amazing hobby of entomology, and fortunately I get paid to do it!"

Do you have a favourite insect, or favourite fun insect fact?
I love them all, in flight, under the water, across the landscape…and even a flea is loveable under the microscope with its truly amazing body sculpturing. I favour landscape-level conservation as that conserves so many individuals, species and interactions. Besides, give nature the right chance, and it will come back.

Steve Torr (Liverpool School of Tropical Medicine)

How would you summarise your work and research interests?
I have worked on tsetse biology and control for over 40 years, starting with the Tsetse Control Branch in Zimbabwe in the 1980s, and then joining the Natural Resources Institute at the University of Greenwich and finally the Liverpool School of Tropical Medicine (LSTM) where I have been leading the Tsetse Research Group for the past decade. Our research focusses on developing better ways of controlling and monitoring tsetse through an improved understanding of their ecology and behaviour. My particular areas of interest have been concerned with analysing how tsetse locate and feed on their hosts and I have been involved in the development and application of baits to attract and kill tsetse. Most of our research is conducted in the field in Africa and currently we are working mainly in Uganda, Malawi and DRC.

Was this your first time at an Ento meeting, or are you a repeat attendee, and how did you find it?
I have been to previous RES annual meetings – at the universities of Aberdeen, Reading and Greenwich for instance – but this is the first one I've been to in a long time. I'm really enjoying the meeting, hearing great talks, meeting old colleagues and friends, and making new ones. I'm based in Liverpool, so of course I am slightly biased in thinking that the organisers have done a brilliant job. I am not an organiser myself!

What do you think the key benefits are of attending these kinds of conferences?
I think it introduces us to new people and work in the field of entomology with a more diverse range of entomology. We have a big (>100 scientists) department of vector biologists at LSTM, but we are working largely on the vectors of human diseases, particularly mosquitoes. It's refreshing to be in the company of people working on, say, insect conservation, insect pests of plants, pollinators, beneficial insects and aspects of insect biology that are just cool!

Do you have a favourite insect, or favourite fun insect fact?
Having spent over 40 years working on them, I have to say that my favourite insect is, of course, the great and wonderful tsetse fly. A tsetse-related fun fact is that they produce a single live larva every ten days or so and, while it seems impossible, the larva is bigger than its mother. If you want to know how tsetse achieve the impossible, have a look at this article: https://pubmed.ncbi.nlm.nih.gov/33030256/.

Susanne Foitzik (Johannes Gutenberg University Mainz)

How would you summarise your work and research interests?
I am a behavioural ecologist and evolutionary biologist working on the evolution of social behaviour, ageing and host–parasite interactions in social insects, mainly ants. From field work to well-replicated and standardised behavioural experiments, we are now doing a lot of genomics and transcriptomics to determine the genetic basis of evolutionary adaptations.

Was this your first time at an Ento meeting, or are you a repeat attendee, and how did you find it?
This is my first Ento meeting.

What do you think the key benefits are of attending these kinds of conferences?
One can get a great overview of different scientific fields working on the same type of study organism. In many other conferences we only meet scientists who work in the same field, but here you will get different kinds of insights.

Do you have a favourite insect, or favourite fun insect fact?
I really like my *Temnothorax* ants, tiny ants with small colonies, which often reside in acorns. They had repeated evolution of social parasitism including dulotic ants, formerly known as 'slave-making ants'. How they coevolve with their hosts, which sometimes rebel again exploitation of their social behaviours, is fascinating.

View the the Ento24 plenary talks on the RES YouTube channel.

Workshop Reports

Public Engagement Through Comics and Games

Fran Sconce (RES), **Rudi Verspoor** (University of Liverpool), **Liam Crowley** (University of Oxford)

This workshop introduced how comics and games can be used as tools for public engagement about insects, and featured the Ento-Club comic by Rudi Verspoor and the Battlin' Bugs card game by Liam Crowley. Participants then developed their own game and comic ideas, including a pandemic-style cooperative board game to conserve endangered insect populations, a hidden identity social deduction game with mimicry and aposematism, a SkiFree-style computer game where harvestmen must avoid predators and keep all their legs, and a burying beetle comic explaining carcass decomposition and parental care behaviours.

Grand Challenges

Simon Ward (RES)
and **Luke Tilley** (RES)

The Grand Challenges workshop was very well attended (considering an 8am start!) and gave us an opportunity to update progress from the Society against the four overarching themes. The attendees were involved in an interactive discussion where we focused on how the RES may be best able to further support the theme areas of Pure Science and Human–Insect Interaction as we develop the 2025–2028 strategy. Ideas were collected on the day but subsequently we invited other feedback to be sent by email and have had a good response. All ideas from the attendees are now being used to develop new programmes to support the Grand Challenges in the coming years and where we can focus our resources to have maximum impact.

