Bulletin of the Royal Entomological Society Volume 44 (3) 2020

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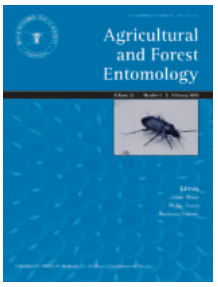

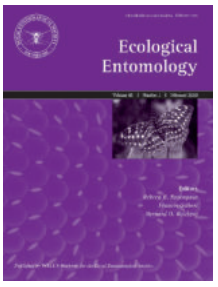

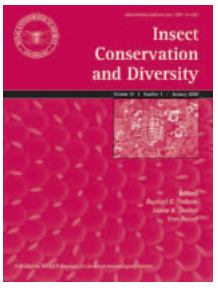

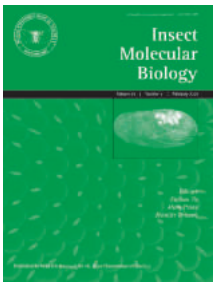

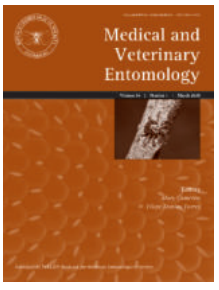

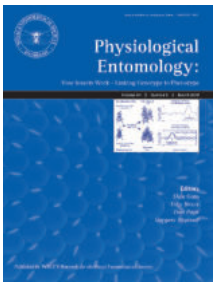

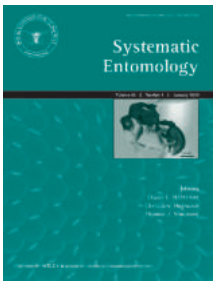

Publications of the Royal Entomological Society

Agricultural and Forest Entomology provides a multi-disciplinary and international forum in which researchers can present their work on all aspects of agricultural and forest entomology to other researchers, policy makers and professionals. RES Members: print £98, online £49
2020 print or online prices: UK £982, Euroland €1,251, USA $1,816, Rest of World $2,114
2020 print and online prices: UK £1,229, Euroland €1,564, USA $2,271, Rest of World $2,643

Ecological Entomology publishes top-quality original research on the ecology of terrestrial and aquatic insects and related invertebrate taxa. Our aim is to publish papers that will be of considerable interest to the wide community of ecologists. RES Members: print £163, online £81
2020 print or online prices: (with Insect Conservation and Diversity) UK £1,628, Euroland € 2,073, USA $3,017, Rest of World $3,518
2020 print and online prices: UK £2,035, Euroland € 2,592, USA $3,772, Rest of World $4,397

Insect Conservation and Diversity explicitly associates the two concepts of insect diversity and insect conservation for the benefit of invertebrate conservation. The journal places an emphasis on wild arthropods and specific relations between arthropod conservation and diversity.
RES Members: print £100, online £50
2020 print or online prices: UK £996, Euroland €1,268, USA $1,840, Rest of World $2,142
2020 print and online prices: UK £1,246, Euroland €1,585, USA $2,299, Rest of World $2,678

Insect Molecular Biology is dedicated to providing researchers with the opportunity to publish high quality original research on topics broadly related to insect molecular biology. *IMB* is particularly interested in publishing research in insect genomics/genes and proteomics/proteins.
RES Members: print £161, online £80
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2020 print and online prices: UK £2,010, Euroland € 2,553, USA $3,715, Rest of World $4,330

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RES Members: print £153, online £76
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Subscription and correspondence concerning back numbers, off-prints and advertising for the seven principal journals of the Society should be sent to the publishers, John Wiley & Sons Ltd, 9600 Garsington Road, Oxford OX4 2DQ. (cs-journals@wiley.com)

Antenna (Bulletin of the Society). Free to Members/Fellows. Published quarterly at an annual subscription rate of £60 (Europe), £65 (outside Europe). This journal contains entomological news, comments, reports, reviews and notice of forthcoming meetings and other events. While emphasising the Society's affairs, *Antenna* aims at providing entomologists in general with a forum for their views and news of current trends in entomology. Subscriptions and advertising enquiries should be sent to the Business Manager at The Mansion House, Chiswell Green Lane, Chiswell Green, St Albans, Hertfordshire AL2 3NS and any other enquiries to the Editors (antenna@royensoc.co.uk).

Handbooks for the Identification of British Insects. This series now covers many families of various orders. Each Handbook includes illustrated keys, together with concise morphological, bionomic and distributional information. A full list of Handbooks with order form is available. See website www.royensoc.co.uk

Symposia. Nos 1-3 were published by the Society; Nos 4-10 by Blackwell Scientific Publications; Nos 11-17 by Academic Press; No. 18 by Chapman & Hall; No. 19 by Kluwer; Nos 20, 21, 22 and 23 by CABI.

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Larva of Elephant Hawk-moth, *Deilephila elpenor* (and accessory).
Photo: Andrew Smith

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EDITORIAL

I worry too much. With the postponement of all meetings, I feared that there would be a dearth of copy for this issue, so put out an appeal for articles. What an incredible response! Instead of a thin edition, I was spoilt for choice, and we have enough excellent copy to fill the next two issues – furthermore meetings are restarting, albeit "virtually". So, may I say a huge "thank you" to all who answered the "call to arms", and offer a huge apology to those whose fine contributions have been deferred. Although we are flush with interesting pieces, please keep them coming. All those we like will get published, starting with the most timely.

There are two timely themes to this issue. One, unsurprisingly, is Covid-19. I thought that, for posterity, we should record its impact on entomology, so I have put together an article based on responses from several members to my request for their views as to short, medium and long-term impacts. David Hubble replied in some detail, and his views form an article in its own right. Robyn Manley's article parallels this theme in the insect world by looking at how the behaviour of bees affects their interactions with other organisms and how this, in turn, affects their susceptibility to viral diseases. Roy Bateman describes conservation work in the Cát Tiên National Park, an important lowland tropical forest area in southern Vietnam, including the effect of the virus on funding through tourism.

The other major theme is women in entomology. Our new President introduces herself and reports on an inspiring virtual meeting she held during National Insect Week (NIW) in which five female entomologists told their stories. NIW, incidentally, was a great success, in spite of lockdown, and a full report will appear in the next issue. Did you know that the British Forces employ an entomologist? I didn't. Kelly Martinou's article is a fascinating read. Dare I mention the next article under this theme? John and Anita Hollier report on the work of Swiss Psocoptera taxonomist Charles Lienhard, including his discovery of the gynosome, or female penis, for which he justly won the 2017 Ig Nobel Prize for biology.

The Postgraduate forum snuck in before lockdown and is reported herein, as is a year's worth of meetings of the Southwest Region. The mastermind behind this very active Region is Peter Smithers but, after twenty years in the role of Regional Honorary Secretary, he is stepping down. To celebrate his achievements, I stole his "Honorary Fellow Interviews" slot and turned the tables by interviewing him. We also profile our Student Reps, Max Tercel and Charlie Woodrow.

With so much fine material, the Reviews section is somewhat squeezed and a backlog is developing. To do the reviewers, authors and publishers justice, all future reviews will be published on-line as soon as they are received, and a few will also be selected for *Antenna* as space allows. *Antenna* itself is now available on-line. At the time of writing, editions from 2014 back to 2010 can be accessed by anybody. Go to www.royensoc.co.uk/antenna. Before long, more recent issues will be available to members only.

So, there you have it: the Covid crisis has revealed that there is a myriad of great entomological stories out there deserving of an audience. Please send in yours.

Richard Harrington

Guidelines for submitting photographs

To maintain a high quality we suggest that submissions for *Antenna* be presented via e-mail or on CD. Files must be in a PC-compatible format, preferably in MS Word.

Electronic images can be embedded in the Word document but we will also require separate electronic images. These should be the full size image (.jpg or .tiff) from the camera even after the author has edited the file.

Please do not submit images that have been printed from a computer on a domestic inkjet or laser printer. Even if the camera is a good one and photo-quality paper is used, the graininess is very hard to deal with. If plain paper is used, the prints are virtually unusable.

If an image is intended for the front cover then the photograph should be in ***portrait format*** and again should be the full size image from the camera even after the author has edited the file.

To give an idea as to what happens when the image is not of sufficient size, take a look at these two photographs. One is 300dpi and the other is 72dpi.

300dpi

72dpi

From the President

Helen Roy

Species interactions endlessly fascinate me. I enjoy thinking about the many ways in which species connect with one another through complex and dynamic ecological networks. I am also passionate about the connections between people and nature.

In the summer of 1976, when the temperatures and ladybird numbers soared, I was 6-years-old and utterly captivated by ladybirds – but I also befriended a rat visiting the compost heap so my path to entomology was not without diversions! Ladybirds continue to delight me but so do their parasites and prey. What is not to love about the beautiful braconid wasp *Dinocampus coccinellae* or the tiny phorid flies, *Phalacrotophora* species, that depend on ladybirds as a host for their parasitic way of life? Or the aphids, prey to many ladybirds, that have so many incredible life history stories to tell of their own. The connections among these species and others ensure the functioning of ecosystems, which benefit people and nature. However, as for many insects, it is evident that the distribution patterns of ladybirds are shifting in response to our changing world. Some species are declining and others are increasing. New species are arriving. The assemblages of species, and the interactions amongst them, are quite different from those that I would have observed as a 6-year-old ladybird enthusiast back in 1976.

Long-term and large-scale biodiversity datasets are critical to our understanding of these complex and dynamic ecological patterns. These incredible datasets have relied on contributions from an inspiring community of biological recorders. I have been privileged to collaborate with these volunteers through my work with the Biological Records Centre (part of the UK Centre for Ecology & Hydrology) and as a volunteer myself with the UK Ladybird Survey. I increasingly appreciate the links within species interaction networks but also the inherent links between people and nature. It is critical that we share our knowledge and excitement for entomology as widely as possible to ensure everyone has an understanding of the importance of their connection with nature.

As we face this time of unprecedented environmental change, there are so many big questions to address if we are to make the transformative changes needed to sustain our natural world. There is not just one right answer. The decisions we need to make, to ensure benefits for people and nature, will require us to work together inclusively. Sharing stories about insects is a fantastic place to begin. As I write this, it is the ninth National Insect Week, which includes an amazing programme of virtual activities available to everyone to celebrate the "little things that run the world".

I have gained so much from membership of the Royal Entomological Society: attending the postgraduate forum as a PhD student in the 1990s and many Special Interest Group meetings over the years; publishing in, and reviewing for, the journals; enjoying the excitement of the very first National Insect Week (and seeing the commitment of the Society to outreach and engagement increase year on year); receiving advice and guidance from other Members and Fellows; simply being part of an amazing community of entomologists from around the world – all this and more has been so important to me. I now have the pleasure of becoming President – an incredible honour for me. I get to give a little back to a Society that has encouraged and supported me throughout my career.

I am only the third female President of the Royal Entomological Society. This is perhaps surprising. To begin to address the balance, Professor Chris Thomas, the outgoing President, alongside others in the Society has instigated many exciting initiatives to work towards a more inclusive and open Society. It is critical that we consider equality, diversity and inclusion in everything we do. It is essential that we take action to ensure entomology is welcoming and accessible to everyone. I was honoured to have the opportunity to share reflections with five amazing women in Entomology during a YouTube event in National Insect Week (see pages 101–105 and https://www.youtube.com/watch?v=aJu6fj9xiRU). In the coming months we will be asking you about your ideas and priorities for the Society going forward but would be pleased to receive your thoughts and suggestions at any time. The Grand Challenges project has now also begun and we will be inviting you to take part in collaboratively identifying the most important issues in entomology.

I am looking forward to seeing our community grow; encouraging the next generation of entomologists; working in partnership to develop a vision for our wonderful Society and engaging people in discussions and debates to demonstrate the relevance of insects to us all. I am so excited to have this opportunity to work with you over the coming months and years to ensure that the Royal Entomological Society is a place where everyone can thrive.

Correspondence

Digital *Antenna*

Dear Editors and *Antenna* readership,

As well as being a Fellow of the RES, I am also a member of Butterfly Conservation and receive its 'Butterfly' magazine each quarter. Like many other charities, Butterfly Conservation is experiencing a large financial shortfall due to COVID-19 and, faced with this challenge, it has looked for ways to cut costs. One initiative has been the decision to produce a digital-only issue of 'Butterfly' magazine for most members (https://butterflymagazine.org/), with just a small print run of the magazine being produced to post to those members for whom they do not hold an email address.

This got me thinking about the possible benefits of digital-only issues of *Antenna* being made available to members who would prefer it. This would not only help reduce costs to the RES for the printing and mailing of the journal, but would also have environmental benefits through reducing paper and energy used in its production.

Best regards,

Dr Graham Small

Response

Dear Dr Small,

Many thanks for your interesting suggestion.

Firstly, I am sure that you will be pleased to know that all copies of *Antenna* published within the last 10 years will soon be made freely available online to all RES members. Furthermore, to widen our readership even further and engage the community in entomology, we are allowing the general public free online access to issues published 6-10 years ago.

The feedback we receive from some of our membership suggests that they enjoy having a printed copy of *Antenna* to browse at their leisure and to share with family members and work colleagues. It is, as I am sure you will agree, an attractive publication to own as well as a good read. However, we appreciate that there will also be members who are concerned about the environmental impact of producing and distributing printed copies.

We encourage our membership to express their views and, depending on demand, will explore the possibility of offering them the option of either receiving both a printed copy+digital copy or a digital copy only.

With kind regards,

Prof Mary Cameron

Honorary Editorial Officer RES

antenna on-line

To view the on-line *Antenna* archive, go to www.royensoc.co.uk/antenna. At the time of writing, issues from 2010 to 2014 are available to anybody. More recent issues will soon be available to members only, and instructions on how to view them will be sent by email or by the Society's monthly newsletter.

Sharing stories in entomology

Perpetra Akite

Ecologist at Makerere University; Department of Zoology, Entomology & Fisheries Sciences. Her research is focused on insect biodiversity, conservation, ecosystem services and community ecology, especially in forests and agricultural landscapes.

Esther Ngumbi

Assistant Professor, Entomology Department and African-American Studies Department at University of Illinois, Urbana Champaign. A Kenyan by birth, Esther earned her PhD from Auburn University, Alabama, USA. She is an entomologist (chemical ecologist) and her research over the years has focused on understanding the multifaceted uses of chemical signals by insect herbivores, natural enemies, plants and their associated microorganisms.

Francisca Sconce

Entomologist leading Outreach and Engagement at the Royal Entomological Society, UK

Seirian Sumner

Behavioural ecologist at University College London. She studies social insects to understand their behaviour, ecology, evolution and role in ecosystems. She is especially interested in social wasps, and is working hard to give wasps a PR makeover! As part of these efforts, she co-founded the Big Wasp Survey in 2017 – a citizen science project to engage the public with social wasps in their back yard. She also promotes diversity among researchers in academia through Soapbox Science, which she cofounded in 2011.

Ashleigh Whiffin

Assistant Curator of Entomology at National Museums Scotland, caring for over two million insect specimens. She studied Forensic Science at Derby University and Master's in Entomology at Harper Adams. Her specialism is carrion beetles, and she co-organises the recording of these beetles in the UK.

Helen Roy

Ecologist at the UK Centre for Ecology & Hydrology and President of the Royal Entomological Society.

During National Insect Week 2020, we had the pleasure of meeting with one another to share stories in entomology through a YouTube live panel discussion. The inspiring and enriching insights shared by the panellists speak for themselves.

What inspired you to become an entomologist?

Perpetra: My rural upbringing has played a big part, but my first encounter with a biology text book that my older brothers brought home from school sealed the deal. These books had the coolest photographs of living things that I was able to relate to when we went out. Between the ages of four and seven, I kept pupae that I had retrieved from the garden. Curiously, what looked like some 'dead thing' moved when I touched it, and that was intriguing. Without any formal science, I simply chose to do what first came to my mind. Since they were from the soil, I would rebury them somewhere, and thus I kept these at home in a broken basin filled with soil and checked it almost every day. Lo and behold, early one morning, I had a collection of newly-emerged insects (later discovered to be Emperor moths and hawkmoths). Then I returned them to where they were dug out from, close to some particular trees in the garden. Luckily it was not long before fascinating caterpillars showed up on these trees and curiosity led me to experience seeing these burrow in the soil. During my undergraduate study, when we were asked to suggest project topics, without hesitation, I came up with "Diversity and abundance of butterflies on Makerere Hill" (where the university is situated). From that day onwards my world is an insect world and, yes, Lepidoptera play the biggest part.

Esther: I grew up on the rural Kenyan Coast. My family farmed. We would go to the farm before and after school and during weekends and school holidays. We worked very hard but, year after year, I would watch our hard work go to waste. What insects didn't take away, drought did, and when a few of the crops made it to harvest, stored product insects would be a problem. This had a big influence on me. We were not alone – my community members would also have insect problems. I wanted to pursue a career that would permit me to study these insects, the diseases they spread and discover how we can use knowledge about their behaviour to manipulate insect–plant systems in order to reduce crop losses.

Fran: An undergraduate field course with Simon Leather when he was at Imperial College. We did lots of different types of insect trapping and I was amazed by the abundance and diversity in the traps, even in temperate UK. I was doing

Perpetra: "If you are someone looking to make a difference, you'd better join the entomologists!"

Esther: "Just as insects are so diverse, by the time I finish my career I hope to see so much diversity that, when I attend a meeting, I can say 'look at this rainbow of scientists'."

Fran: "Showing the human side of entomologists is important; we are real people and there is no one size fits all for who can become an insect scientist."

Seirian: "To capture diversity of gender and backgrounds, we need to be having role models up front who are talking about insects."

Ashleigh: "We need to promote entomology by getting out to schools more and reaching as many diverse students as possible."

Helen: "Entomology unites people from around the world. The joy of working together, with shared aspirations, and the benefits this brings to people and nature is immeasurable."

a general biology degree but was inspired to specialise in ecology and then do a Master's in entomology.

Seirian: I have to confess, I hated insects until my early 20s… I actively avoided anything to do with them. But, after my Zoology degree at UCL, I was dead set on doing a PhD on animal behaviour, and wasp behaviour was what happened to be on offer. At the time, my soon-to-be PhD-supervisor, Jeremy Field, told me that these wasps don't sting… I believed him, but he was (of course) lying! I studied the social behaviour of hover wasps, in Malaysia. To be fair to Jeremy, although these wasps DO sting, their stings are a mere tickle. A few months into my PhD, I found myself lying in the undergrowth of a Malaysian rainforest with a wasp nest inches from my face; each wasp was individually marked, and we were following their behaviours, noting their social interactions and working out what made the colony function as a cohesive society. It was a mini soap opera unfolding before my eyes. I had fallen in love with insects. But not any old cute, pretty insect – I had fallen in love with wasps!

Ashleigh: I actually thought I wanted to be a forensic scientist, so was studying for a BSc in forensic science at the University of Derby, when I was introduced to entomology by Prof. Karim Vahed and Dr Kate Barnes. Forensic entomology ignited my fascination with insects and led me to study for a Master's. I wasn't very certain it was going to lead to a career, but meeting countless inspiring entomologists throughout the course made me very determined to try!

What is your most exciting entomological discovery?

Perpetra: Finding the second (and only male) specimen of a grasshopper species O*shwea dubiosa* (one of the least known members of African forest fauna) in Uganda in 2013 – after the only female specimen described back in 1929 from a single holotype female from the DRC. Nearly 100 km apart and 84 years down the road, this little friend turned up in Mabira Forest in Central Uganda. It was first a photograph (currently the only available adequate field photo of the species) and, after the evening review of the day's shots, my mentor and supervisor gave a big gasp and said "what the hell have you got there?". The next day we set out back to the site with the task finding this mystery fellow. After nearly two hours of searching with no success, my supervisor suggested we abort the search and enjoy the photo. Less than two minutes later, I saw something and simply went for it just in case. When he confirmed it, I was completely ecstatic!

Esther: The discovery that what we see above ground, is sometimes controlled by microorganisms that live below ground. At Auburn University, my research was on how beneficial soil microbes, such as plant growth-promoting rhizobacteria, influence plant health. We discovered that some beneficial bacteria make plants less attractive to insects, while others boost productivity or help plants withstand drought. Three US patents for beneficial soil products emerged from this work.

Fran: Not a discovery as such, but on a field course in Kibale Forest, Uganda, I got to see *Heliocopris* sp. dung beetles flying. These can be over 5 cm in length and specialise on elephant dung. Before the field course, I had been lucky enough to re-curate *Heliocopris* specimens in the Coleoptera collection at the Natural History Museum in London, a rather smelly process! To see them live, and squeaking in my hand, was very exciting.

Seirian educating people about wasps.

Seirian: It's more of a sociological 'discovery', but I've found that with a little bit of education about the importance of the lesser-loved insects (like wasps!) in the environment and how we benefit from the jobs they do, even the most sceptical members of the public can be persuaded to look more favourably on the most maligned of insects. I spend a lot of my time evangelising about reasons to appreciate and admire wasps, specifically the social wasps. The most common response is: "What's the point of wasps? They just bother you at picnics!". Once people hear that wasps perform really important ecosystem services such as population regulators (of other insects!), pollinators, decomposers and even seed dispersers; that the venom of wasps is a complex biochemical soup with potential for killing cancer cells; that wasp larvae are a highly nutritious source of protein and essential amino acids and minerals; that we may have wasps to thank for the origin of paper-making in human societies (I could go on…), this is usually enough for even the most vespa-phobic of citizens to concede that perhaps we should look a little more kindly on our (sometimes) stripy and (sometimes) stingy insect friends.

Ashleigh: Every time I find a species I've not seen before, whether it's during fieldwork or just out on a walk, it feels like a mini personal discovery and fills me with excitement. Working with collections I'm also lucky that I get to travel the world, observing some of the incredible insect

Ashleigh engaging the next generation with entomology.
© Ruth Armstrong Photography

Esther in the lab.

Ashleigh on fieldwork in Cazorla Natural Park Spain
© NMS

biodiversity, without even leaving our cupboards. Parts of the collection have not been worked on at all, and sometimes when curating the collection I come across things we didn't previously know we had. Finding a carrion beetle, *Oxelytrum erythrurum* (Silphidae) collected by Charles Darwin has been one of my favourites.

What is unique to you about studying insects?

Perpetra: The fact that you could find something new any day, any time. Uganda is rich in terms of biodiversity, and most of the insect groups have never been studied. The vast array of habitats, from my backyard or a small village path, to the deepest impenetrable forests in Bwindi, or the high-altitude snow-capped Mt Rwenzori, or the Sango bay-Minziro landscape straddling the Uganda-Tanzania border, and more, leave me insect-awestruck.

