Bulletin of the Royal Entomological Society Volume 45 (1) 2021

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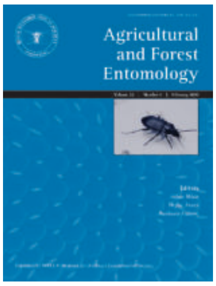

Publications of the Royal Entomological Society

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
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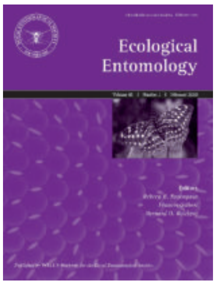

Ecological Entomology publishes top-quality original research on the ecology of terrestrial and aquatic insects and related invertebrate taxa. Our aim is to publish papers that will be of considerable interest to the wide community of ecologists. RES Members: print £163, online £81
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Insect 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
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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.
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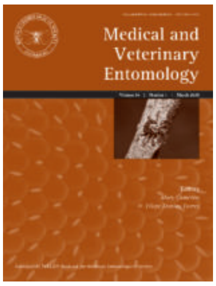

Medical and Veterinary Entomology is the leading periodical in its field. It covers all aspects of the biology and control of insects, ticks, mites and other arthropods of medical and veterinary importance.
RES members: print £94, online £47
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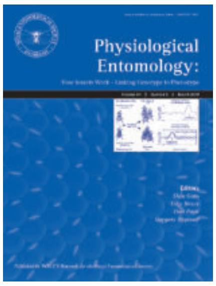

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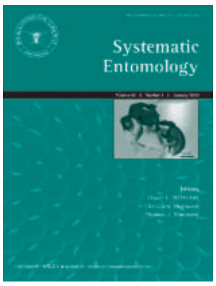

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RES Members: print £153, online £76
2020 print or online prices: UK £1,528, Euroland €1,944, USA $2,825, Rest of World $3,296
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Subscription and correspondence concerning back numbers, off-prints and 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).

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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 20-23 by CABI.

CONTENTS

COVER PICTURE

Vespula germanica by Alan Clark.
Winner of National Insect Week Photography Competition.

Author Guidelines

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

Submissions are made by email to *antenna@royensoc.co.uk* and reviewed by *Antenna's* Editorial team. There are no page charges for publication in *Antenna*, where we encourage use of full colour figures and photographs to accompany text. Standard articles are normally 1,000-4,000 words in length and submitted with four to eight images (file should be original size of image taken and not reduced in size nor cropped heavily).

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COPY DATES
For *Antenna* **45** (2) – 1st April 2021 (DG)
For *Antenna* **45** (3) – 1st July 2021 (RH)
Diary Copy date:
five days before *Antenna* copy date above.

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The following are the subscription rates due on 1st March 2021: Fellows £68.00, Members £62.00, Students £20.00 (first year of membership free), Early career (2 years after studies end) £35.00, Discounted rate – over 65/ country/career break/unemployed/parental leave £45.00. The journals of the Society are available to individual Fellows and Members at preferential rates via the Subscriptions Department at The Mansion House. *Antenna* is supplied free of charge to Fellows and Members not in subscription arrears. **Cancellation of Journal subscriptions must be notified to Subscriptions Department before the 31st October in the year preceding cancellation.**

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

EDITORIAL

So much great material and so little space. I'll be brief(ish). First, I'm going to don my other hat (Chair of Meetings Committee). Please register for the virtual ENTO'21 (see below). By the time you read this, I hope that the main session topics will have been decided, but check the website and if the call for ideas is still there, please answer it! You may still be able to offer theme-appropriate talks for some of the sessions and can offer posters on any topic you wish. The International Congress of Entomology has been postponed to 2022. This is sad, but you can get your fix by joining in ENTO'21. My other request is for articles for *Antenna*. We've had some wonderful contributions during lockdown, but the copy-bank is now dropping. Or write letters – long ones or short ones – it's great to get a conversation going, just as Rowan Edwards' letter in the last issue prompted a response from Dick Vane-Wright in this one.

This is a colourful issue, featuring as it does the results of the National Insect Week photography competition, some amazing pictures of Spanish dung beetles from shutterbug Ray Cannon, and some artistic representations of invertebrates in advertisements, compiled by Peter Smithers. Before all that, Stuart Reynolds presents a sequel to his last Research Spotlight, which discussed why insects acquired wings, and considers why, having gone to all that trouble, some have done away with them. As an undergraduate at Imperial College, I was taught genetics by the great W.D. (Bill) Hamilton. Truth told, his lectures lacked a certain *je ne sais quoi*, and it wasn't until sometime later that I discovered I had been taught by a genius. Bill died 20 years ago and is celebrated herein by Sérvio Ribeiro. Also celebrated is Elizabethan entomologist Thomas Penny, described by John Whittaker as the first significant English entomologist.

Four excellent virtual meetings are reported, updates from Council are provided, and the five new RES MSc Scholars introduce themselves. The Honorary Fellow interviewee is our President, who also has inspiring things to say in her own column.

Very many thanks to all contributors.

Richard Harrington

Welcome to our CEO

Simon Ward has been named as the Society's Chief Executive Officer, a newly created role. He will join the RES in April from the Field Studies Council, where he is currently Head of the East Region and Education Lead.

Simon brings 18 years' experience in the charitable sector with a focus in ecology and geography. He is a Trustee of the Council for Learning Outside the Classroom, a Fellow of both the Royal Society of Biology and the Royal Geographical Society and a former member of the British Ecological Society's Education and Careers Committee. He said 'To be given the opportunity to lead such a respected organisation as the Royal Entomological Society is a huge privilege. I look forward to leading the Society in promoting excellence in entomology, and to the exciting ways in which this can be communicated to a wider audience'.

ENTO'21

23rd - 27th August 2021

REGISTRATION IS OPEN

ENTO'21 will be entirely virtual. There will be two sessions on each of five days, one from 11.00 until 13.10, and one from 13.50 until 16.00. There will also be a "poster room".

Registration is free to members and to non-member students. For other non-members, registration is £50 and delegates will become members (if they wish) for the rest of the membership year.

For information on registration and offering presentations, see: www.royensoc.co.uk/ento21

Richard Harrington
Chair, Meetings Committee
richard@royensoc.co.uk

Correspondence

Species, unique names and type specimens

Dear Editor

The late Robert May used to ask, with a mischievous grin, how was it that astronomers could catalogue billions of stars, while taxonomists couldn't manage even a few million species? The answer of course lies in the fact that stars are unique – each one an individual. In contrast, extant species typically comprise millions of individual organisms – many already dead, some alive now, and potentially many yet to be born. Moreover, the vast majority of these individuals, past, present and future, are never encountered by a taxonomist – or, indeed, by any human at all. Each and every individual organism that makes up a species (an ancestor-descendant lineage) can be, and often is unique – and this is certainly true of sexually reproducing organisms with extensive genetic polymorphism, such as the vast majority of insects.

The conventional taxonomic system operates two simple rules to ensure that each species (as conceived in a taxonomic act) can have a unique name applicable to it, and one simple method to ensure that each name that has been formally proposed can be applied unambiguously to a given species. The first rule is that of homonymy – if ever the same Linnaean binomen (generic name + specific epithet) is applied to more than one species, then all such names bar one must be replaced (there are subsidiary rules concerning how this is done). The second rule is that of priority – if two or more different names are applied to the same species, then there are rules and procedures to determine which one is to be used. The type method ensures that every formally proposed name can be applied unambiguously to *a particular species in a given classification*. This involves the selection of a single specimen for each name to be the 'name bearer'. The task is then to determine which of the millions of species this type specimen belongs to. Whichever one it is determined to be, the name 'borne' by the unique type then applies, *ipso facto*, to that species.

In practice it can happen that two or more names can be attached to the same type specimen (in which case they are objective synonyms – and one must be given priority), that two or more names each borne by different type specimens are judged to belong to the same species (in which case they are subjective synonyms, and one must be given priority), or there is no type specimen (and thus no name) that fits with a given species – in which case the given species is unnamed, and a new binomen can be coined for it (subject to relevant subsidiary rules).

Writing in *Antenna* 44(4), p. 151 (2020), Rowan Edwards states that a binomen "*should refer only to specimens which are considered the same as the type specimen of*" that binomen. The phrase "are considered the same" is problematical because, as indicated above, it is very rarely the case that any two individuals ("specimens") are literally identical. This phrase must be replaced by something akin to "are considered to belong to the same ancestor-descendant lineage". But lineages cannot be observed directly, defined, or totally reliably confirmed by any test – they can only be inferred, discovered or recognised. Moreover, taxonomic systems continually evolve in an unending process of revision – what was once thought to be one species can later be seen, on the basis of evidence, to consist of two or more separate lineages, while others once thought to represent separate lineages can be placed together as a single species. In the former case, appeal to the name bearers (type specimens) is the means to decide which of the available names apply to each of the newly separated species (inferred lineages – some of which might be 'new'); in the latter case, the rules and procedures governing priority will be invoked to decide which of the two or more names formerly in use should be applied to the newly circumscribed species (revised inferred lineage), and which names should be regarded as synonyms.

I get the impression that Dr Edwards, a software engineer, is unfamiliar with the fundamentally provisional nature of biological taxa which lies at the heart of this matter – not only are taxa provisional, they are also undefinable because over time they are mutable. Type specimens are nothing more than a practical device for managing the application of formal names (although only from superfamily down to subspecies level), as the taxonomic system changes through time. I also suspect that a distinction made by G.G. Simpson (1961, *Principles of Animal Taxonomy*, Columbia UP, p. 18) is relevant to this discussion: "… *an individual never is and cannot be classified*. Classification involves only groups … An individual may be referred to or placed in a given group. This is often called 'classifying' the individual, but that is a misnomer. That process is *identification*, which is not the same as classification." An individual is always that individual – but in contrast a group (taxon) is always subject to revision. There can be no guarantee of anything with scientific content signified in taxonomy (taxa) being permanently "correct". As individuals, type specimens are not the basis of classification – they are merely devices used to regulate the use of names (signifiers) when taxonomic changes are made. Their effective use is dependent on accurate identification – matching them to the species recognised within a particular taxonomic framework. Ultimately, this is always a subjective process.

Dick Vane-Wright, Canterbury
dickvanewright@gmail.com

Letter from the President

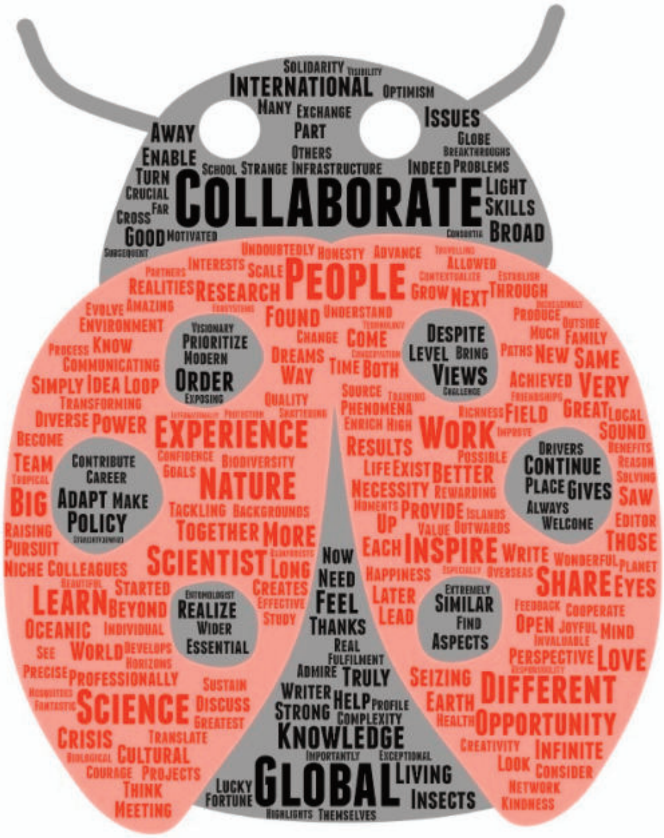
Helen Roy

Spring is on the way! For me, and other entomologists generally, it is an exciting time anticipating the stirring of ladybirds and another season of biological recording. I have been leading the UK Ladybird Survey with Peter Brown FRES for many years now and it is an incredible joy. Following the stories of these beautiful beetles as they unfold across the UK year on year is just captivating. However, the greatest privilege is collaborating with the inspiring volunteer recording community who provide so many records and often have a tale to tell of their fascinating ladybird encounters. We share the intrigue and excitement together. Even through the winter months records of ladybirds keep arriving and it's been gratifying to see some 7-spot ladybirds, *Coccinella septempunctata*, overwintering along the muddy paths I walked during the latest lockdown.