Next Steps for Improving Insect Welfare in Research and Education

Bob Fischer (Texas State University) and **Meghan Barrett** (Indiana University Indianapolis)

Bob Fischer and Meghan Barrett, both from the Insect Welfare Research Society, led this workshop. They presented the results of their 2024 survey that

captured entomologists' knowledge about insect welfare, current practices to promote insect welfare, and views on the efficacy and costs of different strategies for promoting insect welfare (strategies evaluated were initially proposed by entomologists at the 2023 RES SIG). Participants identified resources and guidance that would be beneficial for the successful implementation of these strategies, with the goal of promoting both insect welfare and ethical, reproducible research.

Research Impact and Innovation

Gia Aradottir (Mamore Research and Innovation Limited, and RES Trustee)

The workshop was well attended and was a mixture of lectures and very engaging discussions sparked after participants brainstormed the innovation potential from their research. It is clear that entomologists have much to offer when it comes to creating impact and innovations. Ideas discussed ranged from the molecular to ecosystem level and participants left with the intention of developing a business or impact model for their key ideas. Entomological innovation is thriving and hopefully we will see more exciting ventures come from these discussion.

Getting Funded: small grant applications for research and outreach

Luke Tilley (RES Director of Communications and Engagement)

Over 55 delegates attended this workshop, which explored small and medium-sized funding opportunities from the RES and other learned societies and charitable organisations. A highlight was insight from attendees about the role small project grants can play in bridging the gap between degree courses and employment, or enabling researchers to undertake side projects during larger expeditions and projects. The group discussed the importance of following scientific curiosity to gather preliminary results though small project work to support a bigger funding application, potentially in a new area of research.

The workshop was an opportunity to introduce the RES Small Project Grants in detail, newly launched in 2024, which offer up to £3,000 for standalone research projects. Applications for the next round open on 3rd February 2025. Additionally, the RES Goodman Fund, which aims to advance public understanding of insect science, offers grants of up to £3,000, with the next round opening on 1st January 2025.

For more information on RES Awards and Grants, visit www.royensoc.co.uk/awards-and-grants.

Views from Delegates

Andrew Salisbury
(Royal Horticultural Society)

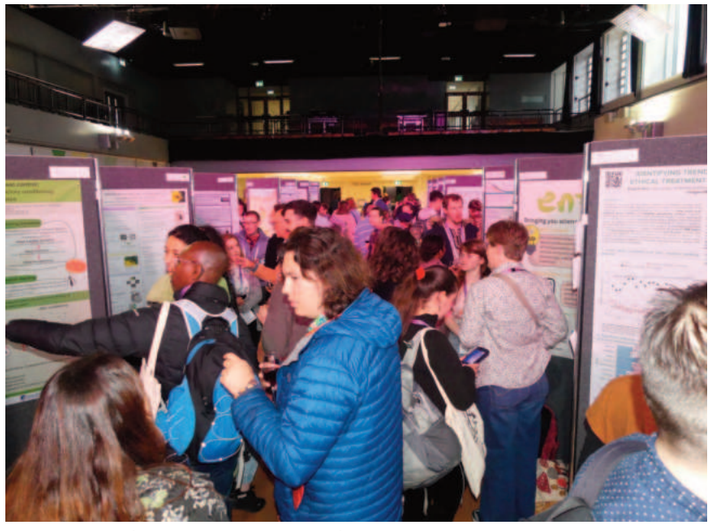
Well, I'm exhausted but exhilarated after three exciting days of entomology. Since my first Ento (Bath in 2006), the conference has been a highlight of my entomological year. I've always found the RES Ento conferences bubbling with chatter, as a collaborative, supportive, engaging and innovative event, and Ento24 in Liverpool did not disappoint.

Growing and building on previous events, this year's included diverse presentations from aphids, sexton beetles, dragonfly conservation, why there are so few marine insects, to complex mathematical modelling and the effects of manual removal 'pest' control. It was difficult for me to decide which of the parallel sessions to attend.

It's an environment where early career entomologists mix with long-established academics and practitioners, learning from each other, and we were delighted that one of our RHS UG summer students, Julia Morgan, gave an excellent presentation *Act or tolerate* about bean aphids.

Whilst I wasn't presenting this year, I still remember my nerves from my first presentation at Ento06. The RHS was an exhibitor, highlighting the varied entomological work of our Plant Health Team. Centre stage was a stunning box of insects gifted in 1954 from the RES as a celebration of the RHS's 150 years. The two organisations have a long collaborative history, and the RES was reminding the RHS of the importance of insects in gardens 70 years ago!

The poster session is an essential part of any conference, and it allowed us to mingle and discuss everything from pan traps and pollen identification to the history of the conference, fieldwork anecdotes and the perennial question "why does your research organism invariably become rare when you want to study it?"!