Esther: I am fascinated by how insects find their host plants, potential mates and how natural enemies of insects are able to find their insect hosts. As a chemical ecologist, I am always curious – wanting to understand the chemical signals (both volatile and non-volatile) that play central roles in almost every possible interaction in multitrophic communities. Through volatiles and volatile signalling, plants, insects, and the complex network of microorganisms with which they associate, can advertise their physiological and ecological states. Importantly, these signals can broadcast the presence of insect pests and abiotic stressors such as drought, which are among the most serious constraints to crop production and food security worldwide. These complex chemical-mediated communications are still poorly understood but, once we decipher them, they could provide novel opportunities to manipulate them to promote crop yields and food security.

Fran: Working at the Royal Entomological Society, I get the chance to meet lots of members at our events. I am fascinated by what drives them in their work and how they came to be entomologists.

Seirian: Wasps in general are very understudied relative to other insect groups, such as bees, beetles and butterflies. Yet, there are more species of wasp in the world than bees, butterflies and possibly even beetles. Social wasps are a small subset of wasps (with around 1,000 species), but they are incredibly diverse in the forms of social complexity they display. In the UK, the only social wasps we have are vespines, which all live in highly complex societies, similar to the honeybee. In more tropical regions, the polistine wasps display the full range of sociality. Most importantly, there are hundreds of polistine wasps that represent the different stages of social evolution between the simplest and most complex societies. These species provide snapshots in evolutionary time, across the major transition from solitary to social living; this is unique with the exception of bees (which, as everyone knows, are just wasps that have forgotten how to hunt). This is what fascinates me about social wasps, and this is why the species I study take me to exotic parts of the world such as Panama, Trinidad, Brazil, Zambia and Malaysia.

Ashleigh: In my organisation I'm one of only two staff working within entomology, but we host between 100 and 150 visitors each year. This is a wonderful part of the job, meeting such a broad range of people sharing similar passions, but each with unique entomological experiences – I find I learn a lot from our visitors.

Encouraging the next generation.

What are your aspirations for entomology in the future?

Perpetra: I would wish to encourage all Ugandans to be insect citizen scientists irrespective of their circumstances. Having all insects recorded, building great insect collections that are well curated, and setting live exhibition centres where everyone and anyone can appreciate the little things that basically run the world is my biggest dream. Also very important to me, is finding the female of the grasshopper species from Mabira. In view of the rarity of the taxon (two specimens in nearly 100 years), I surely must dream! I also want to reduce the gender gap in the study of biology and more specifically entomology generally. Only a few women dare to go beyond the BSc and even when they choose to do the MSc, it's often to protect the job but not out of passion for the subject. Also, they tend to avoid studying insects, especially those that have scary larval stages like Lepidoptera, Coleoptera etc. So, if I can bring some women out of their "fear of biology/insects cocoons", I will have set the pace for the future generations.

Esther: The desire to eradicate hunger and food insecurity, one of the most important global sustainability issues of our times, affecting close to 1 billion people, that is caused by insect pests and drought, will be the driving force in my academic career. I will never tire. With a fresh attitude, a very curious and open mind, I will keep coming to the lab to achieve this goal.

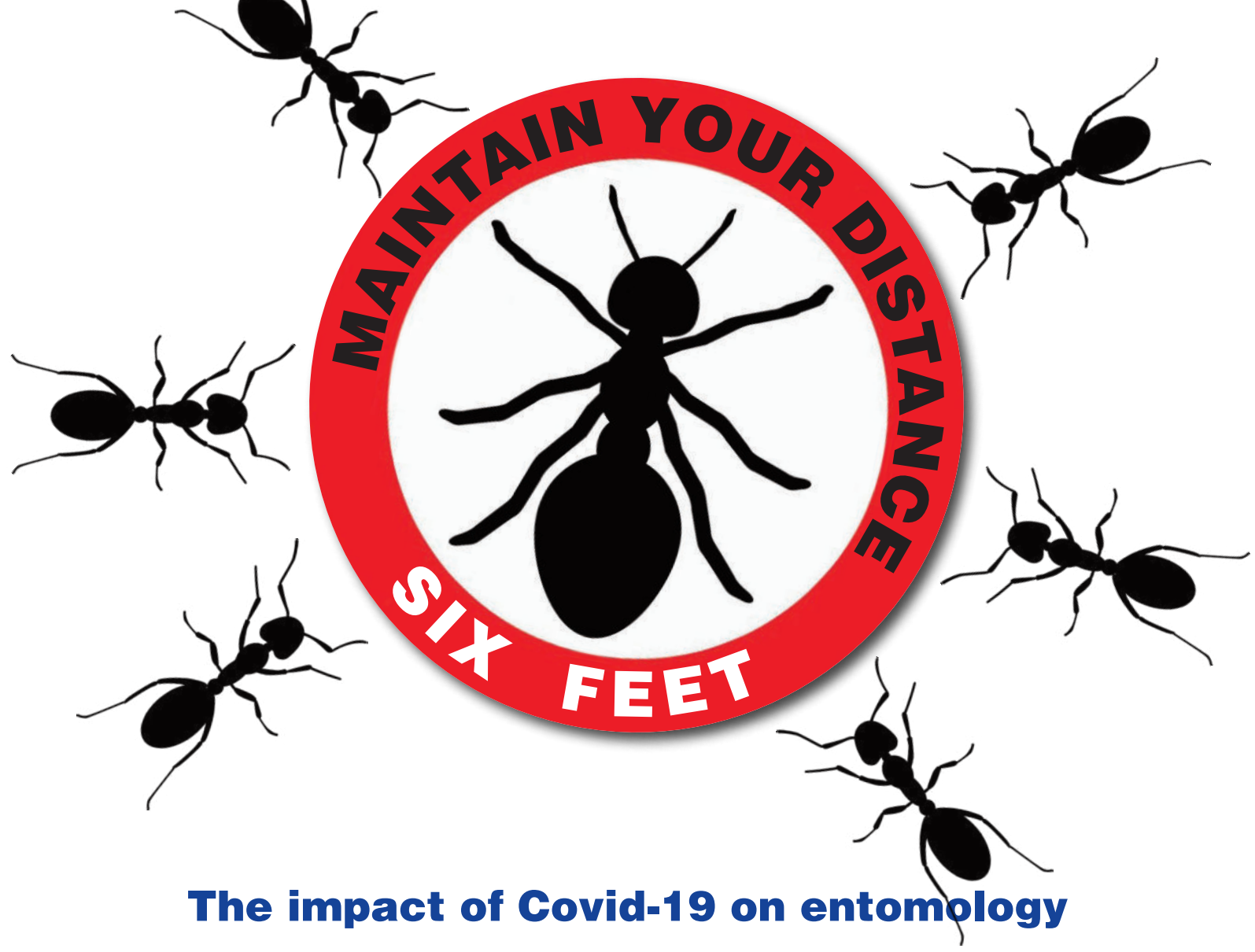
Fran: Raising awareness of the discipline as a study pathway and career, particularly when we need more sustainable pest control of insects that affect humans and plants. I also hope that more people, whoever they are, take time to create beneficial habitats for insects, be it a window box or a whole garden. Lastly, I would like to get around to publishing the papers from my own postgraduate research on Collembola (sorry Simon!).

Seirian: When I started out in entomology as a PhD student, I found it hard to relate to the entomology community: the insect conferences and meetings I went to tended to be dominated by old(ish), white (no 'ish' about that) men. They were (and still are) very lovely people, and incredibly knowledgeable! But…they didn't look like me. It put me off: I instead found my niche in the social insect and evolutionary scientific community, where there were a few people with whom I could identify. In fact, the wasp research community appears to have always attracted a lot of brilliant women – have you read the works of Joy Spocznska (1970s) or Elizabeth Peckham (1900s), and more recently Mary Jane West-Eberhard, Joan Strassman and Rita Cervo? All of them are heroines in my eyes. It is only now, as an established entomologist, that I have become brave enough to poke my nose into the entomological community again. And I realise what I've been missing! So many talented and delightful people, with incredible knowledge: I am humbled and regret the lost years of not being part of this. I would love to see a future for entomology which is more diverse and inclusive. It's clear that entomology as a discipline is brimming with diversity, we just have to open our eyes and look for it. Entomologists should be good at this: after all, we're all obsessed with looking for (and promoting) things that are difficult to spot.

Ashleigh: I hope I can continue to grow and improve my skills as an entomologist and curator. I'm itching to conduct fieldwork outside Europe and it looks like 2021 will be the year for that (fingers crossed)! I also hope that I can be a good role model for future generations, and provide encouragement and support, as my mentors have for me. I want to help make entomology more inclusive and show future generations that entomology is a field for them… entomology is for everyone.

You can see the panel discussion at

https://www.youtube.com/watch?v=aJu6fj9xiRU



The impact of Covid-19 on entomology

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Acknowledgements

The *Antenna* Editors invited RES members to comment on how the Covid-19 pandemic has affected entomological research and practice in the short term, and what the longer-term impacts might be. We are very grateful to the following, who responded to the call: Richard Comont, Michelle Fountain, Scott Hayward, Dave Hubble, Chris Jones, Ashley Lyons, Kelly Martinou, Lisa Reimer, Dick Shaw, Chris Shortall, Max Tercel, Chris Thomas and Steve Torr. It is their views that are synthesised below.

Biological recording

Unsurprisingly, the impacts of the virus pandemic were mostly considered to be negative, but let's start with some potentially good news. There is no doubt that the lockdown has stimulated an increased appreciation of nature, in those with time on their hands and in parents and teachers looking for ways to teach biology to children at home. Supported by pictures and videos posted by entomologists on social media, television and radio programmes, newspaper and magazine articles, often generated by nature-based membership organisations, people have used their spare time to develop an increased awareness of the wildlife, including insects, in their garden and neighbourhood. National Insect Week will doubtless reinforce this drive. Richard Comont (Bumblebee Conservation Trust), being unable to travel as far afield as usual, has found new species to his county sharing his postcode. Richard points out that hanging on to potential citizen scientists is not going to be easy, as there is a danger that the new sparks of interest will fizzle out before the 2021 field season. Dave Hubble (Open University) has written at more length on all of this, and we have published his article in its entirety following this one.

The other potentially good news is that wildlife might have fared better as a result of lower levels of human activity and concomitant lower pollution levels. This will be hard to prove, as there always has been considerable year to year variability in abundance of any given species, and this spring was exceptionally warm and dry, resulting in increased apparency of many insects, which is difficult to distinguish from increased abundance. If reduction in human activity does result in increased insect abundance, this will only be sustained if new habits developed during the pandemic are maintained thereafter.

Those involved in outreach have had to reinvent themselves following thwarted plans to run field days, "bioblitzes", workshops and courses. In some cases, on-line sessions have been organised, but these are generally deemed to be a poor substitute for field sessions with face to face training.

Many long-term datasets face gaps as a result of people being unable to take part in their usual data-gathering activities. This also happened in 2001 as a result of the foot-and-mouth outbreak. As our previous President, Chris Thomas, says: "such breaks lose more information than the (partially) missing year because it is the change between years that is often important, for example if we wish to address the causes of insect declines". In one way, it is unfortunate that the weather was so exceptionally warm and dry during the lockdown period, as it may be a season of particular relevance to climate change studies. Some have struggled on against the odds. My former colleagues from the Rothamsted Insect Survey have taken microscopes home, had suction-trap samples redirected and have managed to continue to produce weekly aphid bulletins, albeit with a few sites missing because the trap operators have been unable to travel.

Applied entomology

The pandemic has had serious implications for Kelly Martinou, an entomologist for the British Army, who is working on surveillance and control of insect vectors of human diseases at the Sovereign Base Areas in Cyprus. Currently working from home, she has had to halt two of her three programmes, compromising the quality of the information she provides to support British Forces around the world. The extent to which she misses her fieldwork and travelling has made her realise how very much she loves her job, as you will see from her article on pages 113–115.

NIAB EMR staff were allowed to travel during the lockdown period if the journey was essential and the phase in the crop development was time critical, e.g. apple blossom. In the early stages of the lockdown, staff visited sites alone. Michelle Fountain (NIAB EMR) says that protection of food resources and critical research into crop protection and production were allowed to go ahead. In some cases, the number of sampling sites was reduced to limit the distances travelled, but more intensive sampling was done at the sites visited, these usually being those nearest to base. In general, all the entomological NIAB EMR studies are running on time with staff socially distancing in the field and working at home wherever possible, e.g. data entry, analyses and writing up.

Sending locusticides to help control this year's terrible outbreaks has proved problematic for CABI, with shipping companies demanding extra payments.

Research programmes

The fortunes of those trying to work at home rather than in the lab have been varied. Some people do not have sufficient access to literature, equipment, space or peace at home to work effectively, whilst others do, especially if work is largely computer-based (and there are no children to be looked after). Most people I have spoken to miss being able to bounce ideas off colleagues or discuss problems in person. Some projects have been put on hold as they cannot be done from home or with social distancing.

Even when researchers have been allowed into their labs, lack of support services has been a problem. For example, Dick Shaw, who works on weed biocontrol for CABI, has found it difficult to get engineers to service equipment such as rearing rooms, quarantine facilities and autoclaves, as a result of many companies putting staff on furlough (surely *the* word of 2020!). Where fieldwork has been permitted, staff have had to travel in separate cars (although Dick points out that at least their cars are hybrids!).

Round Island as Max Tercel is whisked away by helicopter. Copyright Max Tercel

Loss of a season's data is particularly problematic for PhD students, including our very own RES student representative, Max Tercel (Cardiff University). When lockdown started, he was doing fieldwork on Round Island, a small island just north of Mauritius. In order to get back to Britain, he had to wait until a cyclone had blown over and was then evacuated from the island by helicopter. This is a rather dramatic case, but even those wanting, for example, to travel to a nearby potato field to sample aphids, were sometimes unable to do so at a critical time. Similarly, some of the NIAB EMR PhD students have been affected, having to limit or completely avoid visits to farms as part of new farm policies. Fruit growers have been particularly challenged with the extra burden of ensuring that farm staff are protected from external visitors but also acquiring enough staff to maintain plants and pick fruits. For some students, this has meant that normally accommodating growers cannot guarantee staff support for the PhD students setting up trials. In these instances students have elected to do desk-based studies including meta-analyses of already-published literature. All of this, of course, affects entomologists at all stages of their career, not just students. Although students would doubtless prefer to be out earning money on schedule, there are good signs that funding bodies are willing to extend the grants of those thus affected. But will future calls be limited as a result of such extensions? The recession could also hit funders hard, although the Prime Minister sounds determined to increase support for science. Many people have taken the opportunity of research down-time to catch up with reading, writing literature reviews and papers, and data analysis.

Overseas research and extension projects are suffering even more than home-based ones. Lisa Reimer and colleagues (Liverpool School of Tropical Medicine), working on public health issues in developing countries, point out that entomological collections involve entering people's households, so it is important to establish trust, explain research clearly and be visible, particularly in rural areas. Inability to return hence jeopardises the long-term viability of work. Setting up projects takes a lot of investment in time and resources. These will have to be reset before work can resume, assuming that funding doesn't run out. Some objectives have had to be moved from the field (*e.g.* people's homes) to the lab, losing the unique selling point of field-based research. In East Africa, sampling of cattle, and questionnaire surveys of livestock keepers, have been halted. Back home, some of the Liverpool School's researchers have been seconded to Covid research, and equipment requisitioned for virus sample processing, meaning that there is limited capacity to return to lab work. It is not possible to receive samples from overseas due to uncertainties about flights and maintaining a cold chain; the samples are stored in freezers pending resumption of regular flights. All vector-related lab work in the UK (*e.g.* analyses of tsetse and cattle samples for trypanosomes) has been halted.

Scott Hayward (University of Birmingham) is concerned about the future of his Antarctic research programme, as it would be a disaster if the virus reached the remote research station, and precautions will therefore have to be extremely strict. Closer to home, work at the Birmingham Institute of Forest Research Free Air Carbon Enrichment facility has kept going, albeit greatly scaled back, thanks to the fantastic efforts of its technical support team.

Teaching

For lecturers, a huge amount of time has been spent preparing on-line courses to replace conventional teaching in the theatre, lab and field. I can't beat the prose of Ashley Lyons (Liverpool Hope University), so will quote her verbatim: "During the last week of May I lead a Master's module at our field centre in North Wales. It is the first opportunity for the students to collect and identify invertebrate specimens. They set pitfall traps, moth traps, use sweep nets and, for the first time, feel the frustration of their slow human reflexes when trying to catch a hoverfly, followed by the joy of using their complex human brain to outwit one. They sit for hours with their eyes fixed down a microscope before successfully identifying *Abax parallelepipedus*, then burst into hysterical laughter at the magnificent complexity of its name. They won't do these things this year. Or at least I won't get to see them do these things. Classes will be remote and my biggest task will be making sure that the students experience the magic of entomology that got me and so many others addicted to studying invertebrates. No new research specimens will be collected this year, but time to identify the backlog has not materialised so far. Instead, planning for lectures, field trips, alternative assessments and a hundred other administrative tasks has slowed research and will certainly delay publication."

Travel, exchanges and conferences

Physical meetings, visits and scientific exchanges have, of course, come to a complete standstill. The highest profile entomological casualty is the International Congress of Entomology in Helsinki, which was to have been held in July 2020 but has been postponed by a year. Similarly, planned visits of entomologists to other labs have had to be rescheduled, all of which will delay progress with projects and knowledge exchange. On-line platforms have enabled some meetings to take place but most agree that, in general, these are not a good substitute for meeting face to face, or indeed those evening conversations in the bar which stimulate ideas and new collaborations.

Conclusions

Covid-19 has affected almost every aspect of life. Entomology and entomologists have undoubtedly suffered. Some have lost jobs which, barring loss of life or loved ones, is the ultimate tragedy at the individual level. Others have lost data and are relying on funding extension to complete projects. The spread of knowledge has been slowed. Those already well-established are likely to fare better than students and others hoping to start an entomological career. I suspect that more meetings than in the past will take place on-line, many people having become familiar the technology to achieve this. Whilst excellent for our green credentials, there will likely be a gradual return to larger meetings being held in person.

As for the insects, some pests may have gone uncontrolled this year. Some insects may have fared better as a result of reduced human activity. Some which rely on our nature reserves may suffer in the short-term through lack of appropriate management. Longer term, I suspect that the impacts on most species and populations will be undetectable amid the background of the stronger influences we are already aware of – and some we're not.

Broad-bodied chaser *Libellula depressa* recently emerged from the author's pond.

Lockdown entomology – does less lead to more?

David Hubble
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From late March until mid May, we were restricted in the choice of places we could visit to find invertebrates. Some people have gardens, but many do not and access was limited further where public spaces were closed, especially the more species-rich such as parks and reserves. A few had access to areas such as allotments or farms (as with gardens, I count myself among the privileged in this) while others were limited to balconies and window-boxes. At the time of writing, exercise options were being widened to some extent, with driving to other locations being allowed, but many people remained in the same locations, either due to fear of infection or lack of transport.

As I sat in the garden, I wondered whether spending more time in a restricted space led to greater and more active familiarity with it, getting to understand it in detail. I asked myself whether this would, in turn, mean more people engaging with species identification, and whether they'd become new 'citizen scientists'. This felt especially timely given the announcement of the winners of the RES Garden Redesign competition in *Antenna* 44(1), so I decided to look at three threads – my own experience, that of my friends and contacts, and the situation more widely.

The focus here is naturally on insects, but the questions relate to other taxonomic groups, and new identifiers are likely to be generalists, so I stray into the territory of species with greater or fewer than six legs. I am taking a UK-centred approach, but online platforms mean this line blurs at times.

As an entomologist, I'm clearly predisposed to look for insects, and I have access to green space, so my situation is not typical. However, I soon noticed I was spending more time simply watching insects, including common species. With lockdown covering the spring emergence of many species, I was able to see the hairy-footed flower bee *Anthophora plumipes* visiting lungwort, bee-flies *Bombylius major* skimming bare ground, and the re-emergence of brimstone butterflies *Gonepteryx rhamni*. So far, so familiar, however welcome the sight. There were some changes though. With time spare, I put up more drilled blocks to attract the red mason bee *Osmia bicornis*, another spring regular, and the nest tubes on the local community farm showed so much activity that there appeared to be a small swarm. Noticing people hurrying and ducking to avoid them, I put up a sign saying "We Don't Sting" and wrote a short piece for the newsletter. It was devoured. People wanted to know. Since then,

Large red damselfly *Pyrrhosoma nymphula* at the author's pond.

conversations have started about whose pond is generating which Odonata, how many bee species there are and so on. This didn't often happen previously; questions were more often of the 'Is it a pest?' variety and I've spent a lot of time explaining that only a small proportion are problematic to any significant extent. Pragmatically minded suspicion is turning to genuine interest.

Back home, I'd found the cleptoparasitic bee *Nomada marshamella* as in previous years. Checking Falk & Lewington (2015) told me of associations with the bees *Andrena scotica* and probably *A. trimmerana*. The first is commonly recorded in gardens, the second much less so – I've recorded neither, so now I have something to look for. More practically, I've been tasked to find what's causing 'empty bud' in our *Dianthus*. Googling brings up many suggestions, including slugs, moth larvae ('bud worm'), bacteria, viruses, earwigs – the list goes on. So far, there is external feeding damage, but no hole bored near the base. There is frass inside but no culprit, so we are on the lookout for nocturnal visitors, and whatever it is presumably enters and leaves via the bud-tip. The project has been named 'Pinkwatch'. Alongside this, I find myself reading more popular nature-writing, something I do surprisingly rarely as I either go out in the field, or work through more specialist, academic material. I have perused Alys Fowler's *Hidden Nature*, Tove Jansson's *The Summer Book*, Richard Mabey's *Turning The Boat For Home*. With my

Osmia bicornis discovering a nail-hole is a dead end.

horizons narrowed, I am experiencing the natural world vicariously, and friends' Facebook posts suggest I'm not the only one.

It's also the time of year when I start attracting requests for identification, and 2020 is no exception, except there seem to be more than usual, and other known identifiers report the same. I'm not getting the flurry of specimens and photos of flea beetles (Chrysomelidae: Galerucinae: Alticini) I'd expect as no-one is out collecting in the field. Whether that changes with an easing of exercise restrictions is yet to be seen. The usual images of female *Steatoda* (false widow spiders) have appeared on my social media feeds, as well as in Facebook identification groups as people rummage in sheds, possibly with tabloid arachnophobia in mind, although many find them beautiful. However, I've been tagged in many other posts covering a huge range of biota including taxonomically challenging grey mullet in a Southampton marina and even a mystery tropical dropping.