The links between people and nature have always been important to me. In my teenage years, as an active member of a local natural history group, I enjoyed the sense of community and learning alongside others. I still feel the same but now am honoured to be part of a global community of entomologists who are endlessly encouraging, enthusiastically sharing their knowledge and wisdom. The importance of collaborations in ensuring progress in science has been accentuated through the ongoing COVID-19 pandemic, with partnerships across organisations, countries and disciplines being critical to addressing the many and varied challenges and, quite frankly, utter turmoil caused by this virus. Reflecting on my own collaborations I am mindful of how diligently people have continued to work through the pandemic, often in very difficult circumstances, while showing incredible compassion and friendship to one another. To me collaborations bring science to life.

I have had the pleasure of working with many amazing entomologists around the world over the last few decades. Each and every one of them has taught me so much and inspired me in many varied ways. Many of us have been working from home for months but the mostly seamless virtual meetings have enabled us to continue our collaborations. However, I think this is an important time to celebrate the connections we have through our shared passion for entomology. What better way to achieve this than to share the thoughts from some amazing entomologists around the world on the importance of collaboration. I hope you will be as inspired by the responses as I am.

Thank you to all the people who currently give so much time and enthusiasm to the Society – you all make my role as President so enjoyable and rewarding. Thank you to all Members and Fellows for your continued support of the Royal Entomological Society and for making our community so wonderful. There are so many ways to get involved with the Society, whether you are UK-based or overseas. Please do get in contact if you would like any information on current opportunities.



For me, global collaboration is a way of growing as a scientist, learning from the experience of others, and also a way of sharing the results of our own research. It is a good formula to prioritize global interests over individual ones.
Audrey Grez, University of Chile & Ecological Society of Chile

Global collaboration has allowed me to look at problems with a broad and open mind, seizing better the complexity of the living world. It has also allowed me to know a great diversity of people and realize that despite our different backgrounds, happiness comes from very similar things.
Tania Zaviezo, Pontificia Universidad Católica de Chile

For me, global collaborations are an opportunity to share experiences and discuss ideas with people from different parts of the world and socio-cultural realities.
Victoria Werenkraut, Universidad Nacional del Comahue/ INIBIOMA-CONICET, Argentina & Argentine Entomological Society

Global collaboration keeps us looking outwards, opens our minds and provides opportunities for bringing together diverse skills, experiences and perspectives, which helps to fuel scientific creativity.
Lori Lawson Handley FRES, University of Hull

Coming together to inspire others to make the world a better place.
Natasha Stevens, St Helena National Trust

Those who contribute to global solidarity have the opportunity to adapt to changes better by looking at our transforming world from a wider perspective, and as time passes, they find themselves in places far beyond their dreams.
Esra Per, Gazi University, Turkey

The opportunity to cooperate, to exchange ideas and to share knowledge with a global network of colleagues, always creates a lot of confidence and optimism to pursue my research.
Katharina Lapin, Austrian Research Centre for Forests

I truly consider international collaborations as invaluable opportunities to grow, not only professionally but also as a person. Getting together with people that have different backgrounds but share the same interests and love of nature has simply helped me become better.
Cristina Preda, Universitatea Ovidius Constanţa, Romania

Not only can global collaborations inspire new thinking and contextualize your research, they also enrich your life, open your eyes to wider horizons, provide you with the experiences you later dine out on, and, most importantly of all, the life-long friendships that sustain you.
Judith K. Pell FRES, J.K. Pell Consulting & Quadram Institute Bioscience & Member of the Society for Invertebrate Pathology

Global cooperation provides an oceanic richness of knowledge. This is what science is about.
Wolfgang Rabitsch, President of the Austrian Entomological Society

Global collaboration is a beautiful feedback loop – the collaborating network continuously develops over time producing increasingly effective and high-quality science, while as individuals, we learn from each other's experiences both professionally and personally which in turn benefits the next stage of the collaborative process.
Rachel Farrow Mem. RES, Anglia Ruskin University

Learning something about other cultures and understanding new perspectives have been highlights for me from my great fortune to work with many inspiring people in collaborations overseas.
Peter Brown FRES, Anglia Ruskin University & UK Ladybird Survey

As an entomologist, I value my global collaborations because they provide fantastic opportunities to study insects in ecosystems outside the UK, especially tropical rainforests which have such amazing diversity. Through these collaborations, I've been so lucky to help in the training of ECRs, and to continue to collaborate with colleagues throughout their careers.
Jane Hill Hon FRES, University of York & British Ecological Society

Collaborations at the global scale to me are great schools and extremely joyful experiences; you can learn so much about other cultures and the natural environment by working together and solving problems with other scientists from different parts of our tiny planet.
Kelly Martinou FRES, Joint Services Health Unit, British Forces Cyprus & The Cyprus Institute & Member of the Hellenic Entomological Society

Collaboration has helped to improve my profile visibility through exposing my research internationally. For me, "Until you cross paths with other people, you will never know what new things are out there to be learned". And now the technology is there to make it straightforward to work with people even if they are in a different place.
Perpetra Akite, Makerere University & Entomological Association of Uganda & Afrotropical Lepidoptera Society

RESEARCH SPOTLIGHT

Winged or wingless? The continuing evolution of insect flight

Stuart Reynolds

Department of Biology and Biochemistry, University of Bath

Wings are characteristic of insects (or are they?)

It's Zoom time. "Do all insects have wings?" ask my grandchildren, who are unaccountably interested in such matters. "Well, yes…" I answer (and indeed when addressing six- and eight-year-olds it's probably best to emphasise the importance of wings to insects). But I like to tell the truth, and so I quickly have to backtrack: "But there are some that don't".

As every entomologist knows, there are plenty of insects that can't fly because they have reduced or even absent wings. A landmark paper by Roff (1990) estimated that around 5% of extant insects are flightless. It was a pretty rough and ready estimate, but it's often quoted. With potentially several million species of insect alive today, it's certain that there are a lot without wings. Although I don't feel too bad about telling my grandchildren that 95% of insects do indeed have wings, we do have to ask why so many of the descendants of the first pterygote insects chose to get rid of their wings. Surely the insects that we see around us (even those that choose not to have wings) are defined by their intrinsic winginess?

There are cases where the loss of wings appears to be an example of straightforward neoteny, as in female scale insects (Sternorrhyncha, Coccoidea); Fig 1A shows the famous example of the Armenian cochineal scale insect, *Porphyrophora hamelii*, once fabulously valuable as the source of a deep red dye. The female's anatomy is dramatically modified and reduced to an immobile, apparently inanimate scale-like form; by contrast the male looks like a normal winged insect. Whatever is going on here it certainly isn't just about losing wings. But generally, where wings are reduced or absent, morphological changes are limited to the flight apparatus itself, leaving the insect looking relatively normal except for the missing wings. This implies that the loss of wings is not incidental to some other change in the general pattern of development but is specifically concerned with eliminating flight from the insect's behavioural repertoire. In many examples, the wingless condition is found in only one sex, and/or is facultative (we'll examine why this is so later), but there are also many examples where wings are absent from all members of the species. A charismatic and well-known example of the latter condition is shown by the Mormon cricket, *Anabrus simplex* (Orthoptera, Tettigoniidae). This insect (Fig. 1B) is adapted to the harsh, semi-desert conditions of the Great Basin of the western USA. Like locusts, it has two quite different social habits, either solitary or swarming; unlike locusts, however, it moves exclusively on foot. It doesn't need wings and doesn't have any.

I'm not going to give a comprehensive list of wingless insects here, because there are probably tens or even hundreds of thousands of flightless species, but if you want a more complete catalogue you can look in any textbook of

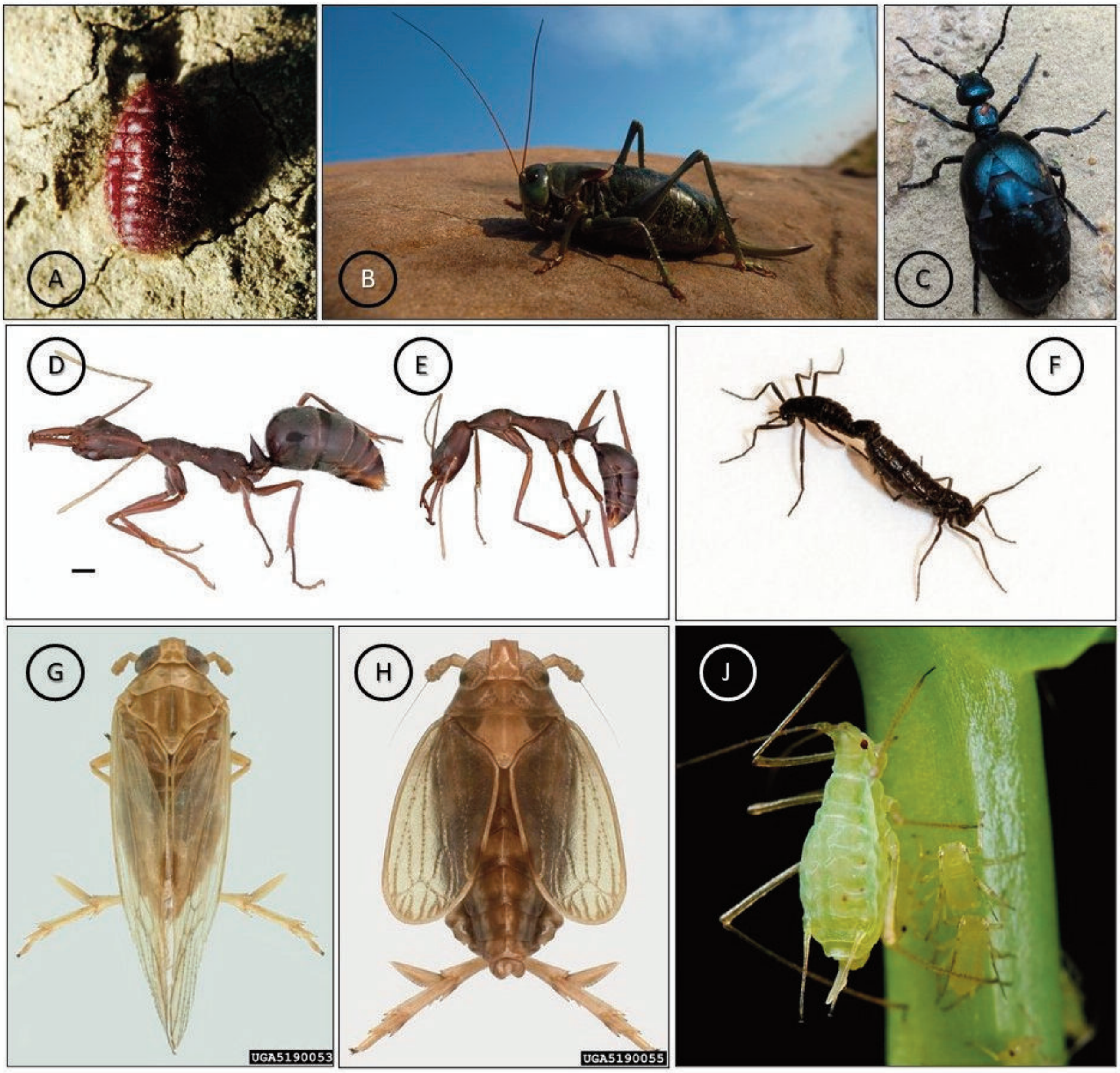


Figure 1. Top row: **A**. Armenian cochineal scale insect *Porphyrophora hamelii*, neotenic female (Photo by Vahe Martirosyanm, CC BY-SA 3.0). **B**. Mormon cricket, *Anabrus simplex* adult female (N.B. long ovipositor) (Photo by Lazarus, CC BY-SA 4.0). **C**. Violet oil beetle, *Meloe violaceus* (Photo by S. Reynolds, University of Bath, unpublished).
Middle row: Left: *Odontomachus coquereli*, Queen (**D**) and worker (**E**), both completely wingless (Montage by M. Molet from AntWeb.org , CC BY-SA 3.0). Right: Mating pair of the Antarctic chironomid midge, *Belgica antarctica* (**F**) on snow (Image courtesy of Drew Spacht, Ohio State University, unpublished).
Bottom Row: Brown planthopper, *Nilaparvata lugens*, adult, macropterous (**G**) and brachypterous (**H**) forms (Natasha Wright, Florida Department of Agriculture and Consumer Services, Creative Commons Attribution 3.0 Unported). (**J**) Pea aphid *Acyrthosiphon pisum*, wingless adult with nymphs (Photo by J. Shipher Wu and Gee-way Lin, National Taiwan University, CC BY 2.5).

entomology. The main object here is to emphasise their diversity. There are examples in most insect orders, but flightlessness is most common in the exopterygotes (with the two orders where the immature stages live under water, Odonata and Ephemeroptera, being notable exceptions). The fascinating Notoptera (recently constituted from Mantophasmatodea and Grylloblattodea) are all completely wingless, as are lice (Phthiraptera). Winglessness also occurs in all species of webspinners (Embioptera), although in some species males may have wings. Termites (Dictyoptera, Isoptera) have multiple castes, some of which are wingless, and although reproductives can fly their wings have basal sutures that allow them to be shed before returning to the nest after mating. Wing reduction or loss is very common among many other exopterygotes (e.g. cockroaches, phasmids and mantids). Wing dimorphisms are common among grasshoppers and other Orthoptera (Scattolini *et al.*, 2020), and winglessness contributes to the crop pest status of many Hemiptera. Scale insects have been mentioned above. Other Sternorrhyncha (e.g. aphids) also display winglessness, but this is either an environmentally controlled or a genetically controlled dimorphism.