Poster session. (Photo Richard Harrington)

Workshops added to the collaborative atmosphere. I went for *Research impact and innovation*, and am glad I did, as an example used for discussion was how to show the potential impact to gardeners of wildlife gardening advice. Thanks, Gia!

Above all, Ento24 was all about celebrating and progressing Entomology: the EntOlympics, pre-conference social, conference bingo, the drawing and art, the Ento fashion – from subtle insect shaped jewellery through to the classic 'loud tie' – added an extra sense of fun. To top it all, this year's venue for the conference dinner, the World Museum, and a visit to the *Bees*: *A Story of Survival* exhibition, with pre-dinner drinks under Sputnik and a Pterosaur added an extra level of nerdity that even I couldn't have anticipated.

A BIG THANK YOU to the RES and Liverpool University teams for an amazing Ento24, and here's to Glasgow in 2025!

Vic Aldcroft
(University of Liverpool)

This was my first time attending an Ento meeting. I was about to get myself a ticket when the offer came through of helping out! It was the perfect opportunity to contribute to the field, as I don't have my research ready yet, but I still wanted to get involved. It was very interesting seeing some unpublished data and what the future will look like for entomology. In particular, I was impressed with the absolute dedication of some of the researchers – I believe one group had reared 300+ generations of a species just for one paper! It was also great to hear about the progress that the *Darwin Tree of Life* project has made since last year and some of the new records they have found.

Ento24 was great for meeting others in entomology, and I received some excellent advice! The opportunities to hear about how to obtain funding and pitching a paper to publishers helped answer a lot of the main questions that prospective students have. It also helped me see what actual scientific posters and presentations look like, as well as realising it is okay to say that you don't know the answers to all of the questions!

All the Buzz at the Ento24 Conference Dinner

Micah Flores (BioMonde)

For those who attended the conference dinner at the Liverpool World Museum, the event came with a tour of the Museum's Exhibit titled *Bees*: *A Story of Survival*. The walk upstairs to the exhibit garnered a feeling of *Night at the Museum* with the stillness of the building and darkness of the other exhibits. This absence of sensory inputs was fitting as what came next was a fascinating exploration of every sensory faculty throughout the systematic outlay of this exhibit. A fantastic set of touch screens helped deliver facts about bee morphology and physiology. Along with some stunning photos of bees, this area appealed to the visual senses. As the exhibit progressed, the lights dimmed, and the sounds of the hive became the focus. I was amazed to learn that the audio in this section was a recording of bee's waggle dance and overlayed with musical and vocal sounds synthesised from the same bee waggle dance recordings. Touchscreen exhibits were found in the next section detailing the origins of bees, photos of bee species across the world and the diversity of species across continents. A cross section of a bee model was on display in the centre, detailing the anatomy of bees.

As we progressed deeper into the exhibit the lights grew dimmer, with apparent pollen grains within a resin being the source of illumination. A section of mirrored walls with floral displays highlighted the transition of a section entitled *Meadows*. Continuing on, hexagonal walls portrayed what life within a hive might look and feel like. Moving through this portion, the sounds of buzzing began and gradually grew louder. A station dedicated to bee communication was presented. Bone conductors were utilised to provide a tactile sensation of the vibration patterns from different types of communication signals employed by honey bees. It was shortly after this area that the highlight of the exhibit was discovered. A real-time video of a bee going through metamorphosis was playing on a loop. This first-hand perspective of the process within the cell of a hive brings justice to this remarkable phenomenon that photographs cannot. Transitioning to the next area, small 'peek' holes gave insight into the variety of nesting sites for various bee species. Passing through plastic curtains, the next experience was that of a bee swarm. The sound grew louder and was emanating from fabric strips hanging within a square structure. This visual experience was likely what a queen bee might experience when protected within a swarm while seeking out her new nest. The sheer silence at the next section of the exhibit, *Vanishing*, was strikingly highlighted by the portrayal within a nearly sound-proof room of what the world would be like without such marvelous creatures. Dried flowers and a video of flowers wilting were harshly portrayed in this area. It was a sombre reminder of the potential fate of the bees so vividly highlighted in the previous sections of the exhibit.

The history of beekeeping was the next section's focus and highlighted the scents of bee hives. The final stop ended with a section where we could write a note on how we will act to help save our environment for bees alongside a single solitary longhorn bee specimen.

It was only fitting to walk back downstairs to the buzz of conversations of entomologists catching up with one another and reminiscing on times gone by. A consensus of those whom I spoke with on the evening was how amazing the various sections were but also how inclusive the sensory aspects were for those who may have sensory impairments. If the exhibit is still there the next time I am back in Liverpool with my family, I will definitely return with my kids!