Next, I posted on Facebook asking whether people were more interested in species identification and the response was both wide-ranging and almost overwhelming. Of course, there's a bias here as negative responses are unlikely but, despite this, the level of positive response still surprised me. From complete beginners trying to identify path-side plants and butterflies seen during daily dog-walks and birds seen from windows, to professionals finding ways to continue their interest, wildlife-watching seems to have caught on as people look for variety in their local area, finding something new during over-familiar excursions. Identification guides are being bought or dusted off for regular use, along with apps like Seek and Pl@ntNet. This extends beyond identification to include increased interest in foraging, with reports of nettle soup, cherry blossom and lilac syrup, gorse wine, and elderflower champagne all being produced when time wouldn't otherwise allow. Unsurprisingly, especially given the warm, dry weather, many people are identifying species with children, and enjoying the sense of achievement which is valuable for our well-being. One friend is playing Who's Poo? (sending pictures for identification) with her nephew, while another said, "having a 3-year-old around is a good excuse for classifying... everything". Off at a tangent, another friend is even refreshing his coding skills specifically for a bug-collecting game he's been intending to write, and now is.

Those with existing skills have been finding new ways to use them. For example, 'The dinosaur on your window sill' is a generalist nature-based Facebook group set up by a lecturer who would otherwise be running a field course overseas. It offers the option to share sightings and ask "a question about biology, from ecology to palaeontology, and everything in between". Some are joining identification groups to help improve their knowledge of different taxa with the Twitter presences of the British Arachnological Society, More Than Weeds and Entobarbie (my favourite new online find) all getting cited. Others are using their skills to produce that long-intended garden list (I confess I still haven't done one). At this point, I feel confident concluding that my social circle is taking a more active interest, but is this representative? It's time to cast my sweep-net more widely.

The Natural History Museum (NHM) has found its identification service very busy. That includes fossils, with people sorting through collections, but also a lot of live sightings, and they recently launched a new Facebook identification group for the UK Biodiversity Centre too. The

Plenty of pollen!

Balancing on cherry-blossom.

NHM is also actively encouraging recording of garden species, such as through the City Nature Challenge in late April, which was online and garden-based for obvious reasons, but gathered several hundred more records than in 2019, many of which were invertebrates. A quick look at the NHM's YouTube channel during lockdown tells me "How to make a nature journal so you can record wildlife like a scientist" (NHM, 2020a) as well as interviewing ecologist Stephanie West about how Gilbert White paved the way for future naturalists, not least Charles Darwin. White was "fundamentally fascinated by the natural world and […] the wildlife around him" and "he was interested in ordinary wildlife at home as much as the extraordinary" (NHM, 2020b). Although he was born 300 years ago, these sentiments fit our current situation, watching the wildlife near our homes. Despite having seen *Rafflesia*, olm (*Proteus anguinus*), golden tortoise beetles (genus *Aspidimorpha*) and many other 'extraordinary' species on my travels, it is good to know I retain a sense of wonder as I take the time to watch a damselfly emerge from our suburban garden pond.

There are many other projects, and the demand clearly exists. For example, launched on 22nd March 2020, Chris Packham's Self Isolating Bird Club has proved extremely popular with around 34,000 members by mid-May. Founded in 2012, A Focus on Nature aims to inspire younger people (aged 16-30) interested in nature and conservation. However, in the absence of their usual events programme, they have been putting enormous efforts into online activity and developing species recorders via social media. It is well known that the accuracy of citizen scientist identification data can be suspect (e.g. Fox *et al.*, 2019) but volunteer records underpin much of our national recording effort, and future recorders are essential. We all make misidentifications, and we all have to start somewhere.

Salticus seeking prey.

Online recording sites are encouraging home wildlife watching and other ways to contribute safely. For instance iRecord suggests the UK Pollinator Monitoring Scheme's (PoMS) pollinator counts and the Royal Horticultural Society's (RHS) cellar slug hunt. Meanwhile, iSpot highlights observations needing to be identified and provides links to projects round the world, as well as giving 'Spotlight' status to difficult and less popular taxa such as moth flies (Psychodidae) to generate interest. I don't know how effective it is, but with that project only a week old it is collecting a fair readership, and I'm tempted to dig out my copy of Withers (1989) and try.

Not everything is lively or positive online though. The conservation-based identification groups Natural Cambodia and Natural Laos show less activity as they are reliant on travel. This is important beyond issues of how we spend our time during lockdown; these sites are part of projects monitoring rainforest destruction, which continues regardless of the pandemic and whether anyone is there to bear witness.

At some point the lockdown will end and we will emerge into some form of normality. We'll head back out into the world, but maybe we'll keep at least a little of this increased love of identification. Over time, we'll be able to tell whether this translates into more records being sent to Biological Records Centres, individual scheme and projects, and through portals such as iRecord. Some new recorders may become experienced ones, and get more involved. To some extent, it will depend on wider social factors. Much has been said about the benefits of slowing our lives down (e.g. Frostrup, 2020) and how many people don't want the new normal to be as hectic as the old one. Will we make sure we build in the time to appreciate insects, and nature more widely? Can we be a bit more Gilbert White? I hope so.

Acknowledgements

Thank you to all those who responded to my online call to share their personal experiences – you are my data sources, and a special mention to Steph West for the in-depth information about the NHM's efforts.

Recently emerged broad-bodied chaser *Libellula depressa* with exuvium.

Osmia bicornis entering our bee-hotel.

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Sampling in the Akrotiri salt marshes with British Forces environmental health techs.

Entomology in the British Forces

Kelly Martinou

Dr Kelly Martinou is an applied ecologist/entomologist. She holds a Master's in Applied Entomology and a PhD in Insect Interactions from Imperial College. For her contribution to British Forces, she has received the award of Commander Strategic Command Four Star Commendation as part of Her Majesty the Queen's New Year's Honours List. If you wish to find out more about her job you can contact her at angeliki.martinou100@mod.gov.uk.

As I was waiting for my lift in order to get into the restricted area of the RAF Akrotiri military base for my job interview, I thought to myself "should I return to the 'comfort' of my shared office at the local university in Limassol?". A young corporal arrived, wearing his beret, and escorted me to the large interview hall. He did not talk much but did wish me good luck. When I saw the Operation Captain in his uniform, I had a moment thinking "Kelly, what are you getting yourself into?". His presence was imposing. However, he did give me a warm hand shake and had a smile on his face, which eased the interview. I apparently had the skills and I got the job. That was five years ago and it turns out to have been a great decision so far.

At the time I applied for the job, I didn't know that British Forces had an interest in entomology. I found out later that an Entomology Unit in the past was an integral part of the Department of Preventive Medicine of the Royal Army Medical College at Millbank, London. This Unit's primary tasks were to provide teaching and training in medical entomology, public health and pest control to medical officers and environmental health assistants, as well as insect identification services. The Unit was also responsible for insect conservation of non-target species on Defence lands, which I think is admirable for a unit that was primarily dedicated to medical entomology and pest control. In the 1980s, Dr N.R.H. Burgess*, Senior Lecturer in Entomology and Principal Scientific Officer, provided consultancy services to overseas territories and operations on a variety of entomological issues, such as looking at a locust swarm on Ascension Island, looking at biological control of mosquitoes in Gibraltar and Cyprus, and mosquito-borne diseases in Nepal. The new millennium found the Royal Army Medical College closed and, unfortunately, the role of the Entomologist discontinued. In the 1980s there was also an

entomologist, Mrs Louisa Constantinou, based at the Joint Services Health Unit, British Forces Cyprus, in the Akrotiri headquarters. Louisa was initially employed as a mosquito controller as there was a big mosquito nuisance problem around the wetland of Akrotiri which, until the late 1960s, was also a malaria endemic site. Louisa's love for studying insects was so obvious that she was soon promoted to lab technician. Despite the fact that she did not hold a PhD, she had an inquisitive nature and she was trained to identify mosquito specimens and run a mosquito surveillance programme. Captain R. Lindsay was so impressed by her skills and willingness to advance in insect science that, when Louisa translated information on insects of medical importance and created a notebook, he said: "*it was so difficult translating this document from English to Greek but Mrs Louisa Constantinou, with the help of a dictionary, can conquer the world*". Unfortunately, Louisa died quite young and she was succeeded by Miss Georgia Konstantinidou. I met Miss Konstantinidou briefly while I was working as a post-doc at the local University of Limassol. I remember when she brought me some mosquito specimens for molecular identification, she was full of excitement about her role as an entomologist, the mosquito world and the Akrotiri wetland. I am now the third entomologist employed in Joint Services Health Unit Cyprus and the only one left working for British Forces. My background and experience have enabled me to undertake more research projects in addition to our surveillance and control programmes, and modernise our integrated mosquito management strategy. We currently run surveillance schemes for native and non-native mosquitoes, sand flies and *Culicoides* midges, native and non-native fish biocontrol agents, as well as running programmes to raise awareness regarding mosquitoes, and also the importance of non-target insects. Every year, we host military staff from the Army, Air Force and Navy, who study environmental health, and we train them on mosquito surveillance, identification and control. The forces' environmental health technicians will later go on operations around the world and practice what they have learnt. Other tasks I undertake are vector surveys and identification, and I provide vector management plans around the world for the Joint Services Command.

Overall, it is a very exciting role and, as it is also a unique role, it comes with great responsibility. "*We don't want a lab rat Kelly…*" (it came as a shock when I first heard that phrase, shortly after my interview) "*…go out and communicate what you do with the rest of the world*". Collaboration at all levels has been key to the success and recognition that the Joint Services Health Unit has received in later years. Apart from the army officers, I work with numerous stakeholder groups from ministerial departments in Cyprus and the UK to local stakeholders, municipalities, private land owners, citizens, teachers, academics and NGOs. For a scientist who had spent the greatest amount of my PhD counting aphids, predators and parasitoids in controlled temperature rooms in the basement of Silwood Park, and a great amount of my post-doctoral career counting and identifying many other insects and feeling perfectly content, having to do so much communication and networking was a challenge.

Communication is a strategy very much needed but it can also be very fulfilling. It is up to us to communicate all the fascinating facts about insects and inspire others. There are so many available tools nowadays that assist in approaching the

Sampling for mosquitoes in Japan during the IPBES team-building day.

Working together with Turkish Cypriot colleagues on the citizen science scheme for mosquitoes we run in Cyprus.

general public. My favourite approach is working with small groups of children and senior citizens at the wetland of Akrotiri, in the laboratory and in the field, introducing them to the world of mosquitoes, informing them about invasive mosquito species, and involving them in the monitoring of beneficial insects. Those of us who work in the applied sector, especially in pest or vector control, need to be able to protect non-target insects and inform the public about the need for environmentally-friendly, integrated vector management plans. I see this as our duty and not as an option. I was always a strong advocate of biological control; there are options not only in the agricultural field but also in the public health field, and most of the pests and vector problems that occur are human inflicted, including resistance to chemical pesticides. There were so many publications last year about insect declines, they made me really sad. Countries like the UK hold datasets that span centuries, and have a long tradition in insect recording based on volunteer schemes, and these declining trends were no surprise to them. This is not the case for many parts of the world. Even for protected areas such as wetlands in Europe, we lack a lot of information regarding insect trends and dynamics. We need more entomologists, enthusiastic citizen scientists and more wardens in these areas. The young army environmental health tech professionals, who come to practice in Akrotiri, learn about 'One health' approaches, so that wherever they are in the world they are able to protect human and animal health as well as the environment. Unless public or animal health practices run hand in hand with ecology and policy, the management plan is going to suffer. Up to now it was the natural environment and biodiversity that paid the toll; this year we had COVID-19, where humans paid the toll. COVID-19 is a lesson that we are still learning, showing that we need thoughtfulness towards each other but above all thoughtfulness towards the natural world. Drastic changes in our behaviour and day-to-day lives are needed.

In 2020, it is very encouraging to see major bodies such as the European Commission placing focus on the field of entomology, e.g. with the EU Pollinators Initiative and The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) planning a workshop linking biodiversity and pandemics. This should be the way forward. More intradisciplinary collaboration is needed among entomologists as well; vector ecologists and public health practitioners should work together with insect ecologists and conservationists. Studies on the direct and indirect impacts of management practices are very much needed.

I consider myself very fortunate. I have had the chance to work with some exceptional scientists and professionals from all over Europe. I had two unique mentors. The first was Professor Denis Wright, my MSc and PhD supervisor at Silwood Park. We often need just one person to believe in our skills in order to advance personally and professionally, and reach our limits. Denis did that for me; he opened doors and gave me opportunities. From Denis, I learnt how to be professional and lead by example. Professor Helen Roy was my other mentor. Her passion for the insect world and her graceful approach towards people is so inspiring. I am excited by the collaborative research that we run, including projects funded by the Darwin Plus Initiative and the COST Action network Alien CSI. I am always pleased to welcome a new student to my laboratory, if interested in vector ecology or insect conservation.

As an entomologist, I still most enjoy observing and counting insects. In the case of mosquitoes, I had to compromise … they have to be dead. Sometimes, I wish I had the patience of a taxonomist and the skills of a mathematical modeller, but most of the time I am super-happy just observing and counting. People also make me happy when I see that little excitement in their eyes when they learn a new fact about insects.

* *Dr N.R.H. Burgess' contribution to medical entomology and pest control is acknowledged in the book;* A guide to Medical Entomology, *by M.W. Service. Chapters 10-19 deal with a plethora of insects of medical importance.*

Figure 1. Inside a commercial *B. terrestris* colony showing worker bees and developing young. Photo by Dominic Cram.

Virus super-spreaders: The impact of *Varroa* on virus transmission in pollinating insect communities

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Amid the devastating Covid-19 global pandemic, the ever-present threat from emerging infectious diseases is all too apparent. In the last few decades alone, the world has witnessed many dramatic epidemics with high rates of morbidity and mortality, including, SARS-CoV in Asia, MERS in the Middle East, Ebola in western Africa, and repeated outbreaks of various strains of influenza.

The impacts of emerging diseases that affect both wild and farmed animal and plant populations are perhaps less obvious, but they are, in many ways, equally important. They too pose a threat to public health by impacting food security, the economy, biodiversity and ecosystems. Outbreaks of foot and mouth disease, mad cow disease and ash dieback, have each come at high cost to the UK. Amphibian and bat populations have seen dramatic reductions in abundance and even localised extinctions across species because of the fungal diseases chytridiomycosis and white nose syndrome, respectively.

There's no doubt that pathogens are pervasive, but what causes certain pathogens to become so devastating? Pathogen ecology is often complex – the majority of pathogens infect more than one host species, and most host species are infected by more than one pathogen. In these multi-host-pathogen systems, can we identify the risk factors driving disease emergence? Pollinating insects provide a fascinating and important system to study such questions.

> *"The life of man would be made extremely difficult if the bee disappeared"* (a quote attributed to Charles Darwin by the French journal "Les Abeilles & Les Fruits" in 1906).

Pollinating insects are a diverse group that spans a gradient of sociality. There are the solitary species (such as hoverflies and solitary bees), the primitively eusocial species that live in annual colonies of a few hundred individuals (social wasps and bumblebees) and of course the eusocial honeybees living in colonies of tens of thousands of workers. We rely on commercially-managed honeybees and bumblebees for the pollination of crops; for example, the intensive agriculture of Californian almonds depends on honeybees, and tens of thousands of boxes of intensively-reared bumblebees are imported to the UK every year to pollinate tomatoes and sweet peppers (Figure 1). Wild pollinators are often undervalued, but they form another crucial part of the picture – pollinating everything from crops to wildflowers (Gallai et al., 2009). We depend on pollinators for our food security, as without them our diet would be much diminished. Yet, researchers have recorded dramatic declines, range contractions and extinctions in pollinator populations across the northern hemisphere in recent years. Emerging diseases are thought to play a significant role in these declines, alongside the burden of habitat loss and fragmentation, pesticide use and climate change (Potts et al., 2010; Goulson et al., 2015).

Owing to our love of honey and centuries of bee keeping, pollinator disease research has historically been honeybee-centric. We know that honeybees suffer from a large number of pests and pathogens – the full range of mites, protozoa, fungi, bacteria and viruses (Genersch, 2010). In other species, we know that spillover of pathogens from intensively-managed populations is a very real risk to susceptible wildlife communities that have not evolved resistance (Daszak et al., 2000). For instance, in 1991, an epidemic of canine distemper virus in domestic dogs in the Serengeti coincided with the extinction of wild dogs. A century earlier, in the late 1800s, African ruminant populations were devastated by Rinderpest, a virus of Eurasian cattle. The recent shift in research interest from honeybees to the diverse community of sympatric pollinating insects, has shown that wild pollinator populations are at risk from viral disease spillover from managed honeybees (Singh et al., 2010; Evison et al., 2012; Fürst et al., 2014; McMahon et al., 2015).

Honeybees host numerous RNA viruses, many of which are now known to be prevalent across a broad range of pollinator species. RNA viruses are notorious because they can jump into new species, making up almost half of recorded novel zoonotic (i.e. originating from an animal source) diseases in humans (Jones et al., 2008).The enzymes that synthesise RNA during viral replication make mistakes but cannot correct them, which causes a high rate of mutation. To put it in context, the viral mutation rate can be around six orders of magnitude higher than in their cellular hosts (Holmes, 2008). This rapid evolution enables RNA viruses to adapt well to novel hosts and cause infection. Intuitively, host species that are more closely related have a higher risk of infection, as the pathogen can adapt to the familiar host environment (e.g. aspects of the immune system are more similar in closely-related species). Further, environmental stresses caused by human civilisation, such as habitat loss and intensive agriculture, can lead to poor nutrition and health in a host population and increase susceptibility to infection (Vanbergen et al., 2013). Thus, pollinating insect communities are certainly at risk from spillover of RNA viruses.

However, before an infection of a new host can occur, the host and pathogen have to meet. What risk factors increase the likelihood of this occurrence and the subsequent spread of a pathogen? Pathogens that are naturally widespread are of high risk. The method of transmission is important too. For instance, pathogens that require direct and close contact with the infected host (by touch, sexual or vertical transmission) are less risky than those that can be transmitted indirectly. Indirect transmission i.e. via a vector (yellow fever, malaria) or via contaminating water, food, air or surfaces (cholera, typhoid fever, common colds and influenza) is more likely to cause an epidemic. As for the hosts, they are at a high risk when biology and behaviour bring them into contact with closely-related infected species, for example, by feeding on the same flowers. The pollinating insect communities are thus prime suspects for disease emergence (reviewed in Manley et al., 2015)

Pollinating insects interact with individuals from the same species and across species in a variety of fascinating ways, each with potential for promoting disease transmission. The social life is particularly risky for disease transmission within a colony. Social insects live in crowded colonies of hundreds of highly-related individuals, providing the perfect breeding ground for pathogens. Social behaviours such as feeding, brood care and grooming further promote disease transmission by faecal-oral and direct contact (Cremer et al., 2007). In solitary species, however, brood care is absent and adults meet only to mate and on flowers. Pathogen transmission via flower sharing has been experimentally demonstrated (Durrer and Schmid-Hempel, 1994; Graystock et al., 2015) and it is likely the main route of transmission between species of pollinator. Bees defecate while feeding on flowers and a faecal-oral transmission route is the probable mechanism for infection from contaminated flowers. Most pollinators are generalists and feed from the same flowers, and plant–pollinator networks poignantly demonstrate how flower sharing could lead to cross-species transmission (Figure 2).

Besides flower sharing, there are many other interesting behaviours that pollinating insects engage in that potentially expose them to pathogens. Both wasps and bumblebees are known to steal honey from honeybee nests. While the evidence is only circumstantial, it is interesting that a study identified deformed wing virus (DWV) in a wild bumblebee colony that was seen robbing honey from nearby DWV-infected honeybee colonies (Genersch et al., 2006). Pollinator colonies also suffer parasitism by other species of pollinator that could cause disease transmission between the parasite and its host, and *vice versa*. For example, a female cuckoo bee will enter a social bumblebee nest, kill the queen and lay her eggs that are then reared by the social bumblebee workers. Also, the larvae of several hoverfly species (e.g. *Volucella zonaria* and *V. pellucens*) inhabit social insect nests as scavengers, exposing them to pathogens by faecal-oral transmission. 'Egg dumping' is when a social bumblebee queen lays her eggs in a neighbouring nest of the same species (O'Connor et al., 2013). 'Drifting', is when an adult returns to the wrong colony and is a common phenomenon in honeybees (e.g. Chapman et al., 2010) and although less common, is believed to occur in bumblebees – mainly when artificial colonies are used near to each other, within a commercial greenhouse setting for instance (O'Connor et al., 2013).

While host and pathogen biology, ecology and behaviour are important, the greatest risk of increased exposure to novel pathogens often comes from man's rapid urbanisation, intensification of agriculture, population growth and international trade and travel. This does not just apply to pollinators. We are increasingly setting the scene for spillover of pathogens across species. Examples include urbanisation and fragmentation of forests in the Midwestern USA is suggested to have disrupted the complex multi-host lifecycle of Lyme disease, causing an increase in disease incidence in humans across the region (LoGiudice et al., 2003). The epidemic of West Nile virus in North America is believed to have originated from the importation of infected mosquito vectors on an aeroplane (Kilpatrick, 2011). Importantly, anthropogenic pressures can present an existing pathogen with a new route of transmission resulting in dramatic disease emergence. For example, the emergence of mad cow disease via contaminated cattle feed (Wilesmith et al., 1988) or the spread of HIV into new populations via infected drug-users sharing needles (Simon et al., 2006). Moreover, novel transmission routes via a vector can drastically increase disease prevalence by injecting high numbers of infectious particles directly into the body and by-passing natural barriers to infection.