Although less common than in the Exopterygota, there are also plenty of examples in which the wings of adult endopterygote insects are reduced or absent. One well-populated order, Siphonaptera (fleas) is entirely wingless. Sattler (1991) reviewed the occurrence of flightlessness in the Lepidoptera, concluding that wing reduction must have evolved many times in this order. Coleoptera also furnish many examples of winglessness, and around a quarter of beetles are said to be flightless (Vogler and Timmermans, 2012). Oil beetles (Meloidae) are a spectacular example (Fig. 1C). These are flightless in both sexes, having extremely reduced and non-functional hindwings covered by very short elytra; these insects are parasites of solitary bees and rely on the host bee for phoretic transport into its nest, their hypermetamorphic triungulin larvae clinging onto the hapless bee's fur as it visits a flower. The female beetle's abdomen is so hugely distended with thousands of eggs that it would be difficult for the insect to fly, but this is presumably the evolutionary consequence rather than cause of flightlessness. Winglessness evidently allows more eggs to be produced. Flightlessness is uncommon in Hymenoptera, which is not surprising as most bees and wasps are pollinators, predators or parasites, and rely on their wings to move between transient resource patches. "Velvet ants" (Pompiloidea, Mutillidae), actually aculeate wasps, are an exception, since females are wingless. And then there are ants. These extremely diverse insects are particularly interesting from the flightlessness point of view. Ground-living relatives of the bees, they have completely eliminated their wings in all but specialised reproductive castes. This makes sense; ants are masters at the division of labour. Workers make a good living feeding on the ground but don't reproduce (well, not normally), and so they don't need wings. Reproduction and dispersal are reserved for specially-adapted male and female reproductive morphs, which in most species have wings. The whole point of sexual reproduction is to mix up the gene pool, and that is where flying comes in.

I could go on like this, but by now you probably get the idea: there are lots of flightless insects.

Costs and benefits of wings

In my last *Antenna* article (Reynolds, 2020) I argued that the acquisition of wings was the reason that insects were the most successful group of animals on Earth. So why get rid of wings once you have got them?

There are no free lunches in evolution. The possession of wings evidently has a cost, and when possession of wings does not confer a more than opposing benefit, then it will be adaptive to reduce that cost by suppressing the offending appendages. In other words, the possession of wings and other associated flight apparatus is always subject to a trade-off against using the resources associated with them for something else (like reproduction). Let's look at just two examples.

Many insects evolve so as to get rid of their wings for good. An example of this is the ponerine trap-jaw ant *Odontomachus coquereli* (Hymenoptera, Formicidae), in which, unusually among ants, winged queens are never found (Fig. 1D, E; Molet *et al.*, 2007). This species is restricted to tropical forest in Madagascar; it lives in small colonies in fallen wood on the forest floor and reproduces only by colony fission and short-range dispersal on the ground. Thus, its habitat is highly persistent in both time and space, and when a colony divides the emigrating ants just look for another fallen log. Under these conditions, there's little need for queens to fly, and they will be more fecund if they don't. Thus, evolution has operated so as to eliminate wings and flight muscles altogether. But *O. coquereli* isn't unique in this. Although it's unusual, ants in more than 50 other genera belonging to 16 subfamilies have independently adopted the same wingless adaptation to their colony-fission reproductive strategy (Peeters, 2012).

On the other hand, when an insect is adapted to live in ecological circumstances that change in a predictable way, wings can be traded in or not according to the current ecological circumstances. The brown planthopper *Nilaparvata lugens* (Hemiptera: Delphacidae), a damaging rice pest, does this. This insect has two morphs with either short or long wings (Fig. 1G, H). Facultative wing reduction coupled with adaptation to consume a widely-grown cereal crop plant is a trait that preadapts *N. lugens* to be a pest. Its brachypterous form reproduces at a high rate, while the less fecund macropter enables dispersal to the next crop. The short-winged form, incapable of flight, develops when pre-adult stages (nymphs) feed on growing rice plants, phloem fluids of which have low levels of glucose. The long-winged form, which can fly, only develops when nymphs feed on senescent rice plants, in which glucose levels are high (Lin *et al.*, 2018). Glucose is thus an environmental signal that migration away from the current habitat will soon be necessary.

The adaptive benefit of reducing or eliminating wings

The acid test for the idea that eliminating the apparatus of flight confers fitness is to look at the reproductive success of alternative macropterous and micropterous forms of the same species when raised together in the same environment. Roff (1984) did this for two species of cricket, *Allonemobius fasciatus* and *Gryllus firmus* (both Orthoptera, Gryllidae). Reading the paper makes you realize how difficult it is to do an experiment like this so that the results are relevant to the lives of free-living insects in the wild. Roff found that the cumulative reproductive output was greater for the micropterous forms of both species, but the difference was statistically significant only for *G. firmus*. Importantly, however, reproduction was significantly advanced in micropters (by around three weeks out of the total adult lifespan of nine weeks in *A. fasciatus*), so that in the real, dangerous world where life can be cut short at any time, the short-winged forms would be expected to be on average more productive. There have been plenty of other studies of this kind (reviewed by Roff, 1990; Zera & Denno, 1997) and in most cases it is seen that where wings are reduced or absent, female reproductive output is enhanced.

The adaptive value of winglessness is however not limited to female reproduction. Males too can benefit. Langelotto *et al.* (2000) found that micropterous males of the North American delphacid *Prokelisia dolus*, were more successful than long-winged males, siring more offspring when mated non-competitively with micropterous females. This was attributed to the transfer of more sperm by the short-winged male during mating, perhaps because more are made due to the reallocation of wing-muscle mass during development of the macropterous form.

But it isn't all about the transfer of traded-off materials. Micropterous females preferred to mate with micropterous males, the latter outcompeting macropters when both morphs were placed together with micropterous females. This was mostly due to greater male-to-male aggression by the short-winged males, although female choice may also have played a role. Interestingly, however, long-winged females preferred macropterous males, so it is possible that assortative mating occurs in natural populations. This is interesting because although wing-length in *P. dolus* is determined by environmental factors, sensitivity to those external cues is heritable and under polygenic control; assortative mating would help to prevent the invasion of natural populations by genotypes with a reduced tendency to develop into macropters despite the apparent higher fecundity of both male and female micropterous forms.

Is there evidence that insect wings are actually evolving now? Like every other trait, wings are subject to continuous natural selection, which can act quickly when the selection pressure is strong. A recently-published paper (Freedman *et al.*, 2020) shows that there have been significant increases and decreases in wing size in the Monarch butterfly *Danaus plexippus* (Lepidoptera, Nymphalidae) over the last 200 years that are correlated with the expansion and contraction of long-distance migrations. But how quickly do the encoding genes decay when selection is relaxed because wings are not used or even not expressed at all? In *N. lugens* functional wings are only expressed when it is adaptively beneficial to do so. But the periodic requirement for the long-winged form to migrate means that genes encoding the flight apparatus are periodically tested against natural selection (typically annually, but under some rice-growing regimes as many as three times per year). Without this, genes required for wings and flight would presumably decay through accumulated mutations, and the ability to fly would be permanently lost.

Against this however, we must note that in some apparently completely wingless insects (e.g. Mantodea [mantises] and Phasmatodea [stick and leaf insects]), insects with functional wings are occasionally produced in normally wingless species, despite the fact that these insects have been wingless for perhaps geologically long periods of time. To add to the mystery, Whiting *et al.* (2003) have pointed out that wings appear to have been lost and regained on multiple occasions within the phylogenetic trees of stick insects. A note of caution here: first, the phylogeny of this order continues to be controversial (Simon *et al.*, 2019), and second, Stone & French (2003) have pointed out that alternative trees without wing reacquisition are at least possible, if the requirement for parsimony is relaxed. But if it is really true that wings have been lost and regained many times over tens or even hundreds of millions of years in this order, why have their wing-related genes not decayed? One strong possibility must be that genes required to specify the flight apparatus have additional functions that are retained even in the absence of wings and are therefore subject to pleiotropic natural selection. A clue to this puzzle is found in a paper by Rajakumar *et al.* (2018), which shows that the growth of rudimentary wing discs is necessary for regulating the allometry of other body structures in the wingless castes of *Pheidole* ants. You may recall that in my previous article (Reynolds, 2020) I pointed out that wings are actually derived from previously-existing body parts in legs and thoracic body wall, so that such pleiotropy seems at least possible.

Environmental characteristics associated with winglessness

Roff (1990) developed the theory of the adaptive value of winglessness as the "habitat persistence model" and this is generally invoked today when explaining the loss of flight in so many insects. He attributed the thinking behind it to a paper by Southwood (1962), who put forward the idea that migration between transient patches is one of the key traits necessary to exploit ephemeral resources. If the habitat is *not* ephemeral, Roff reasoned, then the benefit of having wings would be reduced. He was not the first to have this idea, but his own paper set out the hypothesis and the evidence supporting it particularly clearly. He found that winglessness among insects is indeed well predicted by adaptation to niches that are stable in space and time.

Roff (1990) also noted strong correlations between winglessness and increasing altitude, as well as with increasing latitude (i.e. being closer to the North or South Pole). In fact, when you go to the very tops of mountains or extreme polar environments, you can still find insects and they are often wingless. Fig. 1F shows an image of the midge *Belgica antarctica* (Diptera, Chironomidae), the only insect endemic to continental Antarctica. It has numerous morphological and physiological adaptations to life under difficult conditions including small size (2-6 mm), a tiny genome, freeze and desiccation tolerance, and of course winglessness (Harada *et al.*, 2014).

Roff (1990) attributed this association between wing loss and extreme environments to the increased persistence of patchy resources as one climbs higher or travels away from the Equator to the lower temperatures found there, but he rejected the idea of a direct causal role in flightlessness for temperature *per se*. He argued instead that low temperature slows the rate of succession in producer communities, and that it is the increased environmental stability caused by this that is the direct cause of adaptive flightlessness. But there are other pertinent characteristics of these environments, such as the extreme stress they impose on survival away from the patchy niche to which the insect is adapted (moss growing on rocks for *Belgica*), and the frequent experience of high winds (we'll come back to this later).

Readers will have noted that implicit in everything that has been said so far about the habitat persistence model is the idea that migration between resource patches is costly, and that such costs must be less than the fitness gains acquired through that movement, otherwise the tendency to move will be suppressed by natural selection. What are these costs? The largest of these must certainly arise from the uncertainty of arrival at the desired destination, resulting in premature death or failure to reproduce. But the direct cost of aerial migration due to the consumption of stored energy reserves during flight (notably more than those incurred by walking) and the opportunity cost of investment in the apparatus of flight (i.e. wings and wing muscles) when these resources might more profitably be devoted to additional reproduction must also be non-trivial.

This last point is particularly interesting, because costs of reproduction are usually different between the sexes, with females investing heavily in egg production while males, generally investing much smaller resources in the production of sperm and accessory secretions, have lower costs and would be expected to retain wings to a greater extent. This is indeed exactly what is observed (Roff, 1990; Sattler, 1991; Niitsu & Kamito, 2021).

Darwin redux: flightless insects on oceanic islands

More than 150 years ago, Wollaston (1854) noticed that no less than 178 (37%) of the 482 species of beetle he had taken in the Madeiran archipelago were "either altogether apterous, or have their wings so imperfectly developed that they may be practically considered as such". Charles Darwin, not only the most famous evolutionary biologist ever but also a considerable entomologist (Vice-President of the Royal

Entomological Society in 1838) became interested in this observation, perhaps because he had himself visited Madeira in his *Beagle* voyage. In *The Origin of Species* he discussed Wollaston's findings (Darwin, 1859, *pp* 135-136), suggesting that the Madeiran Coleoptera were an illustration of a general tendency of island insects to flightlessness, and that reduced wings were an ecological adaptation to avoid the increased probability of local extinction caused by accidental emigration from oceanic islands, either through navigational error leading to a fatal journey over the island's edge, or as a result of being blown out to sea by unfavourable winds.