Michael Samway's
Conservation of Dragonflies

ICE2024 XXVII International Congress of Entomology

Francisca Sconce
Senior Outreach and Learning Officer

The 27th International Congress of Entomology took place at the Kyoto International Conference Centre in Japan from 25th to 31st August 2024, with over 3,000 delegates attending. The RES was a bronze sponsor of the event, with an exhibition stand, supported by staff and trustees, promoting our activities including membership options and publications. We were joined by BBC staff working on *Hidden Planet*, seeking stories for this landmark five-part series currently in production.

The conference opening ceremony was attended by Fumihito, Crown Prince Akishino, and Kiko, Crown Princess Akishino, senior members of the Japanese royal family.

Professor May Berenbaum was this year's RES Wigglesworth Award recipient for outstanding services to the science of entomology. May was unable to give the Wigglesworth Memorial Lecture due to health issues, but RES trustee and ICE Council Chair Walter Leal spoke instead and highlighted her outstanding contribution to entomology. We thank Walter for stepping in at short notice.

An evening reception for around 50 RES members was hosted by staff and trustees. It was fantastic to provide this opportunity for our community to get together. The RES Conference Participation Grant supported the attendance of seven members at the Congress.

With colleagues from the Entomological Society of America, we held a meeting of leaders from entomological societies around the world, to strengthen relationships and plan future activities. We found lots of common ground including a need to champion Society journals in a changing publishing landscape.

Senior Outreach and Learning Officer Fran Sconce spoke about RES outreach and education with insects in the *Manga, Comics, and Games as tools for Entomological Engagement* session, summarising activities such as the partnership with Aardman Animations, the RES insect garden at Stratford Cross and interactive exhibits at major science shows.

Delegates enjoyed local drumming and fireworks during the welcome mixer, entomological 'gatcha' toys in vending machines, and insect origami sessions.

The conference was a great success for the Society, and we look forward to ICE2028 in Cape Town.

Banging the drum for entomology.

Grant Reports

entoLIVE: Making Invertebrate Science Accessible

Keiron Derek Brown
Biological Recording Company

"Science isn't finished until it's communicated. The communication to wider audiences is part of the job of being a scientist, and so how you communicate is absolutely vital."
Sir Mark Walport, UK Government Chief Scientific Adviser (2013)

entoLIVE is a series of free educational webinars (and the resulting YouTube videos and blogs) focusing on invertebrate research that was launched in early 2023, with each 1-hour webinar featuring a guest speaker presentation and live audience Q&A session. It gives invertebrate researchers a platform to showcase their work and is a great way for students, amateur naturalists and professional entomologists to learn about invertebrate research projects.

It was launched by Keiron Brown through the Biological Recording Company thanks to a Royal Entomological Society Goodman Award and has continued beyond the initial 40 webinar run thanks to further funding from RES and other partners.

Since launching, almost 60 entoLIVE webinars have been delivered covering topics such as invertebrate sentience, ant navigation, hoverfly reintroduction, bee hotel design and the Rothamsted Insect Survey. Future topics include glow-worm monitoring, dragonfly flight and insect welfare.

The webinars have proven very popular, demonstrating that invertebrate research webinars are in high demand. During 2023, the programme received over 16,600 bookings across 40 webinars (seasons 1 and 2), with bookings per webinar continuing to show a steady increase over time during season 3 (2024). In addition, the resulting 2023 YouTube videos have been viewed over 24,000 times and the blogs have received over 12,000 views.

Feedback surveys have illustrated that over half of entoLIVE attendees gained awareness of new research outputs and over a quarter had gone on to look up invertebrate research outputs as a result of their engagement with entoLIVE. Furthermore, over a third of respondents were motivated to take part in invertebrate research (such as citizen science projects), 35% had used knowledge gained from entoLIVE in their voluntary or paid work and a small number of respondents (5–11%) had referenced research outputs presented in entoLIVE within their own work.

New subjects are being added to the programme all the time so check out the latest free entoLIVE webinars on the Biological Recording Company Eventbrite profile to book your space: https://www.eventbrite.co.uk/o/the-biological-recording-company-35982868173.

You can also catch up with any webinars that you have missed through the entoLIVE blog: https://biologicalrecording.co.uk/category/entolive-blog/.

Applications are still open for the 2025 programme, so if you have a research topic that you would like to submit for an entoLIVE webinar, contact Keiron at info@biologicalrecording.co.uk.

RES Expands Support for Postgraduate Insect Science in 2024

The Royal Entomological Society is delighted to announce the recipients of the 2024 Higher Education Bursaries. This year, the Society has expanded its support for postgraduate insect science by awarding bursaries to two leading institutions: Harper Adams University (HAU) and, for the first time, the University of Reading. This new competitive process has increased the total investment in postgraduate entomology to £20,000, an increase of £8,000 from previous years.

The bursaries will enable both institutions to offer enhanced financial support to students studying entomology at the postgraduate level, helping to create the next generation of insect scientists. Harper Adams University's MSc in Entomology has been a longstanding recipient of the funding and this year we congratulate the University of Reading for its MSc by Research Entomology as well.