Enter *Varroa destructor*. While many of the viruses affecting pollinators have likely been around for a very long time, transmitted by faecal-oral transmission, western

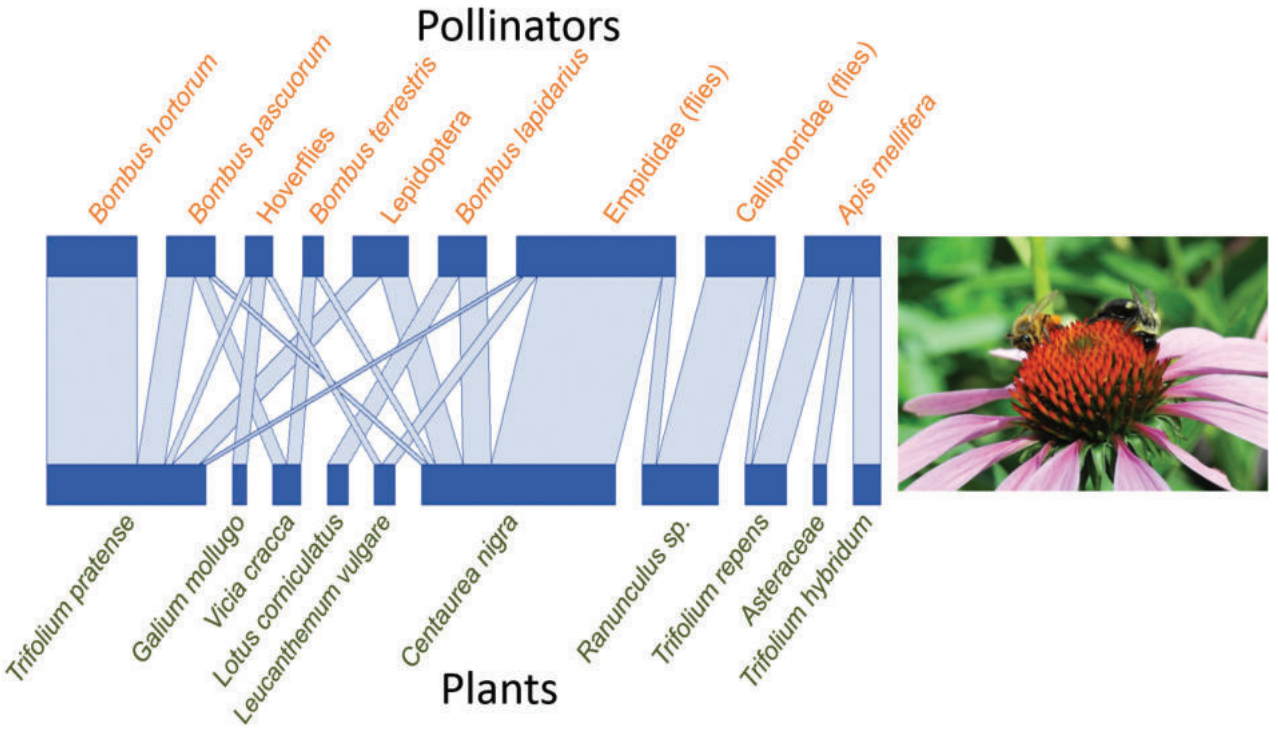

Figure 2. An example plant–pollinator network using data from a farm in Oxfordshire, UK. With pollinator species on the top and plants at the bottom, this network demonstrates that there are plenty of opportunities for exposure to novel pathogens and disease transmission across species via flower sharing. Network diagram courtesy of Dr Vincent Doublet.

honeybees and bee keepers face a more recent threat – the aptly named *Varroa destructor*. *Varroa* is an invasive mite that jumped hosts from the Asian honeybee to the western honeybee early last century because of the global honeybee trade. It has since spread rapidly across the world, arriving in England in 1992. This parasitic mite lives within honeybee colonies, feeding on the developing young, spreading and amplifying RNA viruses (Martin et al., 2012). The arrival of *Varroa* has provided a new route of transmission by injecting viruses directly into the honeybee body.

While *Varroa* directly parasitizes honeybees only, the viruses it transmits are also infectious and prevalent in wild bee populations. The shared use of flowers is a known route of disease transmission within and between pollinator species. Could the presence of *Varroa* in honeybee populations indirectly affect the health of wild pollinators such as bumblebees? This research question was a significant focus of my PhD with Lena Wilfert at the University of Exeter (Manley et al., 2019; Manley et al., 2020).

While *Varroa destructor* has colonised mainland Europe leaving few places untouched, a small number of islands exist around the British Isles and France that still remain *Varroa*-free, providing a natural experimental set-up to test our research questions. We focussed on how *Varroa* changes the disease dynamics of four viruses in honeybees and wild bumblebees by comparing viral prevalence, disease intensity and genetic sequence diversity between these *Varroa*-infested and *Varroa*-free populations.

In the summer of 2015, with my young field assistant in tow (Figure 3), I collected honeybees and two common bumblebee species (*B. terrestris* and *B. pascuorum*) from field sites across England and France. The best thing about working with bees is that they are found on the wing in flower-filled idylls when the weather is warm and the sun shining. While the unsuspecting bee is feeding on a flower, it is simple to catch her in a small pot. Field work can be very pleasant, although admittedly, not for the bees. Unfortunately, the sacrifice is necessary to detect the presence of pathogens that tend to inhabit the gut. Viruses have been recovered from the faeces of bees, and indeed faecal-oral transmission is the likely mechanism for disease transmission across species. It would therefore be kinder, and interesting to understand transmission routes, to collect just the faeces from the insects. Easier said than done. I did initially try to collect bees non-lethally by gently encouraging them to defecate in the collection pot – they use forceful defecation as a defence mechanism, so I tried blowing on them and giving them a gentle shake. However, more often than not they declined to do so, and I was unable to collect the number of samples I needed. Instead, I collected a small number of worker bees (30 of each of three common species) from each site. Although it proved impractical in this instance, I do hope to use non-lethal sampling for future work.The hunt for *Varroa*-free sites took me to some beautiful places – the Isle of Man, the Isles of Scilly, Ushant and Alderney. On these four islands, *Varroa* has been kept at bay. I also visited three islands that have not escaped the clutches of *Varroa* – Guernsey, Jersey and Belle Ile. This was important to determine if the isolation of islands played a role in disease prevalence, as well as the presence of *Varroa*. *Varroa* has spread across mainland Europe, and I sampled at five mainland sites, namely Liverpool, Penryn, Cherbourg, Le Conquet and Quiberon (Figure 4).

RNA is particularly susceptible to degradation, so to bring RNA viruses back to the lab intact you must freeze the collected bees immediately at very low temperatures. I carried with me two dry shippers – large, heavy metal containers that I filled with liquid nitrogen. The nitrogen absorbs into the lining and keeps the interior at sub -80°C temperatures for up to 10 days. They are safe to travel on planes, boats and cars but they do look a little sinister, especially the smoke machine effect when you open the lid. I had a tough job convincing ferry drivers to let me take them

on board, particularly challenging on French soil where my language skills were not up to the task.

Back in the lab in Exeter, I extracted RNA from all the bee samples to determine, at a molecular level, the prevalence, viral load and genetic diversity of four common RNA viruses known to infect both honeybees and bumblebees: two variants of deformed wing virus (DWV), black queen cell virus (BQCV) and slow bee paralysis virus (SBPV). The viruses vary in their life histories and in their association with the *Varroa* mite. Consequently, this will influence the risk of each virus emerging in wild bumblebees.

Deformed wing virus has two main variants, DWV-A and DWV-B. DWV-A is the most infamous to apiculture. By analysing mutations in sequence data over time and geography, a recent study demonstrated that the anthropogenic movement of western honeybees is the source of the globally emerging DWV-A epidemic, likely driven by the simultaneous spread of *Varroa* (Wilfert et al., 2016). *Varroa* and DWV are a deadly duo: together they are associated with high morbidity and mortality, and the subsequent loss of overwintering honeybee colonies. In contrast to honeybees, little is known of the impact of the DWV-complex on wild bumblebees. While the *Varroa* mite does not directly parasitise bumblebees, DWV has been identified as an emerging disease in wild pollinators with honeybees implicated as the source of infection (Fürst et al., 2014). Experimental infections have shown that DWV reduces the life span of bumblebee workers (*B. terrestris)* by a mean of six days (Fürst et al., 2014); worker bees only live for around three weeks, so this decrease could have a serious impact on the functioning of a colony. Further experiments identify DWV-B as potentially more virulent to honeybees than DWV-A (McMahon et al., 2016).

SBPV is closely related to DWV, while BQCV is a member of a different family of viruses. While there are links between SBPV and *Varroa* transmission (i.e. SBPV can be transmitted by *Varroa* (Santillán-Galicia et al., 2014) and is more

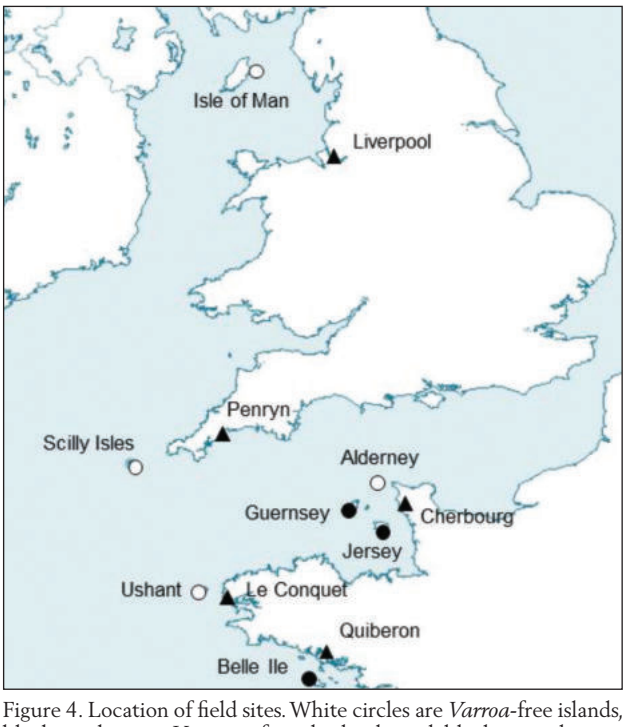

Figure 4. Location of field sites. White circles are *Varroa*-free islands, black circles are *Varroa*-infested islands and black triangles are *Varroa*-infested mainland sites.

Figure 3. Me and my daughter Eva collecting bees during field work in Le Conquet, Brittany, summer 2015.

prevalent in *Varroa*-present colonies (Carreck et al., 2010)), in the wild SBPV has been found at higher prevalence in bumblebee species (specifically in *B. hortorum*) (McMahon et al., 2015), suggesting that honeybees are not the source of infection for this virus. By experimental infection, I discovered that SBPV significantly reduces the life span of *B. terrestris* worker bees when under nutritional stress (Manley et al., 2015). In contrast, BQCV is closely linked with honeybees, but there is currently no clear evidence associating this virus to *Varroa*. BQCV is found across wild pollinators, albeit at significantly lower levels than in honeybees, but we do not yet know how the virus affects their health.

A key novel and significant result is that the presence of *Varroa* dramatically increases the prevalence of RNA viruses in honeybees, but also in sympatric wild bumblebees. For example, for DWV-B the presence of *Varroa* increases prevalence from ~8% to ~65% in honeybees and from ~ 8% to ~15% in bumblebees. DWV-A was absent from our samples from *Varroa*-free islands. The impacts of the potentially deadly association between DWV and *Varroa* on honeybees are well known, and we see the expected increase in prevalence and viral load in our honeybee samples in *Varroa*-infested sites. However, it is interesting that *Varroa* also increases the prevalence of BQCV – a virus with no link to *Varroa* transmission, and SBPV – a virus associated with bumblebees rather than honeybees. A crucial finding was that *Varroa* presence does not increase BQCV and SBPV viral load. This suggests that *Varroa* passively transmits BQCV and SBPV between honeybees, rather than actively increasing the viral load by replication or bioaccumulation. It is possible that the indirect effects of *Varroa* infection, such as immunosuppression or the physical damage from feeding by piercing the exoskeleton, could weaken honeybees and make them more susceptible to other viruses. Moreover, the pathogenic association of *Varroa* with DWV infection could make bees more vulnerable to co-infection by other viruses. Indeed, we found that *Varroa* presence increased the prevalence of co-infections, and specifically that DWV-A infection increases the chances of infection with another virus.

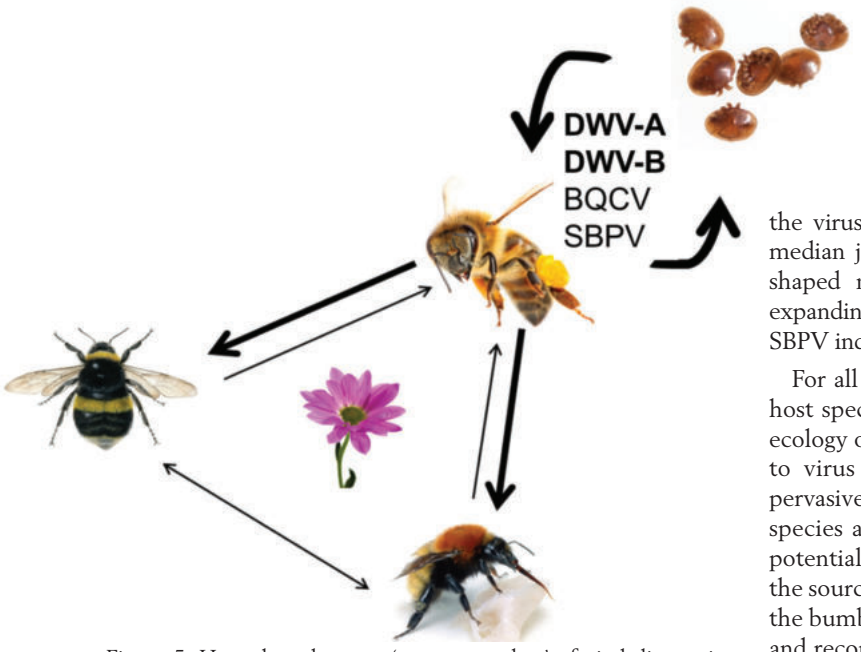

Figure 5. Honeybees become 'super-spreaders' of viral disease in association with *Varroa* infestation. *Varroa* increases viral transmission within the honeybee colony, thus increasing the opportunity for spillover into wild bumblebees (*Bombus terrestris* on the left and *B. pascuorum* at the bottom) via flower sharing. DWV-A and B are in bold to signify that viral load is also increased in all bees by *Varroa* presence, while for BQCV and SBPV only prevalence is increased (reproduced from my thesis, Manley, 2017).

Varroa has no impact on viral variants, but significantly increases prevalence of all viruses irrespective of an active or passive association with transmission by *Varroa*; therefore, I suggest that rather than selection on the virus, transmission by *Varroa* turns honeybees into a 'super-spreader' species; i.e. *Varroa* increases virus prevalence in honeybee populations, which leads to increased spillover to wild bumblebees (Figure 5).

We used phylogenetic analyses and population genetics to look at virus population structure and test for epidemic growth. We found that DWV-B is an emerging viral variant that has expanded exponentially within the last decade. Given that DWV-B is potentially more virulent than DWV-A in honeybees, this is a worrying trend. In contrast, BQCV and SBPV show no exponential growth. These differences between the viruses are neatly demonstrated by the pattern of the median joining phylogenetic networks (Figure 6); the star-shaped network of DWV-B sequences signify a rapidly expanding population, while the patterns for both BQCV and SBPV indicate stable populations within each location.

For all viruses, we find the same strains circulating across host species, which suggests that the different biology and ecology of pollinating insect species are not a limiting factor to virus spillover, and that cross-species transmission is pervasive. However, prevalence and viral load do vary across species and viral pathogen, which in turn influences their potential for transmitting the virus. Honeybees appear to be the source of virus for DWV and BQCV, while we identified the bumblebee, *B. pascuorum*, as the ancestral host for SBPV and recorded the highest prevalence and viral load of SBPV in *B. pascuorum*. The significantly lower prevalence of DWV and BQCV in bumblebee species compared to honeybees suggests that bumblebees are inferior hosts for these viruses. The presence of sub-optimal hosts (i.e. those with lower transmission potential) within a multi-host system could have a dilution effect on transmission and reduce disease prevalence. If this is the case, then biodiversity could be protective against disease risk and it is essential to conserve the diversity of pollinator hosts. Conversely, it is also possible that having more susceptible and infected hosts in the community could increase transmission. However, whether diversity of pollinating insect hosts dilutes or amplifies the risk of disease transmission has not yet been tested.

In summary, we found that wild bumblebees are at high risk of disease transmission from managed honeybees, particularly in combination with *Varroa* mite infestation. Cross-species transmission across pollinators is pervasive, with the same viral variants found in all hosts. We confirm that DWV-B, a virulent variant, is amplified by *Varroa* and is currently emerging across the UK and Europe in both honeybees and wild bumblebees. Other RNA viruses, SBPV and BQCV, appear to be stable but their prevalence in honeybees and wild bumblebees is also

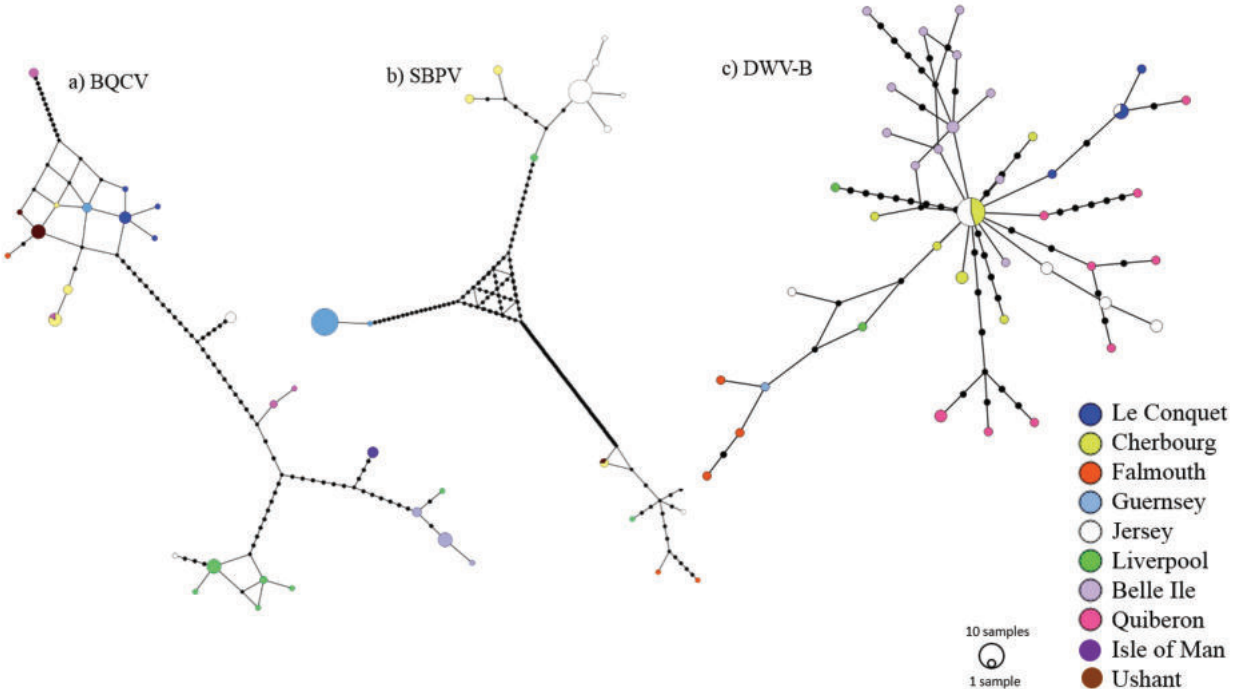

Figure 6: A median joining phylogenetic network of sequences from three viruses a) BQCV (N = 69), b) SBPV (N = 78) and c) DWV-B (N = 58). The colours represent sampling location, the size of the node represents the number of samples with the same sequence and the dashes on branches show the number of mutations between nodes (reproduced with permission from *Molecular Ecology*, Manley et al., 2020).

increased by the presence of *Varroa*. Overall, we show that a specialist vector can increase the prevalence of multi-host viruses, influencing disease emergence across the host community. Both commercial and wild pollinators contribute to pollination services, but managed honeybees, in combination with the invasive *Varroa* mite, represent a disproportional threat to the system.

Our research, and that of many others, reframes our traditional image of the hard-working honeybee in a less favourable light. I would argue that as an intensively managed species, now ubiquitously carrying *Varroa*, and therefore elevated levels of associated viruses, honeybees have become a threat to the health of wild bumblebees. While it can be fraught with difficulty, it is essential that bee keepers attempt to control *Varroa* infestations as best they can. There are no laws to abide by and 'natural bee keeping', where the hive is left to its own devices and no chemical intervention is used to control pests, is very popular in the UK. These choices are made in good faith, in line with an organic way of life and a love of wildlife. However, we now have evidence that controlling *Varroa* mites not only protects honeybees but also wild pollinators, which we all rely on for maintaining food security and biodiversity, from spillover of viruses. Disseminating that knowledge to bee keepers, policy makers and other stakeholders is now key to helping protect wild bees from disease.