Of course, Darwin was suggesting that on oceanic islands insects *evolve* to be flightless in the face of the increased costs of flight imposed by the island environment. As Roff (1990) points out, this hypothesis was very influential for many years, much repeated in books and papers though rarely tested by confrontation with actual data (many references are cited in Roff's paper). Reinvestigating the idea using what was then up-to-date global data, Roff (1990) concluded that Darwin's conjecture was simply wrong. In fact, Roff said, there is no significant difference between oceanic islands and mainland areas with respect to the proportion of flightless forms in various insect orders, and thus there is no need to explain such a general tendency.

Now it is not a small matter to conclude that Charles Darwin might have made a mistake! Unfortunately, Roff's compilation of 30 years ago did not include a sufficiently diverse range of islands. A recent paper by Leihy & Chown (2020) has now collated published data and new observations on the insect fauna of both Arctic and Antarctic islands, then performing a correlational analysis of winglessness against a range of environmental variables. It turns out that the factor most successfully predicting flightlessness on these islands is (by a considerable margin) wind speed.

To be fair to Roff, the new paper goes on to observe that the most probable explanation for the enhanced tendency to winglessness of insects living on these high-latitude oceanic islands is not the danger of local extinction through being blown off-course as Darwin had envisaged, but the increased costs of flight-mediated dispersal as opposed to dispersal on the ground (as Roff had suggested). So perhaps Darwin wasn't completely right; let's just say that he was right but for the wrong reasons.

To me, the main take-home message from Leihy & Chown's success in clearing Darwin's name of simple error, is that science has an absolutely terrific capacity for self-correction. As a result of the reinvestigation, Roff now appears to have been wrong, but the matter is not yet completely resolved, and I predict increased interest in doing more research. But I'll also admit that Leihy & Chown have restored my faith in Darwin. After all, the great man spent almost five formative years at sea, and after rounding the Horn, he probably understood the windiness of high-latitude oceanic islands better than most.

Genomics and the evolution of winglessness

In speculating about why and how pterygote insects might have evolved to lose their wings, neither Charles Darwin nor Derek Roff had the benefit of the wealth of knowledge that has since accrued concerning the genetic control of wing development. The emergence in the later twentieth century of *Drosophila melanogaster* as the developmental model animal of choice, together with the development of sophisticated molecular genetic techniques has now allowed us to define the hormonal signals regulating development, as well as the Gene Regulatory Network (GRN) of transcription factors acting to control the myriad downstream genes that actually make the wings and their associated anatomical structures. It isn't appropriate for me to try to summarise the already voluminous literature on this subject that is relevant to winglessness, and luckily there's a good recent review on the subject by Zhang *et al.* (2019). But I'll make a few comments on how I see research into the evolution of winglessness interacting in the near future with this body of developmental genetics.

The GRN that governs wing formation consists of (at least) 23 genes that interact as shown in Fig. 2A. The network is highly conserved and has been shown to operate in all of the fully-winged insect species that have been investigated so far. It's an obvious prediction that this network might be the target of natural selection when evolutionary wing loss or suppression occurs. This was exactly confirmed when Abouheif & Wray (2002) looked at the expression of a subset of these genes in various species of ant that have both winged (reproductive) and wingless (worker or soldier) castes; in every case where wings developed, all the tested GRN genes were expressed normally. On the other hand, when wings failed to develop, it was found that, although some of the GRN genes were expressed as normal, there was at least one gene that was not expressed. Béhague *et al.* (2018) have now built on that earlier work by looking at additional genes in a wider range of ants (Fig. 2B). The results confirm that for more derived ant species winglessness is achieved by interference with the wing GRN but, intriguingly, they find that the mechanism of wing suppression in early-branching ant species is different. In two species of *Mystrium*, Behague *et al.* could find no evidence of interruptions in the expression of core GRN genes, despite the fact that these ants each have wingless castes.

Because neither Abouheif & Wray (2002) nor Béhague *et al.* (2018) looked at the expression of every gene in the GRN, it's not clear from this work exactly where the network is interrupted in every case, but it's clear that except in *Mystrium* some kind of interruption is occurring. Interestingly, it was found that the pattern of changed expression was not the same in different wingless castes of the same ant species and in the case of *Pheidole morrisi* the pattern of GRN disruption differed between soldiers and workers. This suggests that natural selection has acted in a number of different ways to suppress wing formation, supporting the finding of molecular phylogenetic analysis that winglessness has evolved on many occasions.

But although this kind of research tells us that becoming wingless involves changes in the expression of regulatory genes, it doesn't tell us which genes are actually mutated to cause that change. An important new paper by Li *et al.* (2020) has now provided an example of how such genetic wing suppression could arise. The research involves the pea aphid, *Acyrthosiphon pisum* (Hemiptera, Aphididae) (Fig. 1J), in which multiple wing polymorphisms operate (Fig. 2C), including a genetically controlled wing dimorphism affecting only male aphids. The responsible gene *aphicarus* (*api*) maps to a single locus on the X chromosome (males have one of these, females have two). There are two alleles, one specifying the winged condition, the other producing winglessness. Possession by the male of a single wingless *api* allele is sufficient to suppress wing formation.

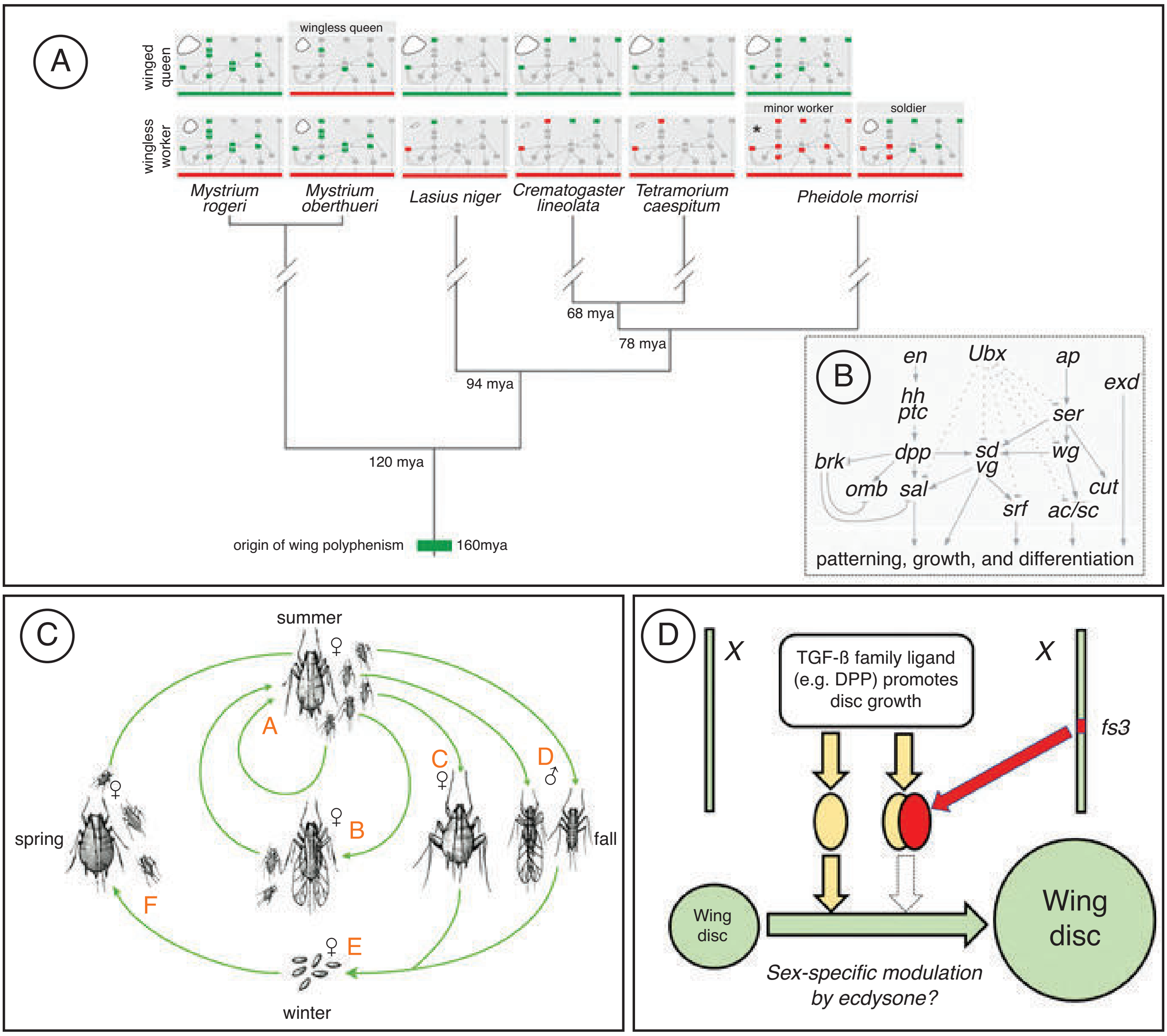


Figure 2.

Gene Regulatory Network (GRN) control in winged and wingless insects.

A. Expression patterns of selected GRN genes in seven species of ant. Grey boxes in the top two rows of the figure show expression patterns for selected genes in different insect species, with winged (reproductive) and wingless (worker and soldier) castes shown in different rows. Boxes each represent the same genes as shown in Panel B, a red line at the bottom of the box indicates that there are no wings, a green bar that wings are formed. Within each panel, conserved gene expression is indicated in green, and interrupted expression is indicated in red; genes not examined are shown in grey. Within each panel is indicated in outline the relative sizes of wing imaginal discs in each species.

B (inset). GRN for wing formation as deduced from genetic studies in *Drosophila* and confirmed in other winged insects; lettering shows regulatory genes and their names; arrows show interactions, solid lines with arrowheads, positive regulation; dotted lines with crosspiece, negative regulation.

For details of the GRN genes see the original paper. A and B are reproduced with permission from Béhague *et al.* (2018).

Molecular genetics of male-specific wing polymorphism in the pea aphid, *Acyrthosiphon pisum*.

C. Pea aphid life cycles including the dimorphism between winged and wingless forms of males (route D). Schematic from The International Aphid Genomics Consortium (2010), CC Public Domain Declaration.

D. Hypothetical scheme for modulation of wing formation by the gene product of *fs3*, a gene present on an insertion in the *A. pisum* X chromosome. DPP (Decapentaplegic) is one of number of TGF-ß family ligands that could be involved, but the principle would be the same with others. My interpretation of conclusions from Li *et al.* (2020).

Sequencing through the *api* region of the genome revealed a ~120 kb insertion in wingless (but not winged) aphids. This region contained several ORFs (open reading frames) but only one appeared to be a gene with the right expression pattern. This gene *fs*-3 encodes a member of the follistatin-family of development-regulating signalling proteins (two similar genes, *fs-1* and *fs-2*, are located in other genomic locations but are not connected with wing dimorphism). Li *et al.* showed that *fs-3* (but not *fs-1* or *fs-2*) is expressed in 1st and 2nd instar wingless (but not winged) male nymphal stages at the time of wing development. *fs-3* appears to have arisen from *fs-2* by duplication and translocation, and to have been maintained over millions of years within *A. pisum* through balancing selection. Because *Drosophila* follistatin is thought to negatively modulate transforming growth factor ß (TGF-ß) signals during fly wing disc development through its interaction with the *activin* and *BMP* signalling pathways (Upadhyay *et al.*, 2017), its apparent role in determining male winglessness is highly plausible. Some of these TGF-ß signals (e.g. Decapentaplegic, DPP) are in fact components of the wing GRN described above. It isn't yet clear, though, how such signalling would affect wing formation in male aphids but not in females. Li *et al.* (2020) speculate that sexually modulated ecdysone signalling may be involved, but more work is needed. The schematic of Fig. 2D gives an idea how all this might work.

Further investigation of the role of *fs-3* in wing formation in both winged and wingless aphids will surely cast light on the evolutionary history of winglessness in this insect. It remains to be seen whether other insects with genetically controlled wingless phenotypes possess similar genes, or even whether the TGF-ß signalling pathway is implicated in mediating the phenotypic effects of other wingless genes in other species, or of environmentally-mediated dimorphic wing phenotypes. But the presently-available evidence suggests that we should expect adaptive reduction or elimination of wings and associated organs to result from the modulation of existing wing development control pathways.