A call for applications went out earlier this year, and each submission was evaluated on academic quality, impact, equity, diversity, inclusion, and institutional commitment. The awarded bursaries will allow these institutions to continue enhancing student engagement with insect science.

The Society will continue to keep its members updated on how these funds are helping to shape the future of postgraduate entomology and the contributions these students make to the field.

For more information, visit the websites www.royensoc.co.uk/awards.

Outreach

Insect Week 2024

Francisca Sconce
Senior Outreach and Learning Officer

Insect Week returned from 24th to 28th June with a range of activities about insects and entomology from RES supporters and partners. As a flagship activity, RES returned to the Big Bang Fair with an interactive stand at the National Exhibition Centre, Birmingham. Activities for the audience of around 20,000 10–13-year-olds and 2,500 teachers aimed to spark conversations about insects and demonstrate insects of economic importance. The stand was supported by Harper Adams University, which funded student ambassadors and academic staff to attend each day, as well as providing aphids and parasitoid wasps for inspection under the RES microscopes. Koppert Biological Systems donated a *Bombus terrestris audax* show hive. RES members volunteered on the stand and shared their varied experiences with the young people.

Entomologists and horticulturalists at RHS Wisley ran daily insect talks as well as opening a moth light trap each morning at their Wildlife Garden and World Food Garden. Ashleigh Whiffin and colleagues from National Museums Scotland contributed multiple events across their sites, including collection tours at the National Museums Collection Centre, a panel event at the National Museum of Scotland and moth trapping events at the National Museum of Flight. The Amateur Entomologists' Society and the British Entomological and Natural History Society (BENHS) collaborated for a day of entomology at Dinton Pastures Country Park, with tours of the BENHS collection and fieldwork in the park, preceded by a moth trapping session with the Berkshire Moth Group.

Composer and musician Karen Wimhurst promoted her music album *JUMP*, starting a UK tour of public performances and workshops about how insects make and hear sound. Created with Peter Smithers and bio-acoustician Charlie Woodrow, the album features nine animals, including crickets and grasshoppers. Singer-songwriter and Zoology graduate Liana Flores shared her debut album *Flower of the Soul* with feature track *Butterflies*. In '60s Brazilian pop style, the track is about "the between-ness when one phase of life ends and another begins". String Theatre and Puppet Barge produced *Insect Circus*, with marionettes based on the world of insects. Special school performances were accompanied by workshops about insects, funded by an Arts Council England Grant, supported by the RES.

Victoria Burton from the National Education Nature Park ran a webinar for teachers about how to monitor which types of insect are visiting school grounds and which plants are supporting them. Francisca Sconce collaborated with STEM Learning London for an online quiz about insects for 180 Key Stage 2 students from schools across London.

Insect Week returns from 23rd to 29th June 2025. Find out more at insectweek.org.

Obituary

Jeremy McNeil

November 20th 1944 – July 18th 2024

By Walter S. Leal
Distinguished Professor, University of California-Davis

Internationally known entomologist Jeremy Nichol McNeil, who died on July 18th, 2024, in London, Ontario, at age 79, was an incredible scholar, a professor, a photographer, a president, a researcher, a mentor, an author, and an ambassador who never met an insect he didn't like nor a crowd he couldn't reach.

A distinguished professor at the University of Western Ontario, his alma mater, Jeremy epitomised the motto, "Be Inspired, Be Brilliant, Be You" and inspired others to "Be Brilliant" and "Be You." And to be bold.

Jeremy was born on Nov. 20th, 1944, in Tonbridge, England. The following year, his family moved to Newfoundland, Canada, where he spent a happy childhood in Corner Brook, a city on the island's west coast. Jeremy returned to England and attended Lancing College, a senior high school in West Sussex with the motto "Be Inspired, Be Brilliant, Be You." He returned to Canada for his undergraduate studies at the University of Western Ontario, where he received a bachelor's degree in zoology, with honours, in 1969. In 1972, North Carolina State University (NC State) awarded him a doctorate in entomology and ecology.

Dr Fred Gould, the NC State William Neal Reynolds Professor of Agriculture and a member of the National Academy of Sciences (NAS), recalled that when he arrived at NC State in 1977, "Jeremy was already a legend for his creative thinking and his ability to test his hypotheses with complex experimental designs. One that stood out to me was testing for three-way interactions that determined diapause in two hyperparasitoid species. It boggles my mind to think of the juggling act he developed to pull this off. There was great synergism between his creative mind and his unflagging perseverance. His enthusiasm rubbed off on the rest of us at NC State."