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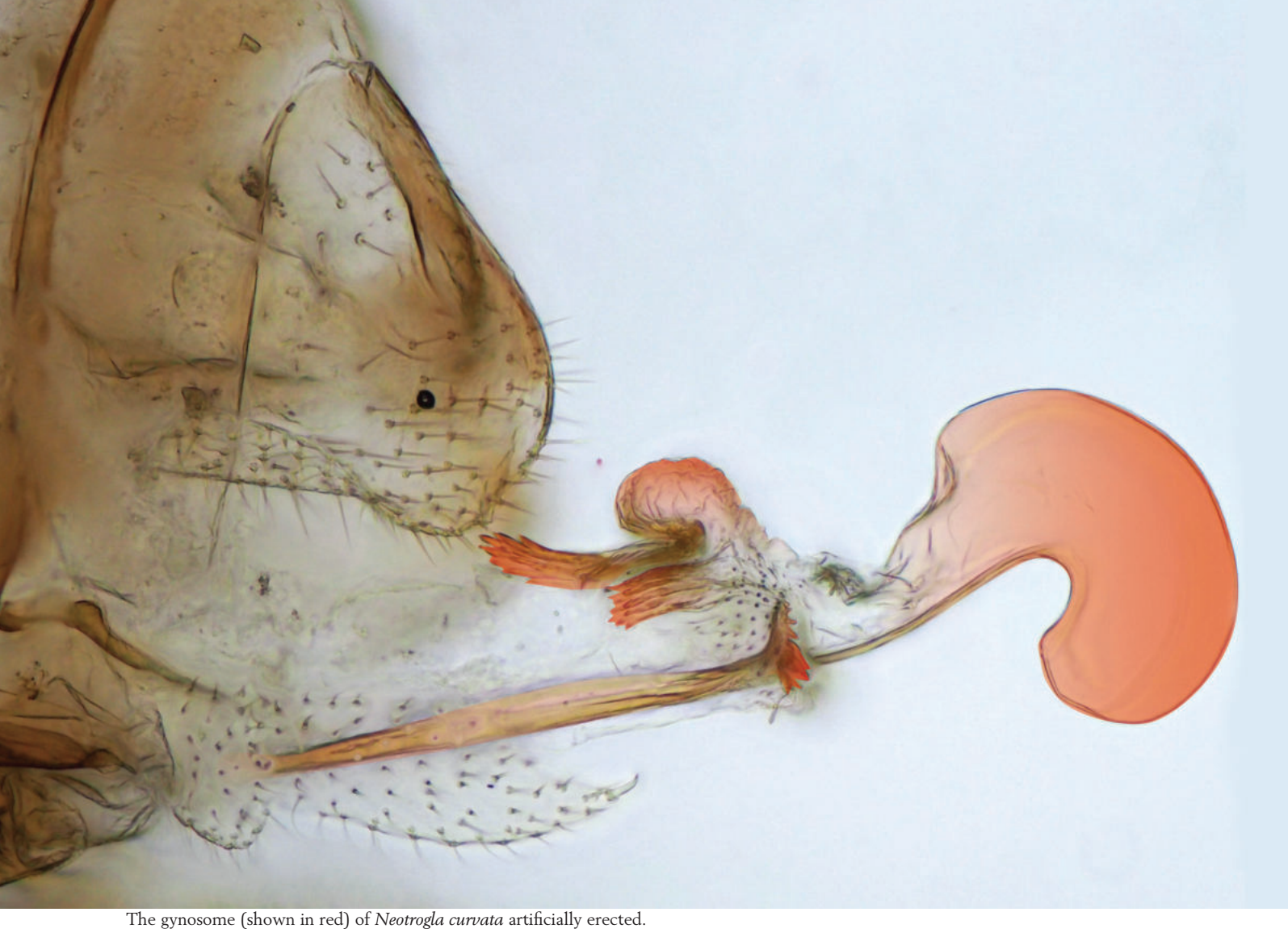

The gynosome (shown in red) of *Neotrogla curvata* artificially erected.

The retired taxonomist and the gynosome – the discovery of the female penis

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At the end of January 2009, Charles Lienhard retired from the position of research officer that he had occupied for nearly thirty years at the Geneva Natural History Museum. His had been a distinguished career in alpha taxonomy, and he had become one of the world's handful of specialists on the Psocoptera (the non-parasitic members of the Psocodea, which now includes the groups formerly placed in the Phthiraptera). Taxonomy is not a science highly esteemed by non-experts, however, and although Lienhard won the ETH Zurich silver medal for his doctoral thesis in 1977 and the A. Constant prize of the French Entomological Society for his Psocoptera volume in the *Faune de France* in 1998, his career raised few ripples in the wider world (Schneider & Hollier 2018).

Taxonomy represents the fundamental first step underpinning any biological research. Communication of findings in other fields requires a framework of knowledge about the identity of species and the relationships between them to ensure all other specialists know which organism they are talking about. But taxonomy is unfashionable in universities. Taxonomic papers are not published in high impact factor journals, and this short-sighted but easily measurable criterion has become overly important in research evaluations and grant applications. What is unrecognised by this metric is that taxonomic publications retain their value much longer than more ephemeral articles, which gain attention when published but are superseded by the next breakthrough. Lienhard's 1998 *Faune de France* keys are still the go-to source for identifying the Psocoptera of the Western Palaearctic and are likely to remain so for many years; similarly, the *World Catalogue and Bibliography* by Lienhard & Smithers (2002) covers the entire literature for the order and is unlikely ever to be replaced in printed form (it is regularly updated in *Psocid News*, available online, and the information has been incorporated into the *Psocodea Species File Online* database). Museums are one of the last bastions in which this painstaking but crucial work is valued, and even there the need to find external funding for projects

is an ever increasing constraint, forcing scientists to bring in topical or spectacular themes to justify basic research. An alarming amount of alpha taxonomy relies on scientists who have retired and no longer need to worry about impact factors.

Retirement was far from being the end to Lienhard's scientific career; coming to the museum once a week, and equipped with microscopes at home, he continued his work on Psocoptera taxonomy. The year before he retired, Brazilian ecologist Rodrigo Lopes Ferreira, Professor at the Center of Studies on Subterranean Biology at the Federal University of Lavras, had approached him with a request to identify specimens collected in the course of his cave explorations. Lienhard was the obvious person to ask because the Geneva museum has a long history of cave fauna research and he had recently described some fascinating cave psocids. While exploring Arnhem Cave in Namibia, the renowned Genevan biospeleologist Pierre Strinati had collected specimens of what turned out to be a new genus in the family Prionoglarididae. This species, *Sensitibilla strinatii* Lienhard, 2000, was the first known insect with trichobothria on the tarsi. Lienhard then examined the unidentified psocid specimens held by the National Museum of Namibia in Windhoek and discovered two more species of *Sensitibilla* and three species of a closely related genus that he named *Afrotrogla* (Lienhard, 2007). Members of this remarkable genus have extraordinarily complex female genitalia, while that of the male are correspondingly simplified. Given the possible Pangean origin of this primitive group of psocids (Yoshizawa, Lienhard & Johnson, 2006), specimens from Brazil were irresistible and Lienhard accepted Ferreira's request.

What he discovered as the packages of specimens arrived justified all expectations: three species of another new genus of Prionoglarididae, dubbed *Neotrogla* (Lienhard, Oliveira do Carmo & Lopes Ferreira, 2010). The modification of the female genitalia was even more pronounced than in *Afrotrogla*, and the male sexual organs were reduced to a small sclerite in a membranous genital cavity. In the drawings published with the original description, Lienhard showed schematically that the female genitalia correspond functionally to a replacement for the phallosome usually found in male psocids. He coined the name gynosome for this unique structure. Lienhard was already collaborating with Kazunori Yoshizawa, a taxonomist, functional biologist and expert in molecular phylogenetics at Hokkaido University, on the phylogeny of psocids, so he sent specimens of the new Prionoglarididae to Japan. Lienhard and Yoshizawa presented their initial results at the 4th Dresden Meeting on Insect Phylogeny in September 2009 but the gynosome, although unique in the animal Kingdom, did not raise much excitement at the time. While in Europe in 2011, Yoshizawa visited Geneva and examined the microscope slides of *Neotrogla* genitalia. The gynosome had been illustrated in 2010 in the resting position, but he now saw it corresponded so exactly with the membranous pouches of the male genital cavity it could function as a normal insect penis. To prove this they needed pairs fixed *in copula*, so Ferreira was recruited to find mating specimens and immobilise them. This was no simple task; the caves were up to a thousand kilometres apart and he had to achieve instant fixing in a cave environment without complex equipment. In the end he used a very old method, putting the pairs first in almost boiling water (about 80°C) and later preserving

The Brazilian cave where *Neotrogla truncata* was discovered.

Two living *Neotrogla* sp. *in copula* (female on top, body length about 3 mm) in a Brazilian cave.; inset: Genitalia of *Neotrogla curvata* mounted *in copula* (gynosome coloured in red).

them in ethanol. Meanwhile, a fourth cave-dwelling species of *Neotrogla* was discovered and described (Lienhard & Ferreira, 2013).

Specimens of all four species were fixed *in copula* and sent to Japan for examination. The results were a triumphant vindication of Lienhard's intuition and Yoshizawa's hypothesis; the erected gynosome fitted precisely into the male genital cavity in each case. This complete sexual role reversal had never been seen before! At this point Yoshitaka Kamimura, an expert on evolutionary biology at Keio University, who had worked extensively on earwig mating, joined the team to help interpret the findings. The female penis was then unveiled in all its glory in *Current Biology* (Yoshizawa *et al.*, 2014), the neologism 'gynosome' being dropped from the title because "female penis" is easier to understand and much more eye-catching. This time the impact was enormous, the press avidly picking up the idea of a male vagina and female penis and such titbits as copulation that lasts between 40 and 73 hours (a rota of staff in Ferreira's lab made observations every 30 minutes). The paper postulated that the large spermatophores transferred from the male by the female intromittent organ serve not only for fertilisation but could also represent nuptial gifts of nutrients that the females, living in a very nutrient-poor environment, need to mature their eggs. Contrary to the normal situation, the female therefore has a strong incentive to mate as often as possible, while the male is making a large investment of nutrients and therefore more reluctant. This paper was awarded the 2017 Ig Nobel prize for biology (an award given to works that "first make you laugh, then make you think") resulting in a new round of press exposure. The discoveries did not end there; in 2018 the team used micro-CT imaging to reveal the first biological switching valve ever discovered, a mechanism that lets female *Neotrogla* hold two spermatophores on the spermathecal plate at the same time (Yoshizawa *et al.*, 2018a). More recently, genetic analyses suggested that a female penis evolved independently in *Afrotrogla* and *Neotrogla* (Yoshizawa *et al.*, 2018b) and demonstrated a West Gondwanan vicariance in the evolution of the subfamily to which *Neotrogla*, *Afrotroga* and *Sensitibilla* belong (Yoshizawa *et al.*, 2019a), as hypothesised by

Rodrigo Ferreira in a cave, having made the first successful fixation of a pair of *Neotrogla in copula*.

Yoshizawa, Ferreira and Kamimura giving their Ig Nobel acceptance speech from a cave in Japan.

Lienhard (Lienhard, Oliveira do Carmo & Lopes Ferreira, 2010). However, the most fundamental question of evolutionary biology remains open: why did a female penis evolve in this small group of cave insects? Some hypotheses giving preliminary answers to this question were published in *BioEssays* (Yoshizawa *et al.*, 2019b).

Lienhard's skills as a taxonomist, his universal knowledge of the psocid literature, and his vast experience in interpreting enigmatic morphological characters made him the starting point and vital contributor to the ongoing project to understand sex role reversal and sex-reversed genital organs in an evolutionary context. As he notes in his autobiographical account of the story (Lienhard, 2020), he could never have done this work alone, and the expertise, insights and technical skills of many people have been essential in developing the study, but he still enjoys the fact that it all started with an old-fashioned taxonomic description illustrated with inked drawings done by hand.

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Looking into Cat Tien National Park from the adjacent Lam Dong province. The Dong Nai river is Vietnam's largest internal waterway and makes an effective frontier against agricultural encroachment (but not poaching).

Entomological triage at the wild frontier

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Cat Tien National Park (CTNP) is one of the most diverse and important remaining areas of southern Vietnamese lowland tropical forest. Re-assessed in 2017, the Park now covers about 826 square km of which about 96% is various types of forest, together with grasslands and wetlands. It is some 160 km north east of Ho Chi Minh City (HCMC), from which it is accessible in approximately three hours. CTNP consists of two segments, separated by agricultural land and ribbon development along an intersecting road. Cat Loc is to the north, but the most accessible area is the south-eastern area of Nam Cat Tien, where the Park headquarters is situated, with easily accessible areas in the range 120-170 m above sea level. The Park is well-known for the endemic golden-cheeked gibbon, *Nomascus gabriellae*, other mammals and for birds, such as Germain's peacock pheasant, pittas, Siamese fireback, green peafowl and hornbills.

This article was nearing completion during the Covid-19 outbreak but, as elsewhere, the pandemic has forced serious reflection and re-evaluation of our priorities. CTNP has many of the species – bats, civets and pangolins – implicated in news stories concerning the origin of *Sarbecovirus* zoonoses. Park Rangers have been in a continuous struggle against individuals and gangs who see the forest as a source of income: trapping animals and cutting trees such as the very valuable rosewoods (*Dalbergia* spp.). However, using the word "poaching" can over-simplify the complex underlying issues[i] and, more importantly, conflict is unlikely to solve the problem. Increasing awareness and protecting ecosystem services, or 'placing a value on the forest for the whole community', is a more positive strategy, but needs a variety of specific implementation approaches. Conservation has entomological implications of course: for example, insects are food for many species of bat and the Sunda pangolin, *Manis javanica*, which feeds on termites. The role of these in recycling dead plant nutrients makes keystone genera such as *Macrotermes* a subject of interest for visitors during guided walks. However, just a few pangolins may be worth the equivalent of thousands of Euros to a hunter, who will risk much to feed his family. Time will tell how the pandemic alleviates this economic pressure through greater public awareness and effective market regulation[ii].

Both public and private conservation activities rely heavily on income from tourism. International eco-tourism has effectively ground to a halt with the pandemic but, in Vietnam, National Parks were able to reopen at the end of April 2020. Whilst it is early days in the Covid-19 recovery, it appears that a stronger shift towards Vietnamese and

It is still possible to see pangolins fairly near our Lodge, but sadly it is also easy to find signs of animal hunting and trapping activities. Three rescue centres are based in the Park and pangolins have been amongst the animals carefully released, especially in remote areas where there is a reduced risk of recapture. Signs of pangolin activity include *Macrotermes* mounds which have been broken-into. Work on termite diversity was carried out by Sam Gandy in 2011[iii], who took this picture of reproductive castes of *M. gilvus*, a dominant mound builder.

expatriate visitors wishing to 'escape from the city' is helping to allow businesses to adapt to the new situation. There is evidently another conflict between seeing wildlife, easily seen when the Park was closed, and mass tourism. For the past ten years, Forest Floor Lodge has attempted to 'add value' with [i] financial support to both the Park and local community, funded by visitor income and [ii] participation in research and education about the Park's biodiversity and ecosystem services. The latter has been in collaboration with the Park's Technical Department and Universities (Nong Lam University in Ho Chi Minh City and two in the UK), with information published on the website www.namcattien.org and elsewhere. Whatever transpires, we believe that there will be a continuing need for comfortable accommodation within a tropical forest setting, together with a biological narrative for visitors, naturally including insects and their role in the ecosystem.

Seasonality, botany and history

Much popular and scientific attention has been placed on 'rainforests', but other areas, typically more than about 10° N and S of the Equator, have frequently been misnamed and are quite distinct. CTNP represents a lowland seasonal tropical (sometimes called 'mixed' or 'monsoon') forest – of the type which, until 50 years ago, extended to the outskirts of HCMC and on into Cambodia, Thailand and Myanmar. Extending further west, similar forest in India may be called 'jungle', a word originally derived from Sanskrit, but having no explicit ecological meaning. Most significantly there is a strong dry season, with little rain between December and March. High overall precipitation (typically 2.5 metres) is mostly from the rainy season and, as elsewhere in the tropics, there is an apparent 'outburst' of insects with the first substantial rains in April-June.

A *Xylotrupes gideon* beetle takes flight over the Ben Cu rapids in September; to the right, the same view in March 2016, when the Dong Nai river was exceptionally low. Flooding, as in August 2019, appears to follow an approximately 12-year cycle, with water levels more than 6 m higher than normal in places. Besides normal seasonality, we would like to understand better the ecological impacts of these extreme events.

Amongst the important trees, the most common species, *Lagerstroemia calyculata* is deciduous, as is the spectacularly enormous *Tetrameles nudiflora*. Other species include *Afzelia xylocarpa*, other Fabaceae, and evergreen emergent trees in the Dipterocarpaceae[iv]. Seasonal tropical forest, especially when disturbed, is also characterised by abundant lianas (hence 'jungle'); several recent papers have described their competitive advantage for growth during the dry season[v]. Botanists have debated how much *L. calyculata* and bamboos are indicators of human disturbance and using the term 'secondary forest' is intrinsically ambiguous. Nevertheless, we use it, but what does it mean?

The concept of 'primary' or 'old growth' forest is an idyll, but on examination likewise fraught with difficulty. An archaeological site to the north of Nam Cat Tien, indicates that sophisticated societies have been navigating the upper Dong Nai river area for at least 1,500 years. Unusually amongst the minorities in Vietnam, the Ma people originally inhabited lowland as well as mountainous areas, including much of what now constitutes the Park. Working in the 1950s and early 1960s, J. Boulbet[vi] gives a vivid description of these people and their original domains in what are now Lam Dong and eastern Dong Nai provinces. The eastern zone of what is now Nam Cat Tien was described as '*inhabité*' (uninhabited), but forest clearance and settlements are indicated in areas near the main river, according to some maps of that period. Boulbet provides us with glimpse of the forest environment, before the ravages of defoliation (wartime spraying with 'Agent Orange' and other herbicides) and even more devastating post-war deforestation. Terms such as 'rich' and 'poor' forest have been widely used, but are related more to commercial (timber) value, so we suggest that, from an ecological point of view, the terminology used by the indigenous Ma people may be more helpful. They had to coexist with their environment and used specific words to describe many local forest types. In particular, 'poor forest' zones include riparian areas consisting not only of streams, but various grades of wooded marshland, swamp forest (*brêe bo'*), lakesides, wet meadow and other grasslands (*srêe, da nau*).

We can be certain that CTNP is one of the few remaining lowland tropical forests in the Indo-China region; this previously remote area, practically inaccessible for decades, makes it a highly under-studied environment. In his 2016 Verrall lecture, Max Barclay described the 'onion skin' nature of the remnant patches of tropical forest: where insect species may or may not be typical of original biomes as represented in museums worldwide. We often ask ourselves: "What makes Cat Tien so special?" and "How do we reply to visitors asking, 'What's that?' – be it a plant, fungus, vertebrate or insect".

Knowns and unknowns

We may be able to give a species name and talk about how an insect, seen during a trek, is surviving in the forest. However, sometimes we even struggle to name a family and have even had to resort to "there are probably many species new to science here". Donald Rumsfeld's famous interview about "unknown knowns" comes to mind. Whereas lepidopterists and odonatologists have regionally-indexed websites (and are able to guess whether an insect is rare or new), there are many gaps with even quite eye-catching groups such as the Orthoptera and certain large fulgorid genera. Other groups such as the Phasmida, and certain coleopteran families, have good 'support networks', but what are the chances of identifying our cockroaches[1] for example? The reality, shared we realise by other entomologists in this region, is that we rely heavily on the internet, but the relevant literature may be old, obscure and not digitised, so the line of least resistance can be to 'crowdsource' the problem.

'Having a go' at our Hemiptera: oriental resin bugs are a frequent sight, exploiting resin to help capture prey (*Ectinoderus sp.* with nymph on the right: as posted in Wikipedia). The resin, either natural or from traditional extraction practices, exudes from wounds in the iconic *Dipterocarpus* trees. *Pyrops coelestinus* is one of our more common lantern bug species – which can generate as much interest as any butterfly.

[1] Entomologists must also appreciate that "This cockroach may be a species new to science" is not entirely appreciated by all visitors.

"Known knowns": the metalmark butterfly, *Paralaxita telesia*, on the left is an indicator of intact tropical forest. *Lachlathetes contrarius* is on the right: At least one of us (JH) can name several of the ant lions and owlflies here – they can look like damselflies from a distance – but for the rest of the Neuroptera and several other orders we go into "known unknown" territory.

Basic insect guides

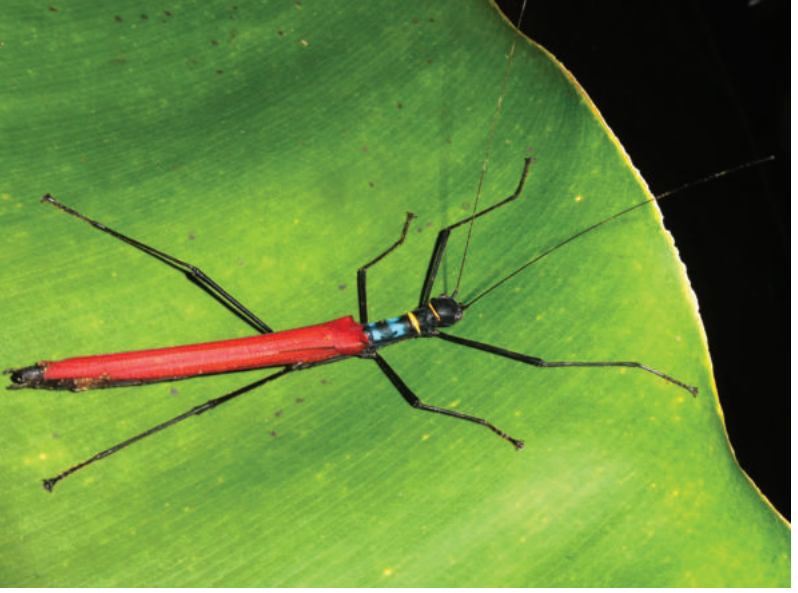
There is enormous scope for coming up with something entomologically exciting and new here – but what to look out for? We have used the word 'triage' in the title of this article because we want to prioritise our efforts and know that even the Park's list of confirmed arthropod families is still incomplete. A well-known tool, used by ecologists and others is the 'morpho-species' concept, but when these become 'morpho-genus X' or 'possibly in tribe Y' we sense that we are on increasingly shaky ground.

Species identification may require help from specialists, but identification to genus or tribe level, with the aid of photos, is helpful we think. As well as contributing to Park species lists, we have prepared online guides, each one initiated by a student project, that can be updated readily. Recent additions include the known genera of Orthoptera Caelifera, Phasmida and Mantodea: the latter having recently undergone extensive revision[vii]; this frequently clarifies matters, but also adds to the magnitude of our endeavour. In addition, we would like more ecological studies, for example, on the many modes of interaction between insects and fungi.

Unique to the Park?

To illustrate why we think the Park is so special, we carried out a web search for species named 'cattien', 'cattienensis', or similar and found more than 20 organisms; we also know that the Park is the type – and only known – locality for dozens more. In more 'obscure' groups, it is highly likely that

A 'discovery' by a visitor on a trail walk – and luckily the authors could name both the fungus (*Phallus indusiatus*) and the monkey grasshopper (*Erianthus versicolor*). But what about the other insects – total of five orders counted – in the picture? We can also suggest that the ants on the right have been attacked by a species in the *Ophiocordyceps* complex and discuss relationships, well known amongst entomologists, between fungi and ants or termites, but we know there is much more to discover here.




Vietnam has a reputation for diversity of Phasmida, but new species are still coming to light. The 'Picasso stick insect', *Calvisia kneubuehleri*, was described only in 2017[viii] from the Dong Nai Biosphere Reserve (of which the Park is a part). It is uncommon, but represents a regular 'find' on forest walks and both the insect and its name are memorable. We understand that the phasmid on the right, with distinctive mottled legs, also belongs to the Necrosciinae, but may need to be placed in a new genus.

species new to science have yet to be identified. Insects previously named after the Park include:

- *Striatosedulia cattiensis*, a grasshopper (Orthoptera: Catantopinae)
- *Stonychophora cattien*, a cave cricket (Orthoptera: Raphidophorinae)
- *Hemisphaerius cattienensis*, a planthopper (Auchenorrhyncha: Issidae)
- *Ecnomus cattienensis*, a caddisfly (Trichoptera: Ecnomidae)
- *Therophilus cattienensis*, a parasitic wasp (Hymenoptera: Braconidae).