Before finishing, I should comment that it's likely that there are other ways for an insect to end up with reduced or absent wings than through interfering with the GRNs that govern wing disc growth. One of these is shown by the geometrid moth *Protalcis concinnata*, which exhibits female-specific wing reduction. The development of the wings is similar in males and females until the pupal stage, when a process of programmed cell death intervenes in female but not male wings. As a result, the female wings shrink and by the time that the adult emerges its wings are only a fraction of the size of the male's (Niitsu & Kamito, 2021). At present there is no indication of how this is controlled.

Acknowledgement

I am grateful for helpful conversations with David Denlinger, Richard Harrington, Hugh Loxdale, Jens Rolff and Klaus Reinhardt, but I am responsible for any mistakes. I thank Drew Spacht for Fig. 1F.

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Invertebrates in advertising

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It is widely accepted in entomological circles that the majority of people have little or no appreciation of insects. Simon Leather, in his famous Never Mind the Roundabouts blog, defined these attitudes as:

Entomyopia – or a lack of foresight or discernment as to the importance of entomology, a narrow view of entomology. Insects are viewed as either pollinators or as a nuisance.

Entoalexia – entomological blindness, a condition in which a person, or organisation, is totally oblivious to the importance of entomology and insects.

I have had many conversations on this topic over a beer at conferences, where fellow entomologists have bemoaned this lack of appreciation. When I have given public talks, there has always been a sense of revelation from the audience; "I had no idea" or "I will view insects in a totally different light now", are frequent comments. However, fifteen years ago, I began to notice that insects were appearing in advertisements, which struck me as strange in view of our perceived understanding of public attitudes. Why would advertisers use images that, as far as entomologists were concerned, would be ignored by, or would repulse, potential customers? The advertising industry is primarily concerned with selling the product, so there had to be something else going on. So, I began to collect images of these advertisements and have now recognised a series of underlying themes.

The most common is the transformative advertisement; ones that use the concept of insect metamorphosis to suggest that this product or service will bring about a dramatic change to the purchaser. A window display for MAC eyeliner (2) uses the Blue Morpho butterfly to link the radiant beauty of the butterfly with the cosmetic, and the wrinkle correction service (3) uses a similar comparison to suggest that a new you will emerge from the treatment. The *Young Lawyer* magazine (4) uses the Peacock butterfly to imply that the changes in legal education training offer a bright new future, transforming the prospects of young lawyers. An abstract butterfly implies that the new retirement home (5) will transform the lives of its residents, and a similar abstract butterfly implies that partaking in the raffle in support of a medical charity (6) will transform other people's lives. The Church has used insect metamorphosis as a metaphor for spiritual awakening (7), offering the Church as an alternative to everyday life, and when the Anglican Church redesigned its robes (8), the same theme was utilised as a decorative motif.

Industry is another common theme that invokes hard work, efficiency and working together. This can be applied to the product itself or the potential customers. The breakdown service Green Flag (9) and the construction Company ORP (10) both use ants to symbolise efficiency and hard work, while Vodafone (11) use bees to imply that its products are aimed at very busy people. The Vienna-based

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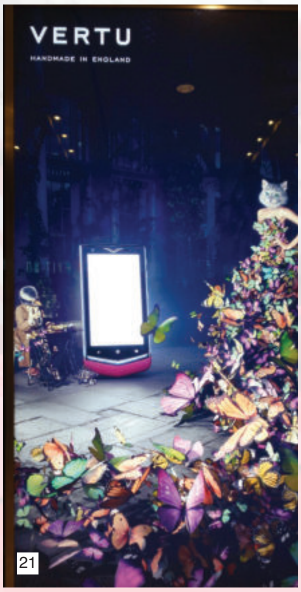

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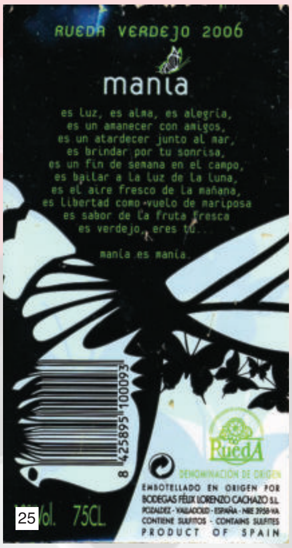

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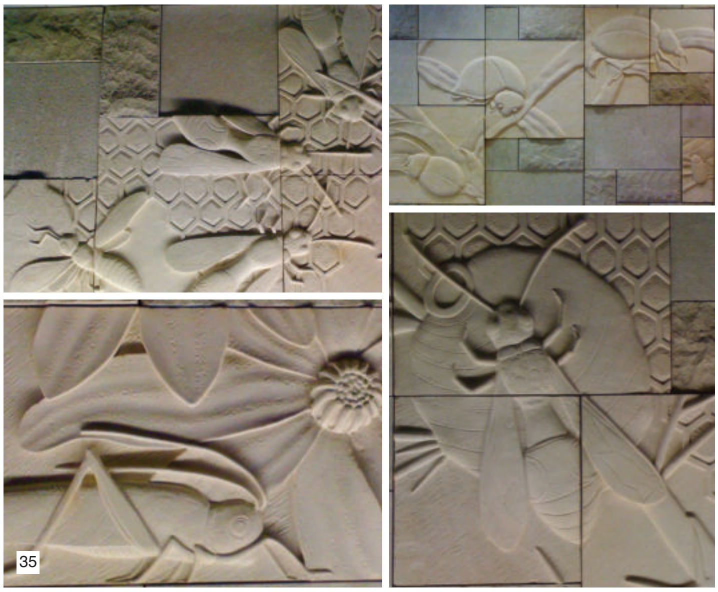
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ERSTE Foundation (12) uses a bee logo to suggest teamwork and productivity.

Naturalness is another theme that is fairly common. Here, insects are used to link the product to the natural world, suggesting a wholesome provenance and implying that the product will be good for you. The Papillon oranges (13) that use a butterfly as a logo and name are a classic example of this, as are the apples (14) that utilise a ladybird to connect to nature. The muesli packet (15) links the cereal to the countryside and hints at relaxed summer days and enjoyment. The cannabis oil (16) uses the dragonfly as name and logo to evoke the concept that it's a natural remedy and maybe hints at a rapid response, while Coca Cola spent a small fortune producing a short film depicting insects stealing a bottle of their drink and then revelling in drinking it, thus suggesting it is a natural product and highly sought after (you may see the film segment on https://www.youtube.com/watch?v=175_yfJCtZ0). The Green Park office development (17) near Reading was built in a natural parkland and claims to place workers in a calm and natural environment which would aid their wellbeing and productivity. All this is represented by a single grasshopper, an insect associated with sunny meadows and an energetic jump.

The Exotic category is rich and varied. A ladies' shoe shop (18) in Hong Kong used spider webs and a giant spider to add a surreal atmosphere and even a hint of danger to its window display. The Spanish ladies' outfitters Lukuma (19) used antlions to give their logo a hint of the exotic, and Waitrose used a tweed-suited bee to exoticise its Christmas pudding (20). The English phone manufacturer VERTU (21), meanwhile, went straight for the pure surreal with its advertisement, that grasps the viewer's attention and hints that its phone will take you to places beyond imagination.

In drinks, the Belgian fruit cocktail Pimpampoentje (22) uses a ladybird to make it appear more natural and, as the ladybird has clear warning colouration, it could be hinting that it's a little daring to try. Clouded Yellow beer (23) plays on the colour and cloudiness of the drink while hinting at rural connections. The Somerset ciders (24) use beetles and a dragonfly to link their beverage with rural settings, and the Spanish wine Manja (25) uses butterflies and some poetic text to associate this wine with freedom and socialising in the countryside.

In the late 1990s a small shift appeared in public attitudes to insects with the release of the animated film *A Bug's Life*. Suddenly insects could be fun, comical, or even heroic figures in a narrative. This was quickly followed by the films *Ants* and *Bee Movie*, so insects could now be seen as friendly and even attractive. The Coffee Bug mobile barista (1) capitalises on this. While the term 'bug' has been associated with the Volkswagen car for many years, the transformation of the car into a familiar and friendly insect was guaranteed to draw customers. The Belgian parking app Betaal Mobiel (26) also offers a friendly and encouraging face to users of the parking meters, and the invertebrate characters on the IKEA napkin (27) offer a friendly and fun image to children and parents alike.

The fact that many invertebrates are robust and powerful is well-known, and Abarth cars (28) have used a scorpion in their badge to denote these qualities, while Volkswagen produced a short animation showing a beetle out-pacing a wide variety of other insects, suggesting that the beetle was way ahead of the competition and also had more fun (the video can be watched at https://www.youtube.com/watch?v=-NGN 4J6F_vI).

Shock and challenge are old devices to attract the attention of potential consumers. The Cultuurmarkt poster (29) shocks, sending a clear message that this event is different, as does the poster for the HyphenMonkeys (30). The sign over the door of the ZZ Pub (31) hints that it is a dangerous place but it could also be fun, while the spider cocktails (32) are certainly a dare. Fly London boots (33) proclaim danger, but in this case it's the wearer who could be seen as dangerous, though alluringly so. The widow sauce (34), meanwhile, needs no explanation.

It seems that, far from possessing a purely negative image, invertebrates can be linked to a wide range of positive ideas. The arrivals lounge at Singapore airport is testament to this, as running the entire length of one side is a carved mural (35) depicting some of the local insect fauna. A bold statement, announcing 'welcome to Singapore and here are some of our local insects', a country that is not shy about its entomofauna, and a country that is marketing itself using its insects.

What can we learn from the advertising executives? The obvious lesson is that the wider public will respond to images of invertebrates in a positive fashion if they are presented in the right way. So, are we, the entomological community, getting this wrong? Do we need to change the way we present the insects that we study, and do we need to change the way we present ourselves as entomologists? If advertising executives can make loads of money by utilising the insects that we love, surely we can tap into this seam of public empathy to change public attitudes and gain much wider support for insect conservation. It has been said many times that you only conserve what you know and love, so let's advertise and inform.

Dung beetle (*Trypocopris* [=*Geotrupes*] *pyrenaeus* var. *coruscans*), Galicia, Spain.

Dung beetles and horses

By Raymond JC Cannon

(rcannon992@aol.com)

I first came across this gorgeous beetle (Fig. 1) in Galicia, in NW Spain. It is relatively common there on the unspoilt heather-clad uplands, and over the years I have seen it many times and taken lots of pictures. It really is a photographer's dream!

There are six species of dung beetle in the Palaearctic genus *Trypocopris* (Geotrupidae), and three occur in western Europe: *T. vernalis*, *T. pyrenaeus* and *T. alpinus*. There are several subspecies of *T. pyrenaeus* (Charpentier, 1825) – at least four – which are found in Andorra, the British Isles, Bulgaria, France, Italy, Luxembourg and Spain. It seems to be most abundant in NW Spain, northern Portugal, and Italy. A shiny, black variety of *T. pyrenaeus*, called the Heath dumbledor beetle, is found in the New Forest, although I have never seen it. It is rare – listed as Nationally Scarce by Natural England (Lane & Mann, 2016) – but not threatened. *Dumbledor* is an Old English word for any insect that flies with a loud humming noise and has also been used for bumblebees.

In Galicia, these beautiful dung beetles can often be seen flying purposefully through the pine forests, like tiny green helicopters, on a mission no doubt, to find a cow pat or some horse droppings. They are a variety called *T. pyrenaeus* var. *coruscans*, and have a striking metallic, coppery-green sheen, which changes colour somewhat as the sun catches the iridescent cuticle (Fig. 2).

Flip one over, and more often than not, you will see a number of tiny phoretic mites on the shiny blue underside (Fig. 3). Hitchhikers! Phoresy, or phoresis, is the transport of one animal via another; but for mites such as these, it is probably best described as a form of assisted migration (Binns, 1982) as they use the carrier beetles to take them on to fresh dung pats, where they feed on fly larvae and nematodes (Niogret *et al*, 2006). One might think that they are rather taking advantage of the beetle for a free ride, but they repay this debt by feeding on invertebrates which compete with the coprophilous beetles over the dung. So, on the face of it, it looks like a mutually beneficial arrangement, although depending on the species involved, phoresy probably spans the whole spectrum from symbiosis to parasitism (Perotti *et al.*, 2009).

It is not possible to say with certainty from a photograph what species of mite these are (Fig. 4); one would have to collect them and examine them under a microscope. But

Fig. 1. Dung beetle (*Trypocopris* [=*Geotrupes*] *pyrenaeus* var. *coruscans*) Galicia, Spain.

Fig. 2. Dung beetle (*Trypocopris* [=*Geotrupes*] *pyrenaeus* var. *coruscans*) shining in the sun

Fig. 3. Dung beetle (*Trypocopris* [=*Geotrupes*] *pyrenaeus* var. *coruscans*) underside with phoretic mites.