Jeremy N. McNeil – the entomologist of 500 t-shirts. (Photo credit: Shelley Yeo, London, Ontario, Canada)

Soon after graduating from NC State and receiving the Entomological Society of America's Gast Memorial Award for the best paper by a graduate student and the ESA's Outstanding Graduate Award (now named the John H. Comstock Award), Jeremy accepted a tenure-track position at Laval University, where he advanced to associate professor in 1977 and full professor in 1982. After three decades at Laval, he left for a Humboldt Fellowship at Hamburg University, where he worked with legendary chemical ecologist Professor Wittko Francke (1940–2020). They shared an appreciation for wine and an unwavering support for chemical ecology, which may have catalysed their life-long friendship. Upon returning to Canada, Jeremy accepted a full professorship at the University of Western Ontario, where he remained until his passing.

Jeremy was one of a kind. "Jeremy liked an argument, a joke, and a new hypothesis or perhaps more astutely, the testing thereof," said Cardiff University Professor John Pickett, former President of the Royal Entomological Society

Jeremy N. McNeil – the entomologist behind the lens (most of the time).
(Photo credit: Paulo Zarbin, Curitiba, Parana, Brazil)

(RES, 2014–2016), Fellow of the Royal Society and a NAS International Member. "We didn't always see eye to eye by any means, but our friendship did not just endure through such interaction but thrived on these exchanges."

Known fondly as "The Bug Man," Jeremy treasured his 500 insect-themed t-shirts. He always wore one when speaking at or attending national and international conferences. "Jeremy went to Canada with his hippy long hair and t-shirts, but won over his colleagues, university administrators, as they came to respect his research and scholarship," said Cornell University Professor Emeritus Dr Wendell Roelofs, a NAS member and a 1982 recipient of the National Medal of Science. Indeed, his wide array of t-shirts served him well, except on one occasion: a dress code prevented him from wearing his favourite attire at an event in Gothenburg, Sweden. He borrowed a dinner jacket from a colleague, Emeritus Professor Dr Staffan Lindgren, University of Northern British Columbia.

Jeremy's recent research focused on the True Armyworm, *Mythimna unipuncta* (Lepidoptera: Noctuidae), a migrant species in North America that responds to environmental cues such as temperature and day length that are associated with predictable seasonal habitat deterioration. He also compared migratory North American and non-migratory populations from the Azores and Hawaii. His studies explored various aspects of migratory behaviour, including the impact of atmospheric pressure, the role of mating and sperm precedence, and the effect of climate change on reproductive success.

Additionally, Jeremy examined the morphology and physiology of moths under different field conditions to understand traits that reduce migration costs. He used stable isotope profiles to identify the origin of migrants and investigate host plant use and lipid utilisation *vis-à-vis* seasonal migration. He employed similar methods to determine where the North American native and univoltine Western Bean Cutworm, *Loxagrotis albicosta*, captured in Ontario originated. His project on the Monarch butterfly, *Danaus plexippus*, investigated whether Monarchs use specific chemical cues to locate overwintering sites.

"Using the True Armyworm as a model, Jeremy contributed significantly to our understanding of regulating lepidopteran reproductive physiology and behavior," said University of Washington Professor Emerita Dr Lynn Riddford, NAS Member and Honorary FRES. "One intriguing finding was that a non-migratory population of these moths matured earlier than a migratory one due to an earlier onset of juvenile hormone biosynthesis. However, the reason for this difference is still unclear."

The professor's research (cited more than 8,000 times) advanced our understanding of chemical cues (=semiochemicals) mediating plant–insect and host–parasitoid interactions and the reproductive strategies of insects that migrate in response to predictable or unpredictable habitat changes. Said Ohio State University Professor Emeritus Dr David Denlinger, Honorary FRES and NAS member: "Jeremy is probably best known for his work in chemical ecology, but his research has impacted numerous additional aspects of entomology. His early work on insect diapause is still one of the best and earliest pieces of evidence showing the impact of plant host quality on an insect's decision to enter diapause."

Jeremy trained 66 graduate students and 12 postdoctoral scholars. University of Western Ontario alumna Dr Joanna Konopka (currently a postdoctoral scholar at Johns Hopkins) remembers him as "the most wonderful mentor and supervisor to his students who took great pride in the success of his trainees. Jeremy gave me the academic and scientific freedom to follow the research directions that were most interesting to me while providing invaluable feedback and advice every step of the way. The chemical ecology training I obtained with Jeremy has been invaluable. I hope I can continue to honour him by doing rigorous science and always asking and considering broader questions in the context of insect biology and ecology."

"Professor Jeremy McNeil," she concluded, "was not only an excellent entomologist and ecologist, but an extremely generous and kind person

Jeremy N. McNeil – a passionate photographer.
(Photo credit: Jocelyn Millar, Riverside, California, USA)

dedicated to serving his scientific, academic, and local communities."