Species of dragonfly have now been added to this list (below) and other classes of Arthropoda include millipedes (Diplopoda), centipedes, spiders and mites. Spectacularly, the velvet-worm *Eoperipatus totoro* (Onychophora) was discovered in 2007, by members of the Russia-Vietnam Tropical Centre. The extensive work of this group of scientists has included Alexander 'Sacha' Monastyrskiy's Park butterfly recording, which is probably fairly complete; however, much more information is needed about moths.

Dragonflies

Odonata associated with streams are excellent for studying seasonality and we know that these insects are:

- Indicators of habitat health, but it is not clear whether high diversity is an indicator of habitat quality[ix], or if more species are found with intermediate levels of disturbance[x], when applied to Odonata in a seasonal forest;
- Very susceptible to changes in the environment;
- Potentially good indicators of pollution and climate change.

Dragonflies can be seen everywhere in the Park, most obviously at its numerous standing water bodies and streams, but also in the forest and along the roads. Visitors are immediately greeted by both dragonflies and damselflies when entering the Park via the river ferry. They are readily seen on roads and forest trails, even when standing water is not apparent. Forest Floor Lodge maintains a dragonfly conservation pond, where about 30 species can be seen, but these are usually common throughout South-East Asia. Generally, more remote parts of the forest contain more species and there is a greater chance of encountering rarities. Before work here started six years ago, there were seven species recorded on the Park list, but now that number stands at 155, including more than 20 new records for Vietnam. We probably have at least one species new to science from several major dragonfly families. For example, the Aeshnidae are now represented by ten species, including a new record for Vietnam and two new species named after the Park: *Gynacantha cattienensis*[xi] by Tom Kompier and JH in 2017 and *Sundaeschna cattienensis* described in 2018.

This is essential natural history and of general interest, but JH is now addressing specific questions about how well Odonata can be used as indicators of environmental health in this very understudied part of the world, as part of his current PhD studies with Harper Adams University. In this work he will correlate these data with environmental variables measured in various riparian areas. It should then be possible to build up an 'environmental preference profile' for each species present. From these data JH hopes to then [i] build models that predict the dragonfly communities at unrecorded sites, from key habitat variables and [ii] use dragonfly community data to create a predictive index (of say, environmental disturbance), by recording species present. Models and indices such as these might also identify where competition and geographic range play a role in community structure. Most usefully, they may help to quantify the health of water bodies near to human habitation (including rice cultivation perhaps), with a view to better management.

Citizen science, wikis, photos: and a request

Little-known taxa need specialist intervention, but there is so much that can be done with the (many thousands of) digital insect pictures that are taken by staff and visitors every year. In practice, enthusiastic photographers post work on forums such as Facebook: Entomology or Flickr – then hope to obtain a correct identification – but how reliable is this and how well can all this effort be retrieved subsequently?

A web search for a genus or species name will probably retrieve a Wikipedia page, if it exists. For all its much-discussed constraints, WP remains a very powerful resource for 'citizen science', especially with its referencing systems (for aficionados, tools such as the *automatic taxobox* which 'handles' higher taxonomy with minimum effort and *taxonbar* that links to known online specialist databases). Associated pages include articles in other languages, Wikispecies and Wikimedia Commons which effectively indexes an enormous number of photos, drawings, insect song recordings, *etc*. It has been pointed out that a good WP page has been subjected to more peer review than many scientific


JH with Ms Nguyen Ngoc Quyen, previously studying at Nong Lam University, sampling for Odonata along a stretch of seasonally-flowing stream for comparison with other riparian sites. Right: *Gynacantha cattienensis* – a locally common dragonfly named after the Park.

papers. Try searching for a very obscure genus name and you may end up with a Swedish or Dutch page on the subject, where there have been projects to computer-generate pages, using information imported from other online databases. Many of these articles would clearly benefit from more human input, but at least there is something to develop further. Anyone can take part (both its greatest strength and weakness) and we suggest that this forum possibly has the most universal impact for general purposes, but of course we will continue to depend on specialist websites such as the *Species Files*. We also suggest that WP/Commons is an excellent place to upload for posterity your good, identified photos of insects and other entomological phenomena.

So, if you are at a 'loose-end in lock-down', how about uploading some of your splendid insect photos to Wikimedia Commons, or perhaps participate in page edits? Material from SE Asia would really help us, but it is also surprising that many articles have yet to be initiated for species from the British Isles, let alone mainland Europe. This surely is in the finest traditions of the Royal Entomological Society, with its reputation for interaction between professionals, students and enthusiastic amateurs. In our case, we need help with any genera and species that might occur in the Cat Tien Forest. Dare we also hope that, if and when travel is again possible, some readers might like to come and help us in person?

We would like to thank the many people who have helped us to date, including several reviewers of this script, and look forward to hearing from anyone who can assist us with our many unknowns.

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Society News

News from Council

The last two meetings of Council on 6th May and 3rd June were somewhat extraordinary in the Society's history, being held entirely by video conference due to the Covid-19 pandemic. In May, Ms Whiteford, the Registrar, reported that the Mansion House was closed until government advice was that homeworking was no longer necessary. However, measures had been put in place to allow staff to return safely once this advice was received. Dr Stockan, Hon. Secretary, reported that all SIG meetings were cancelled until autumn, although it was hoped to run an element of these meetings online where appropriate. Dr Tilley, Chief Executive, advised that The National Insect Week 2020 would now be a virtual 'Ento at Home' campaign. Given that the annual accounts cannot be prepared or audited until the Mansion House is reopened, the AGM has been postponed with a provisional new date of 7 October.

On 6th May the President Professor Thomas, proposed, and Council agreed, that under the current circumstances the Society would freeze all subscription rates for the following year. Dr Tilley, Chief Executive, gave a brief update on the '*Grand Challenges in Entomology*' initiative. A postdoctoral researcher has now been appointed to work on the project; however, the workshop aspect of the project may now have to be a virtual one. One outcome will be a publication in one of our journals. Another virtual meeting had taken place between Dr Tilley, the President, and the RES Gardens competition winners. Plans were agreed to allow a topographical map and an entomological survey to be commissioned, and the project documented through a series of professional photographs that will chart the garden's progress.

Governance Review

In May Mrs Devine gave a brief overview of her governance review report. Council discussed the merits of this report and the best way to proceed. It was agreed that a smaller working party of trustees be arranged with Mrs North being appointed to chair this group. In June, an implementation plan was presented to Council with the aim of developing recommendations to be considered by Council in October.

New trustees

Following the due rotation of trustees in accordance with Chapter 5 of the Society's Bye-Laws, there would be two vacancies on Council after the June meeting. More candidates had been put forward than places available, so this had been opened-up to a membership vote. The new trustees appointed were Dr Gia Aradottir and Professor Adam Hart. The President thanked retiring trustees Dr Watt and Professor Field. The President Elect, Professor Roy, thanked the retiring President for his leadership, wise counsel, hard work and diligence during his term as President.

An update on the RES Governance Review

Over the last year, Lucy Devine from Wellspring Consulting has been working with the RES to review governance. We are pleased to update you on progress. First, we would like to take the opportunity to thank Lucy for her excellent engagement across the RES and to thank everyone who kindly gave their time to meet with Lucy.

Council received the final report from Lucy at the May meeting. The overwhelming response from Council was positive although we were pleased to seek clarification from Lucy on some points. Council has agreed to make changes based on the feedback from the review with the aim for the Society to be the very best it can be. Here we summarise the main actions in relation to membership, which we have captured within an ongoing implementation plan:

- Programme to improve communication with members and so enable the Membership to be more involved with the Society, including representation of Membership views in Council decision-making. As an example, this will include making the Mansion House and the AGM more accessible to you all.
- Reviewing and refreshing how Trustees and Committee members are appointed, to ensure we capture the wide pool of talent in the Society better.
- Reviewing and refreshing how Committees operate and report into Council.
- Addressing some technical areas where the Society's practice does not currently align with the byelaws, charity law or Charity Commission guidance. This will include creating a set of policies to help staff and volunteers do the right thing.

Council has established an enthusiastic and energetic Governance Working Group, chaired by Julie North (Trustee), to deliver these changes over the coming year. The Working Group comprises:

Julie North (Chair),
Helen Roy (RES President)
Tim Cockerill
Rebecca Farley-Brown
Jenni Stockan
Chris Thomas
Shaun Winterton
Allan Watt

We will communicate the outcomes from this Governance Working Group to you all over the coming months and beyond. We will be inviting you to share your views and opinions through participation in a membership survey very soon but meanwhile if you have any thoughts or comments please do not hesitate to contact us at info@royensoc.co.uk.

Meetings

PG Forum 2020

Manuela Carnaghi

Welcome screen at the Postgraduate Forum 2020. Poster created by Manuela Carnaghi with photos from Jill Joiner.

On the 20th and 21st of February 2020, postgraduate students from all around the country and further afield gathered to attend the annual RES PG Forum. This two-day event was held in the historic city of Bristol, at the Wills Hall Conference Centre. The event was organised with the idea of giving an opportunity to postgraduate students with an interest in insect science to share their research and meet like-minded students. The many coffee breaks also provided a great opportunity for students to network and engage, not only with their peers, but also with the four plenary speakers, Dr Sarah Arnold, Prof. Mike Siva-Jothy, Dr Victor Brugman and Dr Karin Kjernsmo. The plenary sessions were not only stimulating and engaging but also delivered some excellent advice on how to build a careeer in entomology.

Thirty-one people attended, 25 of whom were postgraduate students. Twenty-two students gave an oral presentation and 12 students presented a poster. The topics

Students discussing posters on the afternoon of the first day.

The winners of the best presentation competition together with the two RES PG reps. From left to right: Molly Rogers (RES PG rep.), Amy Withers (Second place for Best Poster), Yin Chang (Third place for Best Oral Presentation), Jordan Cuff (First place for Best Oral Presentation), Freddy Sarathchandra (First place for Best Poster and Second place for Best Oral Presentation), Manuela Carnaghi (RES PG rep.).

Group photo at the end of the event.

of the presentations were extremely diverse, covering pollinators, saproxylic insects, tropical vectors, mimicry and colouration of insects, just to mention a few. Having a broad variety of topics contributed to a refreshing event. It is very common for postgraduate students to focus only on their research topic. Thus, events like this help to expand the horizon of a student's research, and might provide opportunities to learn about other techniques.

This year we also had many students in their first year of a PhD. The Forum is a great opportunity for them to be gently introduced to the conference-like environment and to have the chance of creating, maybe for the first time, a scientific poster or a talk.

To make the most of our time in Bristol, two additional social events were organised: the dinner and pub quiz on the evening of the first day, and a guided tour at the University of Bristol Botanic Garden at the end of the second day. These events permitted the students to socialise and have some fun whilst still embedded in an entomologically-rich environment. The pub quiz, in particular, was an exciting way of challenging everyone with some testing questions relating to insect science!

The event was financially supported by the Society and by two sponsors, Koppert Biological Systems, and Watkins & Doncaster. The generous contribution of the sponsors made it possible to offer small travel grants to facilitate the attendance of some students, and to provide prizes for the three best presentations and the two best posters.

Overall, the event was a huge success and the effort put into it repaid well. I am glad to have signed up for it! It was truly nice to catch up with people that I had met at the previous Forum and I really look forward to next year's event!

News from the South West Region 2019

Peter Smithers

SW Region Hon. Secretary (Retired)

2019 has been another busy year in the South West (SW), with a wide range of activities from scientific meetings to exhibitions and film shows. We have had a good spread of meetings in Bristol and Plymouth, but I am still trying to set one up in south Wales, so if anyone would like to help with this please make contact. I am also always looking for new ideas, so if you find something that could be interesting please talk to me or my successor.

Food and Feed Special Interest Group, April 2nd & 3rd, Royal Agricultural University, Cirencester

As reported in the previous *Antenna*, this was extended to a two-day meeting, evidencing increasing interest and 'appetite' in this subject area.

Bristol Meeting, May 17th, Bristol University

The fourth in this series of meetings, it was attended by a small but perfectly formed audience who enjoyed the wide range of subjects covered. This meeting was organised by Molly Rogers. Hester Weaving from Bristol University discussed her Master's project looking at the effect which antibiotics administered to cattle had on the reproductive success of dung beetles, which included lowering the number of eggs that females produced and lowered hatching rates. Dr Verity Jones, from the University of the West of England, talked about her collaboration with Sarah Beynon's 'Grub Kitchen' to trial their new insect protein-based food, 'Vexo', in Welsh Schools, a project that was a great success with many children preferring 'Vexo' over more traditional alternatives (see Verity's article in the previous issue). The other speaker dropped out at the last moment, so I gave a

Beetle exhibition at Bristol botanic gardens.

talk I had given at one of the Ento meetings on Insects in Advertising. The entire audience then adjourned to the nearby 'White Bear' for an extended informal discussion.

Facing up to Beetles Exhibition, July – December, Bristol University Botanic Gardens

This exhibition showcased Michael Derby's series of beetle faces that were shown in York as part of the Insect Festival back in 2009. They have since visited London Zoo and then returned to Plymouth where Michael very kindly donated the work to the Biology Department. However, only half of the images have been put on permanent display, so I sought permission to exhibit the remaining half in and around Bristol. Dr Nicholas Wray, the director of the Bristol University Botanic Gardens, enthusiastically embraced the idea of hosting the remaining half of the exhibition, where it has been a great success... so much so that it is being transferred to the Biological Sciences building at Bristol University till the autumn of 2020.

Insect Film Night at the Zoo, August 7th, Bristol Zoo

This was the fourth evening in this series, and it continues to attract a good audience. As always, we began with a short, humorous film from the *Small Talk Diaries* series. As at previous film nights, we are grateful to Ammonite Productions for granting us permission to show this content. We then had Steve Nichols from Hooded Crow Pictures talking about his film *Damsels and Dragons*. He introduced the film and afterwards answered questions from the audience.

The Secret Life of Flies, August 15th, Bristol City Museum & Art Gallery

As part of the Insect Festival Bristol, Rhian Rowson (the Curator for Natural Sciences at Bristol Museum) had organised a talk by Erica McAlister entitled "*The Secret Life of Flies*". On the night the foyer of the museum housed a bar and a display of Diptera from the museum collection. These raised considerable public interest and many questions. The talk played to a packed house of 120 people and was delivered in Erica's own irreverent style: a humorous and informative account of why the Diptera are both important and beautiful in their own right.

Bugs on the Big Screen, August 16th, Bristol

Bristol has a large screen in Millennium Square in the city centre, which is used to show major sports events and a range of arts performances from opera to holiday movies. I had seen it used as part of the city's *Festival of Nature* and so explored the idea of using it during the Insect Festival. It was amazingly easy and an assortment of short to medium length films was programmed to show over the Friday lunch hour on the day before the main Festival event at the Museum. All was going well until the day, when it rained heavily

Bugs on the big screen.

non-stop throughout. The screen manager and I had put out a dozen deck chairs but the only people to use them were myself, the screen manager, Molly Rogers and her mother (who valiantly turned up to support her daughter). We sat abandoned in the rain while the world of entomology swept across the giant screen above us. Bugs on the Big Screen was a catastrophic failure, but it has opened a door which I hope to go back to on other occasions.

Insect Festival Bristol (IFB), August 17th, Bristol City Museum & Art Gallery

This was a fabulous day; the sun was shining and a real sense of excitement pervaded the Museum. This was only the second time we had run this event so there was a hint of concern that the good weather might draw people away to other outdoor pursuits. We need not have worried. We had twelve stands in a crowded foyer with face painting and *Build a Bug* in the activity room upstairs. The Museum ran tours of their collections in the vaults and Roger and Rosy Key ran a series of bug hunts on the nearby Brandon Hill reserve. The day was a huge success, with 3,330 people passing through the event. We are already making plans for IFB 2021.

Welcome desk at IFB.


IFB - just warming up!

Insects Imagined, September – December 2019, Drawings by John Lamerton at Dr Beynon's Bug Farm, St Davids

A chance conversation with my old friend John Lamerton sparked the opportunity to raise the profile of insects at another venue using John's detailed drawings of imagined insects. An exchange of emails with both Sarahs at Dr Beynon's Bug Farm and the deal was clinched. John's drawings have been on display in their gallery since September 2019 and will come down in the autumn of 2020.

Plymouth Meeting, November 15th, University of Plymouth

The Plymouth meeting is well established, having run for twenty years (maybe more), and always draws a good audience. This year was no exception, with seventy people attending the three talks. We began with "*Don't forget the little guys*" from Jan Freedman. In this talk, Jan outlined the design of the new Natural History Gallery in the refurbished City Museum (now known as 'The Box'). Jan described the journey that visitors would make, from ice age Plymouth through a vast collection of marine organisms in spirit to the new invertebrate display which enveloped the viewer. Dr Carley Benifer from JBA Consulting then talked about the


Bug hunt on Brandon Hill.

John Lamerton at IFB 2017.

"*Sands of Life Project*", which is assessing the biodiversity and conservation value of the Welsh sand dune systems. This is a vast undertaking that aims to look at ten sites, three times a year for three years. There were only a few pieces of preliminary data in at that point, so we look forward to an update in 2021. The final talk was from Dr Susana Pallares, a post doc from Plymouth University working under Professor David Bilton. She talked about her Master's project in southern Spain, where she had investigated the colonisation of saline pools by water beetles. She had been assessing the physiological stress of this behaviour to the beetles and considering the possible effect that climate change may have. There were many questions for all three speakers, but we finally had to leave so we adjourned to the now famous 'Nowhere Inn' for further discussion and a bit of socialising.

Future plans

Plans are being laid, with the help of Stuart Reynolds, to move the Facing up to Beetles exhibition to the rooms of the Bath Royal Institute of Science and Literature (BRISL) in the autumn but the current pandemic has halted progress. We hope to move on this once the situation allows. We are also looking into the BRISL hosting an exhibition of Alfred Wallace's letters, using them with additional material to tell his life story. This was an exhibition that ran at Plymouth University in 2013. Loose plans are being laid for meetings in Bristol and Plymouth next year, Covid permitting. The film night at the zoo has been postponed this year but we hope to run it again in 2021.

Thanks

I would like to thank Molly Rogers for her help in setting up and running many of the Bristol-based events and Jane Akerman for her invaluable support at Plymouth. Thanks also to Rhian Rowson and Ray Barnet from Bristol City Museum, without whom we could not run the Insect Festival, as well as Tim Bray at Bristol Zoo, who champions and facilitates the Insect Film Night, and Nicholas Wray for his enthusiastic support of the beetle exhibition.

Honorary Fellow Interviews

Peter Smithers

by Richard Harrington

The tables have turned! To mark Peter's retirement after 20 years as the Society's Southwest Regional Honorary Secretary, I persuaded him to hand over his "Honorary Fellow Interviews" slot to me, so that I could write about him, for he is, indeed, an Honorary Fellow. Accounts of his interviews usually begin something like "….so we ambled back from the Red Lion, fed and watered, and ready to talk about his/her life in entomology….". Sadly, not this time. For obvious reasons, this was the first Honorary Fellow Interview conducted via Zoom.

When I think of Peter, four major themes come to mind: spiders, entomophagy, insects in art, and outreach. First, though, how did it all begin? I had rather suspected that Peter was one of the many of us who has been fascinated by insects from a very early age. Although, with his father, he used to look at the *Observer's Book of Butterflies* to identify what they had seen after weekend walks, his obsession (I think that's fair) didn't kick off until adulthood. At school, he veered towards the sciences, rather than the arts, and followed this up with a City and Guilds qualification in Laboratory Technology at Bracknell Tech. Whilst there, fellow students talked about a new course in "Ecology" that was being introduced by some London Universities. "Is this real biology?" cried some colleagues. Then a post for an ecology technician was advertised at Plymouth Polytechnic. Having just been on holiday in Devon and Cornwall, Peter really fancied living there. He grabbed a copy of Lewis and Taylor's *Introduction to Experimental Ecology*, read up, and got the job (apparently there were no other candidates!). Soon afterwards he was joined by Nick Greatorex-Davies who introduced Peter to moth trapping, and he was off. Next came beetles and then spiders. He attended a Field Studies Council weekend course on spiders (led by Frances Murphy) and subsequently attended a different one each year, including harvestmen (led by John Sankey) and flies (led by Henry Disney). Peter greatly enjoyed leading field trips with his students and, unsurprisingly, became the go-to person for invertebrate identifications. In the early 1980s there was an influx of young staff, including Ken Thompson, then Mick Utley, who had done his PhD under John Lawton. They introduced a more modern approach to teaching ecology, and ventured further for their field courses.

Spiders

Peter joined the British Arachnological Society and, when it put out a call to produce an atlas of spiders, Paul Hillyard, who was responsible for the Southwest, soon handed over Devon to Peter. He organised a small group to go out one Sunday a month, usually recording on reserves. This was kept up for fifteen years. The warden at the Buckfastleigh reserve suggested they took a look in the caves. This piqued Peter's interest in cave spiders, and he crawled around caves and mines for ten years working out spider life-cycles and what they eat.

Outreach award to local school.

Entomophagy

In 2000, the Dean of Plymouth's Faculty of Science was approached by the City Museum, which had an eight-week gap in its schedule and needed an exhibition to fill it. With Outreach Manager, Karen Gresty, Peter put together an exhibit on what might happen if certain invertebrate groups were no longer around. Would this topic draw people in? Peter was aware that the Liverpool Museum had drawn crowds by offering insects as food, and he followed up on this, giving a talk on why people eat insects in certain parts of the world but not others. So many came that the event had to be repeated in order to cater for those who had been turned away. The press got involved, and the interest grew like topsy. At a meeting organised by Peter in 2001 on the biology of invertebrates in caves, one of the speakers was George McGavin. He had recently been on an expedition to SE Asia with The Marines, during which he had cooked and eaten crickets. He agreed to cook an insect meal for conference delegates which was hugely successful. Since then, Peter has worked with various chefs at events like National Insect Week and the Cheltenham Science Festival. He was approached by University College London to speak at a meeting looking at potential new foods and was subsequently invited by the Royal Geographical Society to participate in a meeting entitled *How to feed nine billion*. That was the week after a World Health Organisation report on edible insects was published. The rapid growth and huge potential of this area gave Peter the idea of launching the Entomophagy (now Food and Feed) Special Interest Group in 2016 and it has met every year since, gathering together players in all areas related to bringing invertebrates more widely into human diets. Peter believes that, before too long, insects will be as mainstream in Western diets as shrimps and prawns.