Fig. 4. Dung beetle (*Trypocopris* [=*Geotrupes*] *pyrenaeus* var. *coruscans*) underside with phoretic mites.

Fig. 5. Dung beetle (*Trypocopris* [=*Geotrupes*] *pyrenaeus* var. *coruscans*) in horse dung.

Fig. 6. Galician pony.

Fig. 7. *Trypocopris pyrenaeus* var. *coruscans* showing eye protector flap.

Fig. 8. Dung beetle (*Trypocopris* [=*Geotrupes*] *pyrenaeus* var. *coruscans*) with fossorial front legs.

Fig. 9. Dung beetle (*Trypocopris* [=*Geotrupes*] *pyrenaeus* var. *coruscans*) rolling some horse dung.

Fig. 10. Dung beetle (*Trypocopris* [=*Geotrupes*] *pyrenaeus* var. *coruscans*) taking off from horse dung.

Fig. 11. Dung beetle (*Trypocopris* [=*Geotrupes*] *pyrenaeus* var. *coruscans*) prior to taking off with wings spread.

Fig. 12. Dung beetle (*Trypocopris* [=*Geotrupes*] *pyrenaeus* var. *coruscans*) turned upside down in thanatosis.

Fig. 13. Dead or moribund beetles.

Fig. 14 (right). Dung beetle (*Trypocopris* [=*Geotrupes*] *pyrenaeus* var. *coruscans*) in horse dung.

Macrocheles glaber mites have been found on *T. pyrenaeus* in France, where they were one of the most common phoretic species collected on a total of 27 carrier species, including 25 beetles (Niogret *et al.*, 2006). *Macrocheles glaber* is a generalist mesostigmatid mite (Acari: Metostigmata) with a cosmopolitan distribution. Another mesostigmatid, phoretic mite which has been found on *T. pyrenaeus* in the Iberian Peninsula, is *Neopodocinum meridionalis* (Moraza, 2004).

Some phoretic species are extremely good at hopping on and off their carriers, for example during feeding stops (Perotti *et al.*, 2009). How they know when a beetle is about to take off – potentially leaving them stranded – is anyone's guess! The dung beetles themselves will also be colonising fresh dung as it becomes available (Fig. 5). In this upland habitat in Galicia, NW Spain, where the photographs were taken, the beetles were found mainly on horse dung. There are lots of Galician ponies wandering in the hills (Fig. 6).

It is interesting to notice some of the adaptations which this dung beetle has for burying in dung. For example, there are distinct flaps on the head which appear to be positioned to protect the compound eye (Fig. 7), and it has strong, fossorial legs for digging (Fig. 8). *Trypocopris pyrenaeus* is a so-called tunneller species, which buries brood balls in vertical chambers in close proximity to the original deposition site (Nervo *et al.*, 2014). However, this species is also *telephagic*, which means that it rolls some of the dung (Fig. 9) and subsequently buries it quite far from the original dung pat (Zunino & Palestrini, 1986). Adults not only remove and bury the dung, but they also feed on it, so, they are doing an extremely useful ecosystem service. If it remains *in situ*, an area up to 12 times larger than the dung pad itself would remain ungrazed by livestock for several months, even up to a year (Nervo *et al.*, 2014).

These beetles are active fliers (Fig. 10). They need to find new sources of food, cow or horse dung, which they manoeuvre back to the burrows they have dug in the ground. Presumably, they have an excellent sense of smell and fly upwind towards fresh sources of dung. On their travels in search of new dung, they seem to land and take off quite a few times. The wings are stored, folded up under the elytra (Fig. 11). These hard wing cases protect the more delicate wings whilst the beetles are on the ground, feeding or pushing their way through dung. Wings do not unfold instantly of course. It takes a few seconds for the beetle to open and extend its wings, ready for take-off. There are no muscles in the wing itself, and the extension of the hind wings of beetles probably occurs as a result of hydraulic pressure, i.e. haemolymph being pumped into veins in the wings. The extension of the wing also involves the contraction of muscles at the base of the wing, located in the thorax, together with an increase of blood pressure (Sun *et al.*, 2014).

Many types of dung beetle stridulate, both when distressed or when communicating with the opposite sex. The stridulatory organ in *Trypocopris* species, is a smoothed keel-shaped structure located on the meta-coxa at the top of the hind legs. This functions a bit like a file, which scrapes against another structure, called the plectrum, found on the coxal cavity of the abdomen (Carisio *et al.*, 2004). Stridulation might serve as a cue to identify potential partners when several individuals of different species are aggregated in a dung pat.

Another interesting behaviour exhibited by these beetles is thanatosis, or pretending to be dead. If you flip them over, they adopt a characteristic frozen posture, with the mid- and hindlegs held together (Fig. 12). After a few minutes however, they turn themselves over again and wander off.

On a final note, these beetles are, I believe, at severe risk of poisoning from ivermectins, veterinary pharmaceuticals given to cows to treat roundworms and other stomach parasites. I was very alarmed to come across a whole group of dead or dying beetles once (Fig. 13), all lying on the ground not far from each other. There was no dung in the vicinity, but the fact that some were moribund and still twitching, made me suspect poisoning. Dung beetles are particularly sensitive to the macrocyclic lactones, ivermectin and moxidectin. Worryingly, ivermectin therapy enhances the attractiveness of dung from treated cattle (Errouissi & Lumaret, 2010; and other references therein). This increased attractiveness may occur as a result of changes in the gut flora of the treated cattle or changes in volatile compounds emitted by dung pats (Römbke *et al.*, 2010). Dung beetles are also at risk because ivermectin remains present in the dung of medicated livestock for several weeks following treatment. Like many out-of-the-way places in Europe, Galicia is gradually moving from largely subsistence agriculture, to more modern farming methods.

If anyone is looking for research projects, I think this beetle would make an excellent insect to study, in terms of its ecology (especially in relation to traditional grazing methods), commensals (phoretic mites), iridescent colouration, the impact of insecticide treatments for cow parasites, the effects of climate change, and so on – particularly because it is so abundant and easy to find in the summer. Just find the dung (Fig. 14)!

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Ingleborough mountain from Eskrigg.

Thomas Penny – a pioneering English entomologist

John Whittaker

The small village of Gressingham, eight miles north east of Lancaster, has two claims to fame. Perhaps the best known is the Gressingham duck, first bred there. But it is arguable, certainly in these pages, that an event of greater significance occurred in the adjacent hamlet of Eskrigg. Here was born in about 1532 Thomas Penny, son of John Penny (Chippindall, 1919). Thomas was a true Elizabethan, who could legitimately be called the first significant English entomologist.

Young Thomas spent much of his time exploring the countryside near to his home and collecting fauna and flora. From species collected by him, it seems that he particularly liked the steep limestone escarpments of Ingleborough mountain, a few miles east of his home, once erroneously considered to be the highest in England. Indeed, J.M.W. Turner enhanced his sketches of the mountain in 1816 because he felt it should look a little higher to meet this claim. Later in life, Penny also collected insects in the Cartmel area (now Cumbria) and Northumberland as well as elsewhere.

It is not clear where he received his early education, but with schooling available at Lancaster (now Lancaster Royal Grammar School; founded 1235) he may well have studied there or at least had contact with scholars. As a teenager, Penny went to Queens' College Cambridge in 1546. In 1550, he obtained a sizarship at Trinity and graduated in 1551, becoming a Fellow of Trinity two years later, and then senior bursar of the College (Raven, 1947).

When ordained, as well as having medical qualifications, Thomas kept his interest in entomology alive and wrote insect and plant records with particularly good illustrations of the latter (Raven, 1947). One was of *Rubus chamaemorus*, which he would have seen as a youth on the high moors around his home in the north of England. It would not be surprising if he was already observing associated caterpillars and pollinating muscids and syrphids, which he drew later in fine detail. He kept some insects in captivity to study life cycles. Unlike Aristotle, he recognised caterpillars as insects rather than worms.

Like many pioneers, his name was destined to be eclipsed by a more illustrious associate. In this case that was Thomas Moffet (various spellings) (1553-1604), a physician who was preparing his major work *Insectorum sive Minimorum Animalium Theatrum*. To have a young northern enthusiast briefly apprenticed to him in London as a medical student was no doubt useful, but it had significant consequences in support of Moffet's ambition to write a major work on insects. Moffet was known for his ability to collate information rather more than for his personal discoveries. Penny's manuscripts containing hundreds of accurate drawings have not survived, but his brother made sure that, according to Thomas's will, they went to Moffet, who incorporated them in his work. Potts and Fear (2000) show that this contribution was a very significant input to the text but, most importantly, many of his drawings were included as wood-cuts in the final version. These are quite accurate and reveal the skill of a talented observer of nature. The book was posthumously published in 1634 through the efforts of Moffet's widow.

Penny became well-travelled, visiting Majorca, Germany, France and Switzerland, where he became friendly with Konrad Gesner (1516-1565). It enabled him to study Gesner's collection of insects just before Gesner died. An unfinished manuscript by Gesner was left to Penny, who also acquired relevant entomological notes by A.F. Wotton of Oxford, born 40 years before Penny. Gesner was the author of perhaps the first reliable zoological work *Historiae Animalium* (1551-1587), though the section on insects did not appear until 22 years after Gesner's death, prompting speculation that Penny may have had quite a bit to do with its inclusion. By this time, Penny was recognised internationally as an authority on insects, and specimens were sent to him from the New World as well as many parts of the Old World.

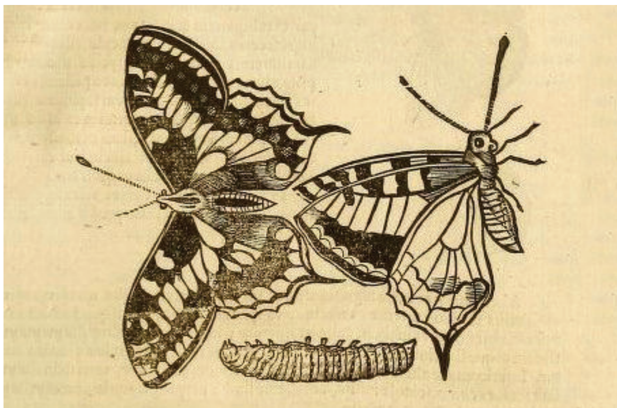
In his later years it seems that he returned to Gressingham or at least retained contacts, since a Dr Penye appears in a 1577 inventory there as creditor for £5 (over £2000 today). He left a legacy to the poor of Gressingham and Eskrigg – unlikely that his skills as an entomologist led to this wealth (!), more likely his marriage to a daughter of the Master of Requests to the sickly young Edward VI.

He died in 1589, by coincidence the year in which Moffet had planned to publish his book for which he had commissioned a frontispiece (not used in its eventual publication) picturing the other three contributors. Through his association with both Wotton and Gesner as well as Moffet, it would be Penny who ensured that their work was included. Thus was written the first comprehensive book on insects published in London. It appeared long after the death of all the contributors.


INSECTORVM
SIVE
Minimorum Animalium
THEATRVM:
Olim ab
EDOARDO WOTTONO.
CONRADO GESNERO.
THOMAQVE PENNIO
inchoatum:
Tandem
THO. MOVFETI Londinâtis operâ sumptibusq; maximis concinnatum,
auctum, perfectum:
Et ad vivum expressis Iconibus suprà quingentis illustratum.
Londini ex Officinâ typographicâ Thom. Cotes. Et venales extant apud Guiliel. Hope,
ad insigne Chirothecæ, prope regium Excambium. 1634.

Title Page of Insectorum Theatrum.

Detail of Moffet's 1589 frontispiece.



Papilio machaon by Penny.

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Celebrating the life of William D. Hamilton: 20 years on, a tribute to his influence on a tropical entomologist's career

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W.D. (Bill) Hamilton, architect of "kin selection theory", died twenty years ago from complications of a malaria infection. I, who was his last Brazilian student, wrote a letter to his late wife, Maria Luisa Bozzi, describing my time with him in the Amazon. I wrote to her about all the knowledge I could never possibly have imagined obtaining as a young tropical biologist from a developing country, which at that particular time was steeped in political and economic crisis. My PhD at the illustrious Imperial College (then University of London), was supervised by Professor Valerie K. Brown and Bill. When Val read the letter, she thought it suitable for more readers, and sent it to *Antenna*, which published it as an obituary (Ribeiro, 2000).

I had already gained my PhD when my friend and tutor died. I was starting a hard but fruitful career in evolutionary ecology of the tropics. After 20 years, I decided to return to *Antenna* and describe how Bill's ideas and way of thinking about nature kept influencing me throughout my career. More recent revisions on his modelling maths, and also the realization that Hamilton's rule is not capable of explaining all insect eusociality, may have, for some people, overshadowed his once declared position of the greatest biologist of the 20th Century. However, without those foundations, much recent progress in sociobiology would not have happened.