Professor McNeil taught chemical ecology, integrated pest management, insect behaviour, scientific communication, and island biogeography courses at Cornell University, Université de Rennes, University of the Azores, University of Chile, Neuchatel University, University of Geneva, Federal University of Parana (Brazil), University of Viçosa (Brazil), and Universidad de la República (Uruguay).

He delivered insect presentations to children at primary and secondary schools in China, Europe, Austria and North America for more than three decades. His outreach activities included regular appearances on local and national radio and television shows. He served as the scientific expert in the French version of the one-hour documentary *The Secret Lives of Butterflies*, and participated in a six-segment series *Survive*. He appeared in the TV series *Infestations*, and the documentary *Phantom Signals*. He worked with the Let's Talk Science organisation to produce a printed and electronic version of an entomology book for preschool students.

Jeremy published 210 papers in the *Proceedings of the National Academy of Sciences* (PNAS), *Physiological Entomology, Ecological Entomology, Journal of Chemical Ecology, Science* and many other prestigious journals. However, he said he was most proud of his children's book, *What Is an Insect?* It's read all over the world and translated into many languages (=Qu'est-ce qu'un insecte?, ¿Qué es un insecto?, O que é um inseto?).

A widely sought and strong leader, Jeremy served as president of the International Society of Chemical Ecology (ISCE) in 1994, the Entomological Society of Canada (1989), the Entomological Society of Quebec (1978), and the Entomological Society of Ontario (2013). He served as the International Secretary of the Royal Society of Canada (2010–2017) and then as its president (2019-2022). He created and served as co-chair (2016–2022) of the InterAmerican Network of Academies of Science.

"Jeremy served with vigour and distinction in those roles and leveraged them for high-level leadership both in this hemisphere and globally," said University of Arizona Regents Professor and Honorary FRES Dr John Hildebrand, NAS International Secretary since 2014. "As co-chair of the InterAmerican Network of Academies of Sciences (IANAS), he energised the organisation and especially its vital programs on Water for the Americas and Women for Science. On the global stage, he was a powerful voice in the annual deliberations on science for policy for the G7 and G20 Summits and projects of the InterAcademy Partnership (the network of ca. 150 national academies of sciences and medicine). In all of his roles, Jeremy was a strong, most earnest and productive contributor to collaboration on pressing issues facing humanity. He was universally respected and will be universally missed."

Among his many honours, Jeremy was elected Fellow of the Entomological Society of Canada (1987), the Royal Society of Canada (1999), the Entomological Society of America (2015), and Honorary Fellow of the Royal Entomological Society (2019). He received the ISCE Silver Medal in 2004 and was elected a Corresponding Member of the Brazilian Academy of Sciences (2018). He was awarded the Fry Medal from the Canadian Society of Zoologists (2008), the Gold Medal from the Entomological Society of Canada (1987), the Distinguished University Professor (2014) and the Hellmuth Award (2020) from the University of Western Ontario, and Outstanding Alumnus (2011) from NC State.

Jeremy was one of the pillars of ISCE. He regularly attended ISCE annual meetings. Ironically, he passed on the day of the latest meeting in Prague, the only annual meeting he missed in recent years.

"In order to be irreplaceable, one must always be different," mused Gabrielle Bonheur "Coco" Chanel (1883–1971), a French fashion designer and businesswoman.

Jeremy Nichol McNeil was a *sui generis* entomologist; an eloquent and charismatic speaker; an entomology and chemical ecology ambassador; a passionate, enthusiastic and dedicated educator; and a dear friend.

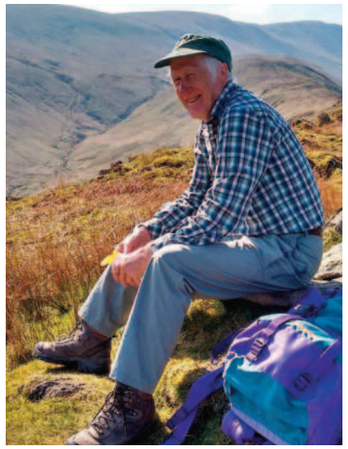
And, irreplaceable.

Obituary

Prof. John Brian Whittaker (1939–2024)

(Vice-President 2007–2008)