Outreach and insects in art

The interface of science and art is an area which has always fascinated Peter. When the Arts Faculty of Plymouth University moved from Exeter to Plymouth, the Plymouth Community Arts Centre was born. Peter got to know the Director and gained access to some funding to explore how the sciences and the arts can work together. He organised a conference and an accompanying exhibition, which ran for a couple of months. The three main speakers at the conference were Professor of Art and History, Sam Smiles, who gave a talk on the history of insects in art, Robin Wootton from Exeter University (and the Society's previous Regional Honorary Secretary for the Southwest), who spoke on the

Bug Hunt Bristol at National Insect Week 2018.

origami of insect wings, and Paul Ramsay on insect vision. Three artists also spoke on how and why they used insects in their work. The event was a resounding success, with nearly 100 people coming from all over the country. "There's something in this", thought Peter. As an organiser of Ento'08, he included an art exhibition in the programme. Working with *Peninsula Arts*, this was a huge success. Other exhibitions, initiated by Peter, followed, including theatre projects. Having met a group of dancers who had worked with schoolchildren to produce a dance about insects, Peter applied to the BBSRC for an outreach grant. Together with support from our Society and the Arts Council, he worked with choreographer Jules Lavel to coordinate a contemporary dance production on insect movement, which was performed at Plymouth's Barbican Theatre, which holds 200 people. *Syncapoda* was a sell-out weekend, after which the production went on tour around various festivals and venues in the south west. Later, Peter worked with Electric Voice Theatre to produce the one-act opera "Miriam", which charts the life of Miriam Rothschild in her own words; this premiered at Ento'13 in St Andrews and it is still doing the rounds today.

Pete on canopy walkway Borneo.

Travels

In 1997, Peter's colleague Paul Ramsay organised a student expedition to explore the ecology of the Andean páramo in Ecuador and asked if Peter fancied coming along. It was an amazing trip. They were in Ecuador for two months visiting a range of high-altitude habitats, both terrestrial and aquatic. The work each student undertook was to be their third-year dissertation, while Paul and Peter oversaw these and undertook projects of their own. The collective work was pulled together in a book 'The Ecology of Volcán Chiles'. Many invertebrates were collected, of which nine were new to science: eight carabid beetles, one of which was named after Peter (*Dyscolus smithersi*) and a false scorpion (*Cystowithius smithersi*), that lived among the dead leaves of the giant rosette plants (*Espeletia pycnophylla* ssp. *angelenis*).

Post-millennium, the university began to explore the possibility of exotic field trips for their ecology students, and one such trip was to Danum Valley Research Station on Borneo. In 2005 Peter blagged his way onto the trip as an extra pair of hands and then, to his shock and horror, the trip leader, Linton Winder, obtained another job and left a month before they were due to go. A colleague of his took up the reins but, as Peter was the only entomologist going, he was given all Linton's teaching – a steep learning curve. Two weeks at Danum Valley was a stunning experience and he returned for the following five years until the university deemed the trip too expensive.

Roles in the Society

During the 1990s, Peter set up the *Devon Invertebrate Forum*, giving local naturalists the opportunity to meet and exchange ideas. Dorset and Cornwall joined in and it became the *Peninsula Invertebrate Forum*. In 2001, when Peter became Regional Honorary Secretary, it seemed sensible to merge the two. Take a look at the report on activities in the Southwest Region over the past year or so (pages 134–137) and Peter's enthusiasm for, and huge contribution to, Society events will be immediately obvious.

In 2005, Peter was approached about the possibility of becoming an *Antenna* editor. "I froze in my seat. All the editors until then had been world-class entomologists – and they are asking me. And I can't spell!" His colleague, Paul Ramsay, persuaded him to go for it, and he never looked back, introducing various innovations and continuing in the role until 2017. It all became much easier when Andrew Smith was appointed printer. Prior to that, Peter had to do his own formatting.

Peter has also done a turn on Council, including a year as Vice President.

Now retired, Peter remains as keen as ever to ensure that as many people as possible are made aware of the importance of insects, warts and all, but remembering that their benefits vastly outweigh the problems they cause. What singles out Peter, is the hugely diverse and imaginative ways in which he achieves this. Freed from bureaucracy, I am sure that there is much more to come – watch this space!

Profile: Student Representatives

Max Tercel

I'm not sure of the exact moment insects began hypnotising me, but it must have happened pretty early-on in life. Some of my oldest memories are of ants marching along the pavement on their foraging trails. Terrestrial arthropods have been the focus of my education, curricular or otherwise, ever since. This was greatly enhanced by my attendance at Harper Adams University to study for an MSc in entomology, for which I was selected as one of the five Royal Entomological Society's scholars, and I also won the RES MSc Prize during this time! Thus, I'm incredibly grateful to the RES for such amazing support over the years. I'm now studying for a PhD based at Cardiff University in the Molecular Ecology and Evolution lab with Prof. William O.C. Symondson. My project is focussed on elucidating the trophic interactions of introduced ants on Round Island, Mauritius, and how they fit into the wider ecological network. This involves harnessing the power of high-throughput sequencing to reveal the diet of these ants. Furthermore, by setting up quadrats all across the island, we can sample the invertebrate community, describing it for the first time. In addition, collection of the native dominant invertebrate predator, the centipede *Scolopendra abnormis*, allows us to look at the diet of an important native predator in parallel to that of the introduced ant species. Do these introduced ants preferentially select certain prey species? Is there dietary partitioning or overlap between introduced ant species and native predators? Can certain native species co-occur with certain ant species but not others? These are some of the additional questions I hope to answer during my PhD. It's all so incredibly exciting for a myrmecophilous human! I'm greatly looking forward to helping run the next Postgraduate Forum for the RES and I can't wait to spread all the #EntoLove! I hope it will be productive (and fun) for the entomological postgraduate community.

Charlie Woodrow

My first introduction to insects was like many: jars and food containers full of whatever I could find in my small urban garden. This interest soon led to tanks full of stick insects, nets of moths in my bedroom, and all the mounted specimens eBay could offer! I enrolled onto a BSc in Zoology in 2016 at the University of Lincoln, and over the following 3 years had the growing realisation that I would never quite be interested pursuing a single field. Instead, I found a fondness for interdisciplinary work in evolution and ecology. My key research project at Lincoln was an assessment of the coevolution of avian malaria parasites and their songbird hosts. This project was a brilliant mix of fieldwork, lab practical, and theory, and led me to further interests in malaria parasites and their associated insect vectors. During the final stages of this degree in mid-2019, with still no idea what I would do next, I accepted an offer to be a temporary research technician for a curious project at Lincoln. The description for this project was to use transparent and ultrasonic katydids, which have an inner ear similar to the mammalian cochlea, to better understand the processes and mechanics of hearing. My role would be the maintenance and breeding of these katydids. These amazing insects gave me great interest in pursuing the next postgraduate role within this lab. In October 2019, I enrolled as the new PhD student on this ambitious project and started the role by describing a new genus of transparent katydid from Ecuador. My interests have since expanded to a broad variety of invertebrate topics, such as the rearing of neotropical katydids, the evolution of acoustic communication, and insect photography. Through presenting work from this role at the Orthoptera Special Interest Group in November, I was introduced to the fantastic RES. Since then, I have taken a greater interest in all of our spineless friends and was delighted when this rep opportunity became available! I am very much looking forward to organising future events and meeting fellow enthusiasts and scientists.

SCHEDULE OF NEW FELLOWS AND MEMBERS

as at 6th May 2020

New Fellows (1st Announcement)
Mr Richard John Lewington

Upgrade to Fellowship (1st Announcement)
None

New Fellows (2nd Announcement and Election)
Professor E Benton (as at 4.3.20)
Dr Matthew Lincoln Gimmel (as at 4.3.20)
Mr Michael John Friend (as at 4.3.20)
Dr Ross Piper (as at 4.3.20)
Dr Yannick Wurm
Dr Juliano Morimoto
Dr Arjun Shukla

Upgrade to Fellowship (2nd Announcement and Election)
Dr David Thomas Williams
Dr Islam S Sobhy

New Members Admitted
Mr Lee Robert Bison (as at 4.3.20)
Mr Kieran Anderson
Mr Tim Newton

New Student Members Admitted
Mr Stu Straw
Miss Amy Louise Carter
Miss Rachel Turner
Ms Keir Flowerdew
Mr Mark Andrew Bridges

Re-Instatements to Membership
Dr Mark Ramsden

Re-Instatements to Student Membership
Mr Harrison Lambert (as at 4.3.20)

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as at 3rd June 2020

New Fellows (2nd Announcement and Election)
Mr Richard John Lewington

New Members Admitted
Dr Joseph Mark Roberts
Mr Glenn Millar
Mr Richard Roe

New Student Members Admitted
Mr C Woodrow

Deaths
Mr Walter Wilkinson, 1956, UK

Reviews

The following reviews are available on the *Antenna* website:
www.royensoc.co.uk/antenna/reviews

Wasp, by Richard Jones.
Reaktion Books. ISBN 978-1-789141-61-0. £12.95.
Reviewed by Adam Hart.

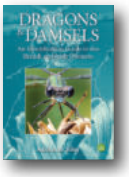
Courtship and Mating in Butterflies, by Raymond J.C. Cannon.
CABI. ISBN 978-1-789242-63-8. £95.00.
Reviewed by Richard Harrington.

Concise Guide to the Moths of Great Britain and Ireland (Second Edition)
by Martin Townsend and Paul Waring. Illustrated by Richard Lewington.
Bloomsbury Wildlife. ISBN 978-1-4729-5728-3. £18.99.
Reviewed by John Walters.

Butterflies of South Africa: A field guide (Second Edition), by Steve Woodhall.
Bloomsbury Wildlife. ISBN 978-1-4729-7371-9. £25.00.
Reviewed by Peter Smithers.

Aphids as Crop Pests (Second Edition), edited by Helmut F. van Emden & Richard Harrington.
CABI. ISBN 978-1-7806-4709-8. £180.00.
Reviewed by Jen Banfield-Zanin.

Extraordinary Insects, by Anne Sverdrup-Thygeson
(translated from the Norwegian by Lucy Moffatt).
Mudlark, an imprint of HarperCollins Publishers. ISBN 978-0-00-831635-8.
Hardback £14.99; e-book £6.99.
Reviewed by Stuart Reynolds.



Dragons & Damsels: An Identification Guide to the British and Irish Odonata,
by Adrian M. Riley.
Brambleby Books. ISBN 978-1-9082-4164-1. £22.00.
Reviewed by Richard Harrington.

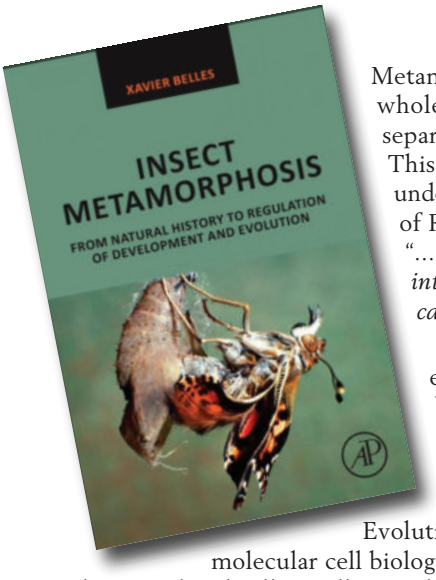
Nature Underfoot, by John Hainze (illustrated by Angela Mele).
Yale University Press. ISBN 978-0-300-24278-2. £20.00.
Reviewed by Peter Smithers.

Hawkmoths of Australia. Identification, Biology and Distribution
(Vol. 13 in Monographs of Australian Lepidoptera)
by Maxwell Moulds, James Tuttle and David Lane.
CSIRO Publishing. ISBN 978-1-4863-0281-9. AU $220.00 (ca £120).
Reviewed by John Tennent.

Insect Metamorphosis, by Xavier Bellés.
Academic Press. Paperback ISBN 978-0-12-813020-9;
eBook 978-0-12-813021-6. £78.15.
Reviewed by Stuart Reynolds.

Insect Metamorphosis

Xavier Bellés
Academic Press
Paperback ISBN 978-0-12-813020-9
eBook ISBN 978-0-12-813021-6
£78.15



Metamorphosis, especially in its complete form, is one of the most striking phenomena in the whole of biology. It is as though a single life-form occupied two (or even three) entirely separate and alternating bodies that transformed from one to another during each generation. This has fascinated interested observers at least since the ancient Greek philosophers. To understand why metamorphosis is so strange to us, just stand back and appreciate this remark of Robert Evans Snodgrass [*Smithsonian Miscellaneous Collections*, **122** (9), 1-124 (1954)]: *"…in entomology we commonly think of metamorphosis as the transformation of a larval insect into the imago. In so doing, however, we overlook the fact, quite as extraordinary, that a caterpillar hatches from the egg of a butterfly."*

Is the caterpillar really the same individual animal as the butterfly? How is this extraordinary transformation achieved? What is the proximal reason for the change in body form? And how did the process evolve? Among other reasons for its perennial interest is the notion that metamorphosis is a larger scale, and therefore experimentally accessible, model for the development of an embryo from a fertilised animal egg.

In this excellent new book, Xavier Bellés, from the CSIC/UPF Institute of Evolutionary Biology in Barcelona, tackles insect metamorphosis with a special emphasis on molecular cell biology, but also relates this to the biological processes that are initiated and regulated by the hormonal and cell signalling pathways he describes. Bellés is an expert on this. He is one of a small number of scientists who worked out the nature of the MEKRE93 pathway, the regulatory system of three transcription factors, Met, Krüppel, and E93, which respectively direct the formation of the larval, pupal and adult stages of holometabolous insect development. A lot of the reason for writing this book was to explain how this pathway accounts for much of what is seen to occur during metamorphosis.

An important point, however, is that Bellés's own research concerns metamorphosis in hemimetabolic insects (i.e. those that undergo incomplete metamorphosis and don't have a pupal stage). This gives him a special perspective on the evolution of complete metamorphosis (i.e. that undergone by holometabolous insects). One of the take-home messages of the book is that the same signalling pathway is present in both kinds of insect and has been adopted during evolution by holometabolous insects for their own purposes with only minor adaptations. Moreover, Bellés is also an accomplished traditional entomologist with an interest in cave insects, some of which show extraordinary metamorphic adaptations. This allows him to write with authority on some of the more extraordinary variations in metamorphosis that are seen in non-model insects, and the book is particularly good on this topic, last covered with authority by Snodgrass [1954, *op. cit.*].

The resulting book is very good indeed. Its publication is an important event for entomology because it is the first attempt for many years to bring together in one place everything that is known about insect metamorphosis. It should certainly be in the library of every institution where insect science is studied. It is also an important book for all those who study animal phylogeny and evolution in general. Its publication is timely. Although there have been multi-author collections of papers about insect metamorphosis, the last major single-author scientific book about insect metamorphosis that attempted both to be comprehensive and to provide an authoritative overview was published no less than 66 years ago [Wigglesworth, V.B. (1954) *The Physiology of Insect Metamorphosis,* Cambridge University Press]. Thus, Bellés's book is now the most obvious starting point for advanced students of entomology, especially graduate students beginning to work on this topic for the first time, and also of course the authors and revisers of general textbooks of entomology.

The book is best described as a monograph, although it is much broader in its scope than most such publications. As is to be expected, Bellés gives due prominence to the work of his own group on metamorphosis, but he ranges very much wider than this, and I would say that he has been scrupulously fair in dealing with the contributions of others. This is particularly important because there are still points of significant controversy in the field.

Writing this book can have been no mean task. The sheer mass of literature on insect metamorphosis is intimidating. Weighing the importance of all those papers requires a great deal of experience. This kind of sifting, comparing the work of many individual scientists to theories which may be of long standing (and which sometimes deserve to be overturned!), is an essential component of the collective scientific enterprise. I am firmly convinced that a book is sometimes the best way of doing this, and I am heartily glad that Bellés has attempted this task on behalf of the community of students of insect metamorphosis.

The book is not always an easy read because it is packed with detail and includes a very large number of references. This is obviously a very strong point. Its breadth and depth go much further than any available recent review paper (examples are the several papers in a special issue of *Philosophical Transactions of the Royal Society* (Vol. 374), and the excellent recent review paper in *Current Biology* by J.W. Truman, 2019). I'd like to tell you exactly how many references

there are in Bellés's book but because they are listed at the end of each chapter and many are thus listed multiple times, they are hard to count. I confess that I would have preferred a single list for the whole book.

This raises an interesting point. The reason that the references are listed in this way is presumably because the book is also available in electronic form, one chapter at a time (each chapter has its own DOI identifier). In preparing this review, I used a real printed copy of the book. But I suspect that most readers will actually look at the electronic version, and I fear that this probably means many people will just look at one chapter. They probably won't actually read the book all the way through, as it deserves. Perhaps I am getting to be a bit of an old fogey, but to appreciate the integration of a subject that a good book can achieve, I think that you have to read the whole of it.

Stuart Reynolds

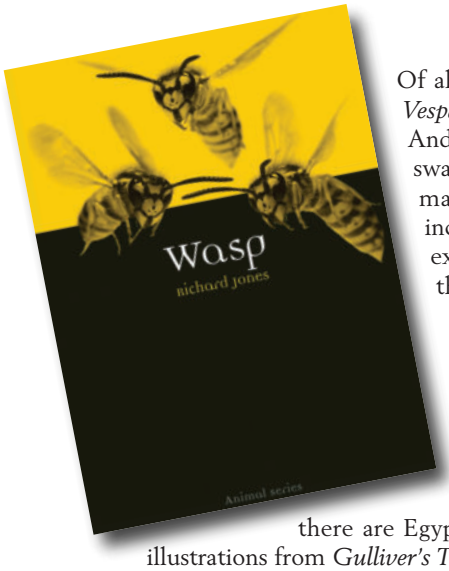
Wasp

Richard Jones

Reaktion Books

ISBN 978-1-789141-61-0

£12.95



Of all the insects, it is the wasps, by which I mean the social wasps of the genera *Vespula* and *Vespa*, that get by far the worst press and have the most work to do to improve public relations. And whilst we entomologists might implore the public (as indeed I have many times) "not to swat them", to "appreciate their beauty" and to "marvel at their social lives", I am confident that many of us have lashed out in irritation as summer progresses and eating outside becomes increasingly annoying. This latest book by Richard Jones, simply entitled *Wasp*, is part of the excellent Reaktion series and, throughout its pages, Jones does his absolute best to stick up for these most vilified of insects.

A handy paperback-sized volume, the first thing that struck me about the book was just how lavishly it is illustrated. Few pages are without some kind of figure or photo and in many cases the illustrations are in colour. As a consequence, it is an enjoyable book just to leaf through, especially the many illustrations of wasps in popular culture, and more niche culture. The wasp-woman chimera, unimaginatively called Wasp Woman, from the 1959 film of the same name is particularly striking for those of us who know recently elected Fellow Dr Seirian Sumner (UCL), who tweets under the name WaspWoman. Elsewhere there are Egyptian wasp hieroglyphs (or is it a bee? – the jury is still out apparently), cigarette cards, illustrations from *Gulliver's Travels* and even a Japanese sword hand guard featuring a wasp. These cultural references sit alongside more realistic depictions of wasps and wasp biology, ranging from photos to figures from classic wasp-related texts.

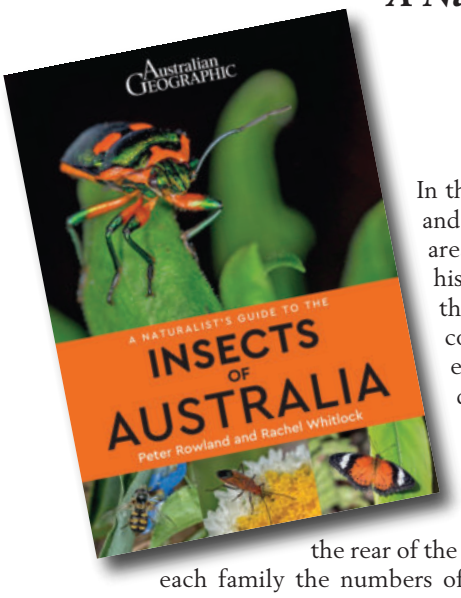
When it comes to content and readability, the book is no less impressive. With a book like this you want a combination of comforting, familiar content, things you knew at one point but had forgotten, and plenty of material that is new and interesting. Each chapter is loaded with all of the above and the narrative flows along at a great pace without ever getting too technical or too simplified. A nice touch is the weaving of different types of content (for example the cultural and historical angles as well as the biology and ecology of wasps) throughout the book rather than isolating each to a specific chapter. A particularly interesting chapter is titled "Tabloid Mayhem". For those of us who deal regularly with the hysteria that wasps provoke, this chapter has a familiar ring. However, with analyses of the children's programme *Fifi and the Flowertots* woven in with the coming of *Dolichovespula media* and the Asian hornet, there is always a surprise or two in store.

Like all the Reaktion books, this book is written to be read, not to be dipped into occasionally as a reference work. It certainly fulfils that purpose but its shepherding together of so much "wasplore" may well mean it finds a place on the "wasp shelf" of many of us – it is certainly on mine.

Jones ends the book with the words "Now is the time to take a stand with the wasps. The truth is out there, but to deliver it the wasps need all the help they can get". With this book, Jones not only stands by the wasps, he gives them a big dose of the help they need to become, if not loved, then at least less loathed.

Adam Hart
University of Gloucestershire

A Naturalist's Guide to the Insects of Australia



Peter Rowland & Rachel Whitlock

John Beauty Publishing

ISBN 978-1-912081-80-6

£9.00

In their introduction, the authors clearly state that this book sets out to cover a range of genera and representative species that are commonly encountered or broadly distributed in the eastern area of Australia that runs from Darwin to Adelaide. It is a book that will appeal to natural historians of all ages who want an easy-to-transport guide that will offer basic information on the insects they might encounter while traveling around eastern Australia. The book is small, colourful and attractive so it will have instant appeal to travellers and tourists. It covers twenty-eight orders of insect with a brief overview of each in the introduction. The common or distinctive families in each order are then illustrated with photographs of representative genera and species. Each of these is accompanied by a description of the species plus notes on its distribution, habitat and biology.