Bill died after visiting Africa, seeking HIV's spillover routes, from monkeys to people. On the 20th anniversary of his death, 7th March 2020, I was working frenetically to predict the dissemination of COVID-19 across the main Brazilian cities, using ecological neutral models and concepts (Ribeiro et al. 2020a,b). Also, I was halfway through my sabbatical in a department of parasitology, where I started to shift my career dramatically, from an insect–plant ecologist, to a human disease ecologist. I am still working on theories of host–pathogen interactions and still trying to answer some of the most intriguing questions which once were posed to me by Bill.

It was during my first field work after the lockdown that I started to think about his persona and influences on me. While writing this, I am back in the Atlantic rainforest, investigating the mechanisms that help large arboreal colonies of the ant *Azteca chartifex* to have long healthy lives. I realized that this is the same type of question which Bill used to ask. What is the sex ratio of horn beetles, and how does that affect the size of the horns? What is the proportion of asexual plant species annually colonizing the slopes of the Marimauá riverbed during the dry season, in the widest water flood variation in the world? Are those unpredictable habitats unfriendly to plant natural enemies, thus favouring the most aggressive pioneering plants? Questions like these shaped my PhD, for which I asked whether the large populations of *Tabebuia aurea*, actually among the largest monodominant tree stands of the tropics, would exist in the Pantanal Matogrossense because of the highly unpredictable climate and recent evolution of the Pantanal Biome. Could these abiotic factors protect the trees from herbivory, compared with the highly predictable, and evolutionarily old, Cerrado biome (which happened to be a fairly correct hypothesis – Ribeiro & Brown 1999; 2006)?

I had two field work expeditions with Bill in Brazil that culminated in my PhD. First, in the Atlantic rainforest, in July

1990, and in the Amazonian reserve of Mamirauá, in January 1991. For me, to be in the field with such a scientist, and a thorough observer of nature, was a privilege. I learnt that the deepest questions one may have about evolution, interactions, changes in population sizes and ecosystem structures, will be realized only by a long-term contact with the natural world. I am still conducting as much field work as I can manage. In the forest with my students, I teach those things I just begin to comprehend after 20 years returning to this same forest and following a long-term research project. Still, the way I look and the observations I produce in the bushes echo from those days in Mamirauá, when Bill used to approach me with his hands covered with *Solenopsis* ants to show me the strength of their bites, or with a bunch of leaves asking me to chew them; that would paralyse my tongue for several minutes. No matter to me that current progress in ecology is towards the analytical tools, centred on overall hypotheses closer to maths than to biology; what still influences my hypotheses are observations based on a good and lasting contact with nature. The best hypotheses I am still offering to test come from the way I learned to look at nature with Bill.

It is easy to understand the tropics if you are born here, but it seemed even easier for a dedicated mind such as Bill's, although raised in a temperate latitude. Until recently, there were not many science jobs in developing countries, making it difficult for tropical biologists to settle in places like Brazil. This scenario has changed in this century and the majority from my generation managed to get a job in science and to keep an international career after returning home from a PhD. I am a member of the Azorean Biodiversity Group, where, by the way, at least one project was totally inspired from my last conversation with Bill, who called my attention to the arborescence of insular *Erica* species (Ribeiro et al. 2003; 2005). I also helped to create, and am an active member of the IBISCA (Insects Biodiversity In Soil and Canopy) group, which provided me with the opportunity to meet some of the best tropical forest entomologists, broadening my career perspective (Ribeiro & Basset 2007; Basset et al. 2012). Since I got my job in the Federal University of Ouro Preto, in 2002, I have managed to bring to Brazil one of the largest canopy training courses on the planet, assuring safety training for scientific climbing and pioneering canopy research. The course was funded by the British Embassy/Global Canopy Programme and ran from 2003 to 2010 (Fontoura et al. 2007; Majer & Ribeiro 2007).

Nevertheless, I came back to Brazil at a difficult time, and somehow successfully fought for my position as a scientist in the country (Ribeiro et al. 2001). Brazil is a country that, despite its hectic political life (still reflecting 20 years of dictatorship that lasted until 1985), was so respected and admired by Bill, who held us Brazilians in great esteem (and had even greater esteem for our forests, where he wished to be buried). During the years after Bill´s death, especially from 2005 to 2015, Brazil increased its post-graduate programmes nationwide, and the consequence was an increase of more than 400% in doctorate vivas. We opened up new universities and courses, invested as never before in science, technology and higher education, changing our global position and economy dramatically. That progress did not last, and the present government policies toward science and nature conservation have shown us how hard a path it is to become a stable and prosperous country. However, the scientific careers started during those years are more resilient than those that came before me, a fact that we hope will allow us to contribute to a quick return to a sustainable, responsible development, and recover our international respect.

Any contribution I may offer for a better scientific future for Brazil, and for a climatically safer world, started with the friendship, support and guidance of my supervisors and the fantastic generation of brilliant ecologists of Imperial College at Silwood Park, from 1995 to 1998, especially my dear Val. Nevertheless, the one responsible for making me understand the importance of a humble, powerful, thorough, and inspired scientist, capable of untangling the tropical banks of life, was William D. Hamilton.

On the last day of the field work where I wrote this essay, I bumped into a nest of *Polybia rejecta*, a vespid frequently found associated with our studied ant species, *Azteca chartifex*. Bill, to my knowledge, was this first to describe this association (Chapter 8, page 302 from the Volume 1 of the "Narrow Roads of Gene Land"). I got stung three times and, contrary to all previous attacks in other trips, those caused a strong allergic reaction that took me to the closest hospital. I could not help but laugh remembering his usual "try this here" approach for experiencing the forest.

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Society News

News from Council

Meetings of Council

Meetings of Council were held on 29th October 2020 and 2nd December 2020, and a special meeting of the membership was held on 7th October 2020, all using video-call platforms. The following is a summary of the main points from these meetings.

Special meeting of the membership

Fifty Members and Fellows attended, exceeding the quorum of 35. Following an introduction from the President and a question-and-answer session, attendees voted to amend certain bye-laws, as proposed, by 45 votes to 2 with 3 abstentions. These and future changes will modernise the governance of the Society to help it deliver its charitable objectives for the benefit of members and the public. Feedback following the meeting showed that members are very positive about the future of the Society and pleased to learn that there will be more opportunities to contribute to its success. We are extremely pleased to engage with everyone and look forward to working with you all. Please do get in contact if you would like to hear more about how you can get involved with the Society.

Ethical investment

The Society is moving all of its investment portfolio to ESG (Environmental, Social and Governance) investments. These seek good returns commensurate with long-term positive impacts on society and the environment.

Student subscriptions

Student membership of the Society will now be free for the first year. Please do encourage students to join.

Funding support

The Society has agreed to support EntoPOC, which aims to increase the participation of people of colour in entomology. The Society is also investigating ways to support the LGBTQ+ community of entomologists. The Society has supported the restoration of the grave of pioneering agricultural entomologist Eleanor Ormerod. There will be more on this in the next *Antenna*.

Grand Challenges project

The survey deadline was extended to 20th November 2020 due to Royal Mail postal issues.

Membership Committee

The Membership Committee has been restarted under the chairmanship of trustee Dr John Baird. The Committee will monitor and review the Society's services to its Members and Fellows; ensure that there is a framework for accountability in relation to fulfilling the Society's charitable purpose; organise consultations with the membership; improve communication with professional and amateur entomologists; liaise with other committees to implement new initiatives from Council to improve the benefits of membership; monitor the composition of the Society in terms of equality, diversity and inclusion; and strive to increase membership around the world.

Outreach and Development Committee

Trustee, Prof. Adam Hart has become the new chair of this committee. The last meeting discussed podcasts, educational resources, the INSTAR and PUPA magazines for young entomologists and National Insect Week.

Other matters

Other matters discussed included: a timetable for development of a range of policies; the Society's awards and grants; supporting the International Congress of Entomology; reviewing the regionalisation programme; Ento'21 and other meetings; future income from publications; library issues; and insect identification enquiries from the public. More on these matters to follow soon but please do get in contact if you have any queries.

ENTO'21

23rd - 27th August 2021

Grant Reports

The Royal Entomological Society MSc Scholars 2020

The Royal Entomological Society provides scholarships to aid students studying for an MSc in Entomology at Harper Adams University. This year, Rita Morais, Alp Notghi, Lucy Pocock, George Ryley and Jen Thomas were selected from a very strong field, and they tell their stories below.

Rita Morais

I have a bachelor's degree in biology and specialised in environmental biology. Through that, I came in contact with entomology. I did some volunteer work at the entomology lab in my previous university (Faculty of Sciences of the University of Lisbon) where I had my first impression of the discipline. However, it was only when I started to go outside to look for insects myself and tried to identify them, that my passion truly began to develop. I have also worked on the Red List of mainland Portugal's invertebrates, which gave me insights in terms of how sampling is done and processed afterwards, and on how to make an insect collection. I have started my own collection very recently.

Although I have had this experience, I still consider that a lot of my basic knowledge is very raw. By coming to Harper Adams to study the MSc in Entomology, I wish to strengthen my knowledge in a much more organised way. Modules like "Biology & Taxonomy of Insects" and "Diversity & Evolution of Insects" really appeal to me because I think I will get the specific insights I need to build on my background knowledge. The modules related to data processing and analysis will be very useful too because they will remind me of many of the methods that I have used previously in my bachelor's degree. The modules related to applied entomology will be wonderful because they will be completely new to me. I am looking forward to all the modules, though.

My major interest is directed towards the Heteroptera, which I would love to work on in the future and develop the current knowledge further. Unfortunately, many countries, like Portugal, don't fund projects related to invertebrates. The money usually goes to projects involving vertebrates or projects that do not involve conservation. I think that, recently, studies that describe a species and its biology are looked down upon because we are past that point in many areas of biology, but when it comes to entomology and invertebrates we are only at the beginning.

Having been awarded this scholarship I am now even more motivated to focus on my studies and pursue my passion. I will make the most of this experience in the hope of building my own knowledge and also increasing the general public's interest in insects.

Alp Notghi

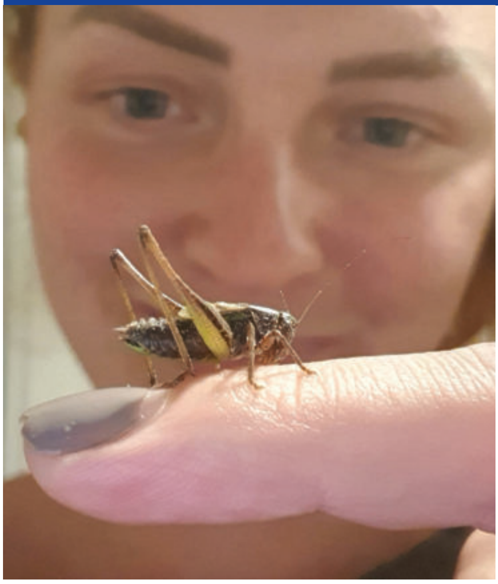
As a schoolboy I identified caterpillars and moths, looked after ant colonies, bred cockroaches, sketched beetles and collected butterflies, encouraged by visits to the special insect collections at nearby Wollaton Hall. Volunteering and work experience with the National Trust introduced me to ecology and conservation. I chose an undergraduate zoology course which allowed me to focus on entomology in the final year. Although my dissertation was on insect behaviour, arthropod pest management was even more fascinating, so the "Biological Control" and "Pesticide Technology" modules offered by the Entomology MSc course sound particularly relevant. The draw of applied entomology to me is that entomologists have responsibility not only to control pest species but to minimise harm to non-target species and the wider ecosystem. I aim to build a skill set for applied entomology that will be attractive to commercial agricultural companies, including expanding my statistics competence to incorporate constantly evolving research techniques. Other aspects that I would like to explore include ecological entomology, disease vectors and nutrition.

My entomological fieldwork experience began on a trip to Guyana in 2012 with Operation Wallacea. Working alongside professional scientists, my job was to prime dung beetle traps along transects to estimate the size of ecologically important insect populations. Then, while visiting the Masoala peninsula in

Madagascar last summer, I learned from a researcher in entomophagy how key insect species can supplement the diets of economically deprived communities. Fulgorid plant hoppers (in Malagasy '*sekondry*') were managed as sustainable livestock for village farmers. These insects are rich in essential proteins and minerals, can be fried in their own body fat and, most importantly, do not destroy their food crop but only harvest its sap. The remit included educating locals about which plants attract these insects, when to harvest and how to sustain the food source. Seeing how projects like this can reverse poverty-related human problems opened my eyes to the wider utility of insect science. This year I served a brief internship (shortened by Covid-19) with a forensic entomologist identifying blowfly species, after following lectures on this subject at DANES 2019.