By Ian Hodkinson



Many of us were saddened to hear of the death of John Whittaker in September this year. John was born in Rossendale, in industrial East Lancashire, on 26th July 1939 and was proud of his roots. He attended Bacup and Rawtenstall Grammar School from where he was admitted to the Department of Zoology at Durham University, graduating in 1960 with a BSc (Honours, 1st Class) in Zoology. His love of the outdoors was already apparent when as an undergraduate he led a small expedition to Iceland to examine zonation of animal communities around the icecap. This study formed the subject of a talk given at his old school in 1961, as reported in the school magazine *The Squirrel*. Mr Whittaker was "received with great enthusiasm – despite technical imperfections of the projector"! He was by then a research student in his old undergraduate department where he came under the influence of his doctoral supervisors Prof. Jim Cragg and John Coulson. Cragg had already established a research group to study the ecology of moorland animals, at sites on the Moor House National Nature Reserve in the northern Pennines. John's investigation of *Auchenorrhyncha of Pennine Moorland with Special Reference to the Cercopidae* gave title to his doctorate, awarded in 1963. John was one of a vintage cohort of Durham research students who became household names in British ecology and included Bill Heal (Protozoa), Malcolm Cherrett (spiders), Bill Block (mites) and Bill Hale (Collembola). His work on the population dynamics of the spittlebugs *Neophilaenus lineatus* and *Philaenus spumarius,* convinced him of the importance of gathering long-term data sets, and he continued regular population sampling for 30 years, later adding the Heather Psyllid, *Strophingia ericae*, to the species regularly sampled.

A period followed at the Bureau of Animal Populations, Oxford University, where John was recruited as a scientific officer by Charles Elton. There he experienced the contrasting insect environments at Wytham Wood, where his spittlebug work continued. His move, to take up a lectureship in the Department of Biological Sciences at the recently established Lancaster University in October 1966, created the platform for his subsequent work. One of his first initiatives there was to purchase the extensive insect collections of the bankrupt Manchester biological suppliers Flatters and Garnett. He soon became involved in the International Biological Programme Tundra Biome project at Moor House that compared biological productivity at sites around the northern hemisphere. I was employed by John to work there on the Heather Psyllid.

In 1973 John visited us at the Environmental Sciences Centre (University of Calgary) and fell in love with the Canadian Rockies. Subsequently he made several visits, working on Collembola and litter decomposition in aspen woodland with Sue Visser and Dennis Parkinson. His early detailed work on plant–insect–predator interactions at Lancaster, involving the effects of insects feeding on dock (*Rumex obtusifolius*) and the impacts of Wood Ant (*Formica rufa*) predation on caterpillars feeding on oak, provided further model insect-plant systems that he was able to manipulate experimentally in later work. Much of his subsequent research involved collaborations with departmental colleagues of complementary expertise, including Terry Mansfield and Peter Lea. Several important papers flowed from the joint work. These reported initially on the impacts of the gaseous pollutants NO_x and SO_2 on his model insect–plant systems but soon expanded into global climatic influences, including CO_2 and UV radiation, funded through projects such as the NERC TIGER initiative. We should also not forget John's research students: 25 PhD and several Master's students benefitted from his wise and considerate counsel.

John was awarded his higher doctorate in 1986, a personal chair in Ecology at Lancaster in 1987 and served twice as Head of Department (1983–1986 and 1991–1994). He was President of the British Ecological Society in 2001–2003. John's outstanding service to Lancaster University was recognised by an Emeritus Professorship (2004) and an Honorary Fellowship (2006).

Following his retirement in 2004 John actively pursued his lifetime passions outside biology. He was a keen researcher and collector of fine antique furniture by Gillows of Lancaster. As a lifelong hillwalker he regularly undertook, despite advancing years, strenuous hikes and scrambles over the peaks and ridges of the Lakeland fells. Lately, he achieved his lifetime ambition to write a published detective story. His novel *No Pic-Nic in Cumbria* was published in late 2022. Inevitably the story involves hidden secrets in a Gillows' writing desk. John will be sorely missed as a mentor, friend, raconteur and one of life's true gentlemen.

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).

March 2025

Sat 1 — 1 March — **Young Verrall Lecture 2025**

Wed 5 — 5 March — **Verrall Lecture 2025**

Mon 31 — 31 March–1 April — **RES Student Forum**

June 2025

Mon 23 — 23–29 June — **Insect Week 2025**

September 2025

Tue 9 — 9–11 September — **Ento25**

October 2025

Tue 9 — 13–17 October — **XII International Symposium on Aphids** **(external event)**

For full details on all RES meetings please visit

www.royensoc.co.uk/events

Royal Entomological Society

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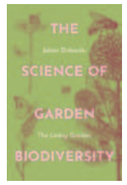

The Science of Garden Biodiversity
Julian Doberski
Published by Pimpernel Press
ISBN 978-1-914902-09-3 (paperback)
Reviewed by Dr C.M. Collins

The Good Bug
George McGavin
Published by Michael O'Mara Books Limited
ISBN 978-1-78929-669-3 (hardback)
ISBN 978-1-78929-671-6 (ebook)
Reviewed by Richard Harrington

Insects: Discover the Science and Secrets Behind the World of Insects
Edited for the Royal Entomological Society
by Emilie Aimé, Jane K. Hill, Helen Roy and Allan Watt
Published by Dorling Kindersley, Penguin Random House
ISBN: ISBN: 978-0-2416-8592-1
Reviewed by Stuart Reynolds

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