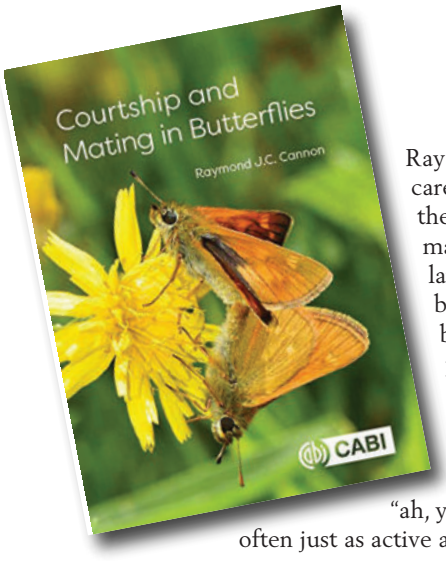
While this guide only sets out to offer the briefest of overviews of insect diversity in eastern Australia, it sets this in the wider context of the incredible diversity that this fauna offers. At the rear of the book is a table that lists all of the insect orders and the families that they comprise, listing for each family the numbers of genera, species and subspecies that they contain. This very neatly gives the reader an appreciation of the vast number of insect species found in the region.

There is also a brief account of insect lifecycles, a glossary and an index, plus a list of useful websites and references for further reading.

For anyone unfamiliar with the insects of this region this book is excellent value for money. It is a small gateway to a vast subject and will, I hope, stimulate many of its readers to go on to acquire a greater interest and appreciation of Australian insects.

Peter Smithers

Courtship and Mating in Butterflies



Raymond J.C. Cannon

CABI

ISBN 9781789242638 (hardback)

£95.00

Ray and I were at Imperial College together way back when, and both of us began our research careers studying aphids. Ray moved to the cold hardiness of Antarctic invertebrates and then the impact of invasive invertebrates. Neither of us worked professionally on butterflies but, like many entomologists, both have a deep fascination with them which, in Ray's case, started rather later with the advent of digital photography. He has taken some truly marvellous pictures of butterflies around the world, many of which feature in this book. This is not, though, a picture book with a little supporting text; rather it is very much a textbook with a few supporting pictures. At 375 pages, it is not likely to be read in a hurry and this review, I confess, results from selective reading on the topics that I thought would interest me most. For example, I have often witnessed the phenomenon of "hill topping" and am aware of the trade-offs between "perching" and "patrolling". I now have a much deeper knowledge of the extent of, and reasons behind, these behaviours, and many more. I often found myself thinking "ah, yes, I've seen that – so that's what they were up to". I hadn't realised, though, that females are often just as active as males in soliciting courtships.

After an introduction to the origins, evolution and taxonomy of butterflies, together with a summary of a few pioneering and influential studies on courtship, there are nine chapters dealing with different aspects of the behaviour and mechanics of courtship and mating (mate choice, mate location, vision, courtship (two chapters), mating (two chapters), chemical communication, wing colours). The book has the content and feel of a symposium volume, and it is remarkable that Ray has compiled each of the ten chapters himself by wading, joyfully it seems, through copious papers and volumes (there are 59 pages of references!), succinctly synthesising key points. Of course, only a tiny fraction of the world's species has been studied in this regard, but Ray attempts generalisations where appropriate and with care, and couches the behavioural research findings in their evolutionary, phylogenetic, physiological and ecological contexts. Whilst the book is about butterflies, in many senses butterflies are models, as some of the concepts are applicable across a wide range of organisms.

At £95, this book is perhaps more likely to find its way to university libraries than private bookshelves. It's well worth getting your hands on, though, as, next time you see butterflies indulging in some strange behaviour, you will know exactly where to go in order to find out what it was all about. In the process, your knowledge of, and fascination for, this iconic insect group cannot fail to be enhanced.

Richard Harrington

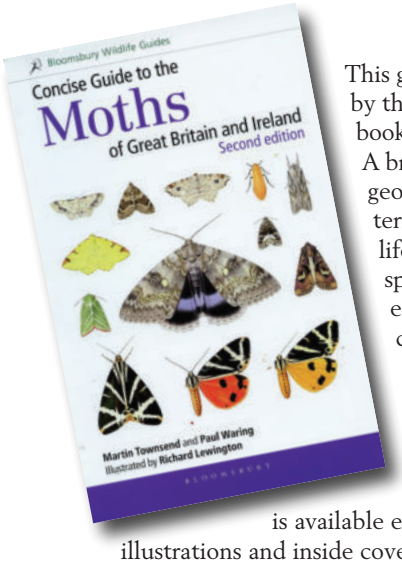
Concise Guide to the Moths of Great Britain and Ireland (Second Edition)

Martin Townsend and Paul Waring. Illustrated by Richard Lewington

Bloomsbury Wildlife

ISBN 978-1-4729-5728-3

£18.99



This guide is a companion to the *Field Guide to the Moths of Great Britain and Ireland* Third Edition by the same authors, designed to be used in the field. It has a spiral wire binding which enables the book to be folded flat. Over 1,700 illustrations are used to enable identification of nearly 900 species. A brief introduction and description of the abbreviations used is given. These include current status, geographical distribution and habitat preferences. Annotated illustrations then show the terminology used. These are all clear and easy to understand. All the 'macro' moths are shown at life-size except the 'pug' moths which are slightly enlarged. As this is an arbitrary selection of species established in the early 1900s in Richard South's guides, some of the larger 'micro' moths e.g. Small Magpie and Brown China-mark are also illustrated, along with a caddisfly which may confuse the beginner.

The brief species accounts are shown opposite the plates and contain the main identification features. The superb illustrations by Richard Lewington portray the moths in a consistent way that photographs just can't match and contain a distillation of over twenty years of close observation and interpretation of the identification features. It is true that more information will be required to identify some of the problematic groups, e.g. the waves and pugs, but this is available elsewhere in the Field Guide and in online resources. There is plenty of space around the text, illustrations and inside covers to add additional notes. The latest taxonomic order is followed and recent additions to our ever-changing moth fauna are included, providing an excellent up-to-date reference.

This book would have been a dream to me when I started studying moths in the mid-1970s and I thoroughly recommend it to anyone with an interest in British and Irish moths.

John Walters

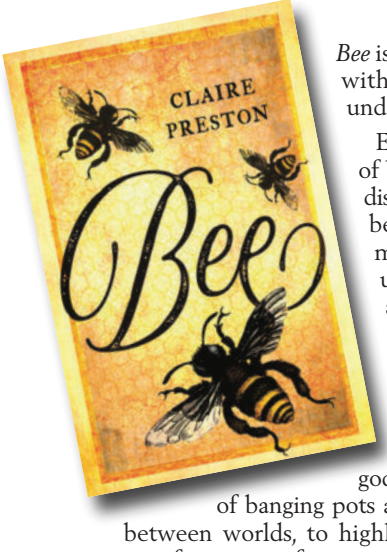
Bee

Clair Preston

Reaktion Books

ISBN 978-1-78914-048-4

£9.99



Bee is another of Reaktion's distillations on the cultural relationship that human civilisation has established with the animal kingdom. In *Bee*, Clair Preston describes the domestication, exploitation, gradual understanding and interpretation of the honeybee and its society.

Early chapters introduce this relationship and outline the biology of the honeybee, as well as the history of bee keeping. The following chapters examine bee society as a model for human political systems, and discuss historical perspectives on the colony's cleanliness, civil order and social stability, a view that presents bees as pious, chaste and hard-working creatures. These chapters also outline some of the misunderstandings and incorrect assumptions that early apiarists have made. *Bee* then examines the many uses that humans have made of bees and their products, ranging from honey itself to beeswax, propolis and the production of mead, but also looks at the value of bee pollination to agriculture and the use of bee products by the pharmaceutical industry. The book then goes on to examine the influence of bees on the arts, from the perfect design of the hexagonal cell to its influence in architecture, from ancient Greece to the Alhambra and Gaudi's more recent buildings. It also looks at the creation of the beehive hairstyle and the influences of bees in both madrigals and classical music.

The chapter 'Bees in Folklore' examines references from Shakespeare and bees as nurturers of the gods; Pan, Dionysus and Zeus were all fed by bees as babies. It offers a history of 'tanging' (the practice of banging pots and pans to attract bees), how the Mormons adopted bees as their emblem and bees as messengers between worlds, to highlight but a few of the fascinating references. In the chapter 'Bee Movie', Preston describes the transformation of our view of bees in the 19th century from diligent worker to mere mechanical parts in the hive machine, a view driven by the industrial revolution and the rise of factories. Then, in America, anti-communist sentiment added to this view presenting bees as a Marxist enemy, a view that was aided by the famous B horror movies which often featured bees as monsters.

The final chapter looks at real and fictional celebrities who have taken up bee keeping as a retirement occupation and also offers an outline of colony collapse, along with a look at possibilities for the future, where bees could be trained to detect drugs, explosives and landmines.

Bee offers an in-depth account of our relationship with bees via a kaleidoscope of illustrations and historical accounts. Unlike other books in this series it is a history rather than an overview of our cultural links with bees, but viewed as such it offers an excellent but densely packed chronology of this relationship.

Bee is an excellent addition to the libraries of beekeepers and naturalists who are looking for a greater appreciation of this ancient craft.

Peter Smithers

Diary

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 Honorary Secretary.

MEETINGS OF THE ROYAL ENTOMOLOGICAL SOCIETY

COVID-19

We continue to follow the current Covid-19 Government advice and work from home as much as possible. Mansion House is currently open on Wednesdays and Thursdays only, but remains closed to visitors.

Our Librarian will not have access to our collections from home, but will be happy to try to locate references available to download from the internet.
val@royensoc.co.uk

Our online shop remains open.

Infection and Immunity Special Interest Group
Thursday, 24 September – Friday, 25 September, 2020
Web-based video-conference.
Please see *http://infectionandimmunity2020.mystrikingly.com/#home* for further details.

Data, Ecology and Electronics & Computing Special Interest Groups
Monday, 19 October, 2020
Web-based video-conference.
For more details, please see RES website.

Scottish Regional Meeting
Wednesday, 4 November, 2020
Web-based video-conference.
For more details, please see RES website.

Orthoptera Special Interest Group
Wednesday, 11 November, 2020
Web-based video-conference.
For more details, please see RES website.

Pollination Special Interest Group
Tuesday, 29 June – Thursday, 1 July, 2021
Pollinators in Agriculture
Copthorne Hotel, Slough

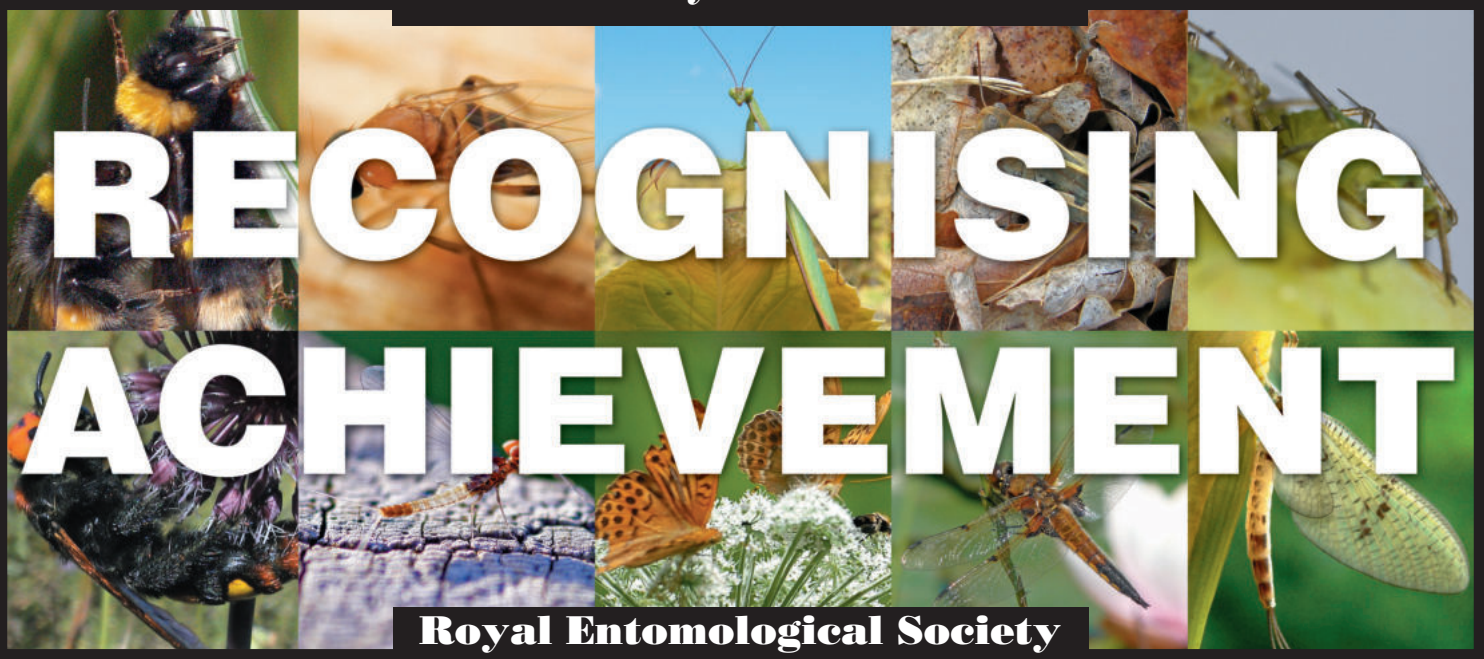
NON-SOCIETY MEETINGS

XXVI International Congress of Entomology, Helsinki, Finland, Re-scheduled 19 July – 24 July, 2021
'Entomology for our planet'

International Conference on Urban Pests, ICUP2020, Re-scheduled 13 September – 15 September 2021, Barcelona

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

www.royensoc.co.uk



RECOGNISING ACHIEVEMENT

Royal Entomological Society
– Society Awards –

For more details on these Society Awards please see www.royensoc.co.uk

THE ROYAL ENTOMOLOGICAL SOCIETY STUDENT AWARDS

Award Criteria: Any article about an entomological topic that would be of interest to the general public. The article to be easy to read, in a popular style and no longer than 800 words.

Prize: Winner £400, runner up £300, third place £200, all three articles published in *Antenna*.

THE L.J. GOODMAN AWARD FOR INSECT BIOLOGY

Award Criteria: For advancing the education of the public in the knowledge, understanding and appreciation of all aspects of insect physiology and behaviour, thereby promoting the control and conservation of insect species.

For promoting research into aspects of insect physiology and behaviour through online, digital or printed material.

For supporting exhibitions, meetings, lectures, classes, seminars and courses that widen the understanding of insect physiology and behaviour.

Grant: No individual award shall exceed £3,000 and not more than £6,000 shall be awarded each year.

THE ALFRED RUSSEL WALLACE AWARD POSTGRADUATE AWARD

Award Criteria: For postgraduates who have been awarded a PhD, whose work is considered by their Head of Department to be outstanding. The research involved should be a major contribution to the science of entomology.

Prize: £800 plus certificate, plus one year's free membership. The winner will also be invited to present their work at a Society Meeting.

J.O. WESTWOOD MEDAL – AWARD FOR INSECT TAXONOMY

Award Criteria: The best comprehensive taxonomic work on a group of insects, or, related arthropods (including terrestrial and freshwater hexapods, myriapods, arachnids and their relatives). Typically, this will be a taxonomic revision or monograph.

Prize: A specially struck silver gilt medal inscribed with the winner's name. Also costs incurred in attending the International Congress of Entomology, European Congress of Entomology, or other major meeting (specified by the adjudicators) to present his/her work.

RES JOURNAL AWARDS SCHEME

Award Criteria: The best paper published in each Society Journal over a two year period. Each of the Society Journals participates biennially.

Prize: £750 and certificate for each participating Journal.

THE WIGGLESWORTH MEMORIAL LECTURE AND AWARD

Award criteria: The outstanding services to the science of entomology. The award will be made to a researcher who has contributed outstanding work to the science and who best reflects Sir Vincent Wigglesworth's standards of personal involvement in every aspect of his/her research.

Prize: A specially struck gilt medal inscribed with the winner's name. Also the costs of attending the International Congress of Entomology to give the Wigglesworth Lecture.

BOOK PURCHASE SCHEME FOR FELLOWS AND MEMBERS IN DEVELOPING COUNTRIES

Award Criteria: To provide assistance in purchasing specialist taxonomic books, that will assist in the identification of insect groups being studied in developing countries and their regions. Applicants will be required to demonstrate need and specify particular texts.

Prize: Any one applicant may be awarded up to £250 in a three year period. The Society will purchase the texts awarded and send them to the applicant. The applicants may, themselves, provide any additional funds in excess of the amount awarded.

OUTREACH AND CONFERENCE PARTICIPATION FUNDS

Award Criteria: ORF: Grants to support activities which further the Society's aims. This may range from, help to purchase equipment, to help in funding expeditions/meetings. CPF: Grants to assist applicants who are participating in a meeting or conference in some way, e.g. presenting a paper/poster.

Prize: ORF: Monetary grant. CPF: Monetary grant.

Royal Entomological Society
www.royensoc.co.uk

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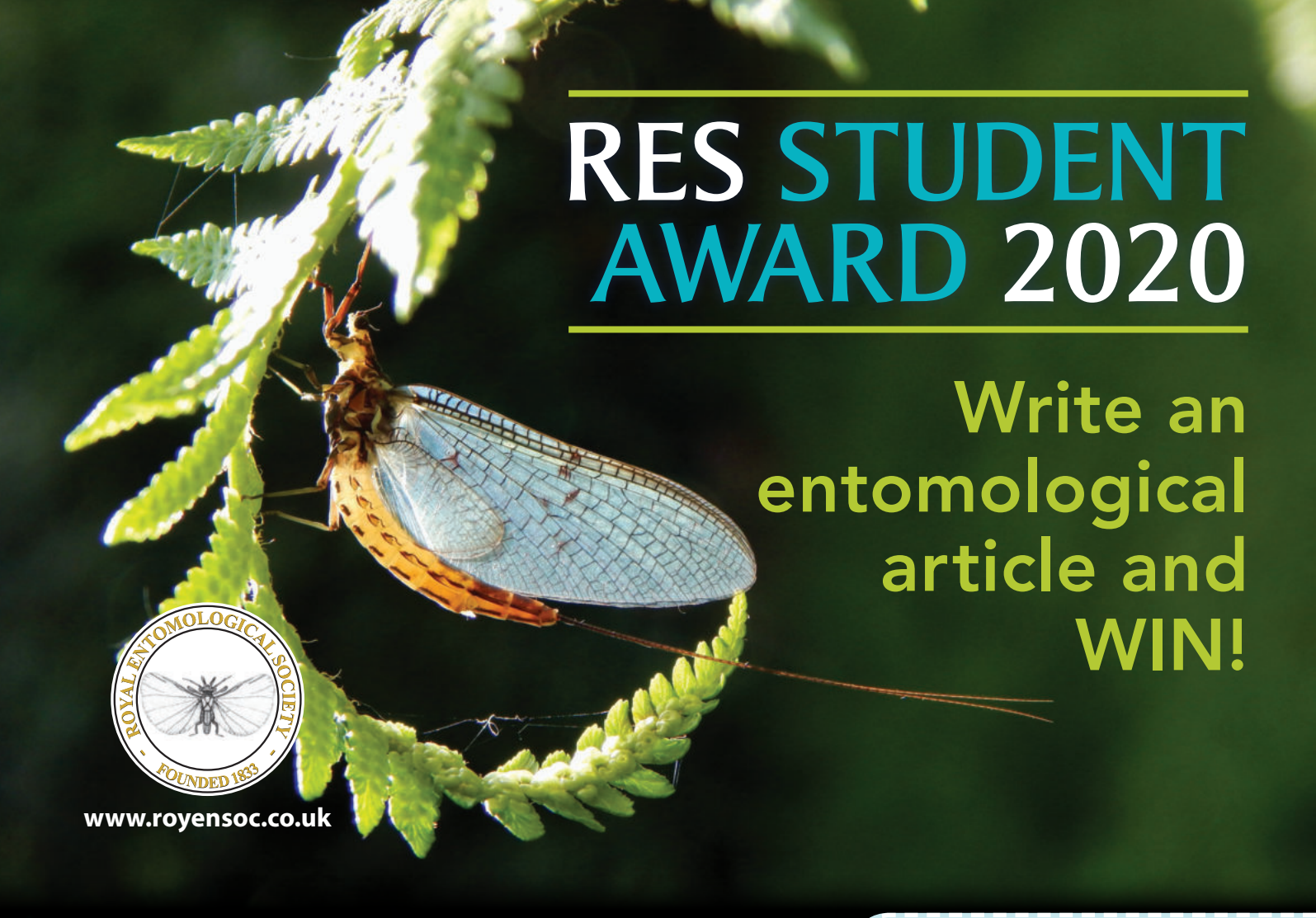
E-mail: info@royensoc.co.uk



RES STUDENT AWARD 2020

Write an entomological article and WIN!

www.royensoc.co.uk

REQUIREMENT

Write an article about any Entomological topic that would be of interest to the general public. The article must be easy to read and written in a popular style. It should be no more than 800 words in length.

WHO CAN ENTER?

The competition is open to all undergraduates and postgraduates, on both full and part-time study.

PRIZES

First Prize: A £400 cheque and your article submitted for inclusion in *Antenna*.

Second Prize: A £300 cheque and your article submitted for inclusion in *Antenna*.

Third Prize: A £200 cheque and your article submitted for inclusion in *Antenna*.

ENTRIES

You can send electronically via e-mail to **kirsty@royensoc.co.uk**

Alternatively, complete the attached entry form, and submit it with five copies of your entry to:

The Registrar,
Royal Entomological Society,
The Mansion House,
Chiswell Green Lane,
St Albans, Herts
AL2 3NS

For further information telephone **01727 899387**

Please include:

- Your name and address (including postcode)
- Your e-mail address
- The name and address (including postcode) of your academic institution
- Evidence of your student status e.g. student I.D. card

THE JUDGES

The judges panel will be made up of three Fellows of the Royal Entomological Society. The judges decision is final.

CLOSING DATE

The closing date for entries is 31 December 2020. The winner will be announced in the Spring 2021 edition of *Antenna* and on our website.

PLEASE CUT AND RETURN THIS PORTION WITH YOUR ENTRY

Article title: _____

_____

_____

Student name: _____

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Address: _____

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Telephone: _____

E-mail: _____

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Name of academic institution:

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