The RES scholarship will allow my lifelong interest to expand into an absorbing career. Student loans cover fees and subsistence but do not stretch to accommodation. Whilst studying at Derby, I lived at home to save money and cycled to campus daily, a 30-mile commute on cycle paths. To study at Harper Adams, I will have to rent accommodation there and fund occasional travel home; these extra living costs for the year will just be covered by the generous amount offered. I am extremely grateful for the opportunity provided by the RES with this scholarship. It will allow me to study full-time and immerse myself in the subject, make fullest possible use of the postgraduate experience and research opportunities, and ease my transition into future employment.

Lucy Pocock



With global change occurring at an unprecedented rate, species decline has been propelled into the forefront of the media and scientific research. Whilst large charismatic fauna are often the targets of conservation efforts, it is insects that underpin the food chain and ultimately the survival of many species, including humans. With conservative estimations suggesting that there are around 4-6 million insect species worldwide, accounting for at least 75% of the world's animal population, there is inevitably vast amounts of information still to be discovered.

The lack of habitat information for many rare (or simply under-recorded) insect species, is what has driven me to define the habitat characteristics of the bog bush cricket *Metrioptera brachyptera*, on behalf of Lancashire Wildlife Trust (LWT) for my undergraduate dissertation project. With species rapidly declining and extinction rates estimated to outweigh discovery by around 50%, defining such conditions has proved vital for the conservation of many species. My study has provided LWT with invaluable information to aid a reintroduction strategy for *M. brachyptera* to one of their regenerating peat bog sites. I now breed *M. brachyptera* in my spare time, on behalf of LWT. This has proved a tricky species to breed in the past, with species-specific information lacking. So far, the project is going well and the small population of three pairs has produced almost 350 eggs. However, this species has a diapause of two years and must be subjected to specific incubation cycles, so the hard part isn't over yet! The (hopefully) resulting population will be used to populate the bog bush cricket reintroduction project, which is part of a much larger project to restore peat bogs in the Manchester Mosslands. The lack of information available for the bog bush cricket brought up many more questions than answers in my dissertation project and breeding programme, and I hope to continue studying the species for my MSc research module.

My path to entomological enthusiasm started in 2015, with a trip as a conservation research volunteer to the Peruvian Amazon rainforest. I contributed to many surveys, but it was butterfly surveys I enjoyed the most. The sheer quantity and diversity of insects caught in the traps amazed me, as did the botfly larvae most people acquired. Upon learning about the host specificity, multiple life stages and morphological forms that botflies and many insects have, I evolved a strong desire to delve further into entomology. When I returned from my time abroad, I applied for a Wildlife Conservation degree at Liverpool John Moores University and decided to keep some insects to expand my knowledge. I currently keep two species of phasmid (*Sipyloidea sipylus* and *Phobaeticus magnus*) and have one *Hymenopus coronatus* individual, the latter of which also requires me to keep many insect feeders. During my time at university, I pro-actively sought to develop my skills in ecology and entomology, with a view to pursuing a career in ecological consultancy as an entomologist. I participated in multiple invertebrate identification events held by the Tanyptera Trust, along with attending the British Ecological Society Summer School in 2017. During the summer school, I was impressed with the entomology day held by lecturers from Harper Adams University. I knew from then that I wanted to take my studies further with the MSc in Entomology. I have been a member of the Royal Entomology Society since. The hard work throughout university paid dividends; I am currently employed by an ecological consultancy firm and I feel privileged to say that I absolutely love my job!

Having started university later than most of my peers, I have gained experience in many different career fields. I am now thankful that I didn't rush and have found my absolute passion. I look forward to putting my skills into practise, in an MSc course and career filled with variety and discovery.

George Ryley

Growing up, I knew I was destined for a career in the wildlife sector, but it wasn't until around 2016 that my passion for invertebrates was truly ignited, when I was introduced to insect survey methods by my dear friends Liam Olds and Chloe Griffiths. Very quickly, I acquired my own sweep net, DSLR camera and a variety of pots, and was soon spending much of my spare time conducting my own surveys, immersing myself in the sheer joy and diversity of this wonderful class of animals. I naturally progressed to the world of biological recording, and I was submitting all of my insect finds, which spurred me to go and find even more, especially as my local area is considerably under-recorded for a number of insect orders. This has all encouraged me to broaden my entomological knowledge in areas such as life histories, background ecologies, and explanations for physical appearances and behaviour. What I find exciting is that, relative to many other animal orders, there are still many knowledge gaps to investigate and fill. Also, given how entomology is rapidly becoming a frontier science because of the importance of insects to humans and that their abundance is declining, I feel there has never been a more perfect time for me to capitalise on my passion for them by defining my career in this subject.

In that light, starting the Entomology course at Harper Adams seems like the natural next step for me. Given my recording activities, the "Biology and Taxonomy" and the "Diversity and Evolution of Insects" modules particularly excite me for the skills development in the preparation of specimens and use of microscopes for identification, as well as the mounting of dried specimens and curation and sampling techniques. These are skills I will be able to apply instantly to my recording activities and broaden the range of species I can make records for. When out in the field, I find myself pondering the place of certain insect species in their ecosystem, their life histories and the various requirements they have from the environment in order to persist and thrive, so I am also very much looking forward to the "Ecological Entomology" module. Such knowledge will also aid insect-orientated conservation and habitat-management strategies that I intend to include in reports for my surveyed sites as part of my insect recording project.

Without this scholarship, my financial situation would mean that I would have to find some paid work but, thanks to winning it, this will not be the case, and I will be redirecting the saved time and money to both my studies on this Entomology course and my developing insect-recording project in mid and west Wales. I'll therefore be able to focus more on my coursework, exams and dissertation study, whilst also having a platform outside of the university in which I can continue to develop everything I have learned. In short, this scholarship will provide me with a plethora of opportunities to make the most out of my studies at Harper Adams and provide firm ground for the next step in my entomological career...... and I can't wait to start!

Jen Thomas

From an early age I have had a keen interest in wildlife and a curiosity to discover more about the natural world, spending much of my free time birdwatching and ringing birds. Over recent years, I have undertaken a number of field surveys on birds and invertebrates, and my love of learning has led me to improve my field and microscope identification skills of solitary wasps, bumblebees, woodlice, flies and other invertebrates such as earthworms and snails. I have thoroughly enjoyed the practical side of these courses, improving my field skills, preparing samples as well as using and understanding taxonomic keys.

Identification of insects is a challenge I greatly enjoy. Having spent time volunteering within the Natural History Museum and doing outreach for the wider public, I am excited to broaden my understanding of entomological research and put this into context. The roles of insects, their life history and building on my practical skills, are all areas where I would like to improve my knowledge and understanding as part of the Entomology course at Harper Adams.

I am particularly looking forward to the module "Biodiversity and Ecosystem Services". Most of my current knowledge is based around the conservation side of biodiversity, so I am very keen to learn more from the agricultural focus that this module provides.

I will continue to work as a research data manager for a polar research institute whilst studying entomology. Modules about "Research and Information Skills" and "Experimental Design and Analysis" will complement my work by giving me greater understanding of the conception and implementation of projects from a researcher's point of view.

I am very grateful to receive this RES scholarship, which will allow me to continue to work part-time. Whilst working on my research project, I would like to build on the knowledge I have acquired during the lectures by getting some practical experience in a field-based, entomology-related voluntary role with a view to combining this with my current work in the future.

Meetings

Data, Ecology, and Electronics & Computing Special Interest Groups

Online Meeting on e-Ecology, 19th October 2020

Convenors: Mark O'Neill (Tumbling Dice), Ashley Lyons (Liverpool Hope University), James Gilbert (University Of Hull)

Report by Richard Harrington

Figure 1. RFID-tagged bees (Sarah Barlow).

We all know that insects are a critical part of our ecosystems. We also know that many are in steep decline due to human activity, that the natural ecosystems on which we depend are hence under threat, and that we are also at increased risk from new zoonotic pathogens as a result. There are data to support these assertions but they are still very limited, bearing in mind their crucial importance. Recent developments in computing technologies have been game changing in many areas of our daily lives. The aim of this meeting was to highlight the potential of edge-computing (computing done near the source of data), IoT (Internet of Things) technologies and artificial intelligence to measure biodiversity change, climate change and ecosystem degradation in real time. This the convenors termed *e-ecology*.

The Society's President, Helen Roy (UK Centre for Ecology & Hydrology), set the scene by explaining the urgent need for transformative change to address biodiversity loss and ecosystem degradation, citing evidence of declines from BRC (Biological Records Centre) and other data, much of which has been provided by volunteers and contributed to the latest (2019) RSPB-led UK State of Nature Report. This shows an average 13% decline in species abundance and a 5% decline in species distribution since 1970. Striking innovations in image analysis apps have assisted identification, and such techniques will continue to improve. It is now possible to show trends for thousands of species, and such data are vital in persuading politicians to act. A special issue of our journal *Insect Conservation and Diversity* (Volume 13, Issue 2, 2020) presents new empirical evidence on insect population trends and suggests ways forward. Mark O'Neill suggested that machine-learning algorithms could help in this endeavour and also enable integration of data from very different databases.

The meeting's keynote lecture was given by Chris Hassall (University of Leeds), lead researcher in the BioDAR project (www.biodarproject.org), who highlighted the potential of weather radar networks in monitoring the abundance and diversity of insects. Weather radars produce observations every five minutes across the UK at 100–1000m resolution. It has long been known that insects are seen by weather

Figure 2. Using the Rana automated motion vision system to monitor pollinators of rare penstemons in Utah (Sarah Barlow).

radars, and recent dual polarisation radars, which receive and transmit both horizontal and vertical polarisations, have greatly improved the ability to identify insects (as a group – not to individual species) and their diversity from their shape, by using algorithms trained with the help of 3-D models made using Micro-CT scanners. The BioDAR project aims to define the taxonomic limits of weather radar, whether radar-defined biodiversity metrics can offer new insights for environmental and ecological researchers, and whether such metrics can be rolled out nationally, or even globally, as a measure of biodiversity. Insect data can now be extracted from radar data then clustered into key groups based on morphology. Evaluation programmes are at an early stage but appear promising. Radar Shannon diversity (clusters) appear to correlate well with biological Shannon diversity (species).

Sarah Barlow (University of Utah, and University of Newcastle) and Mark O'Neill (Tumbling Dice) described three novel technologies which, when combined, have the potential to provide an integrated e-ecology platform. Prototype long-range RFID tags (Figure 1) with a range of 1.5m are being used to track bumblebees in the field. Standard (passive) RFID tags are limited to a range of 1cm. It is hoped that production versions of the long-range tags will increase the detection distance further. The prototypes are about half the weight of a bumblebee, but the aim is to reduce their size. In answer to a question, Sarah and Mark agreed that a mesh network of tags could increase their effective range, and that they could potentially be interrogated by drone-borne radar when following targets. An automated video monitoring system (Rana), based on active motion vision, is sensitive to small-scale biological interactions, e.g. bees visiting flowers. Resulting movies are motion-compressed so that relevant activity is easily viewed. The Rana unit comprises a web camera, datalogger and power supply, and data can be accessed via wireless connection to a smartphone. Sarah described the use of Rana in a conservation project, based in Utah (Figure 2), studying the pollinators visiting two rare, endemic penstemons, which are threatened by the oil and shale-gas industry infrastructure. *Penstemon scariosus* var. *albifluvus* (Figure 3) received nine times as many visits (mostly from *Osmia* bee species) as *P. grahamii*. Structural Equation Modelling was used to look at direct and indirect relationships between visits and a range of biological, environmental and physical landscape variables, with the aim of providing management recommendations. A deep-learning intelligent image-recognition system (DAISY-II) filters spurious information

Figure 3. A specialist pollen wasp, *Pseudomasaris vespoides*, visiting flowers of *Penstemon scariosus* var. *albifluvus* in an oil-shale desert region of Utah (Sarah Barlow).


Figure 4. Stag beetle, *Lucanus cervus*, male (Paul Kitchener).

and helps to identify species, for example, in Rana images. The time taken to train the DAISY-II algorithm is less than an hour, a great improvement on other systems.

Rana was also used by Luca Pegoraro (Royal Botanic Gardens, Kew, and Queen Mary University, London) to study pollination of plants in the family Asteraceae in the European Alps. Polyploidisation is leading to macroevolution, and sympatric mixed-ploidy populations can be used as natural experiments to investigate the early stages of speciation. In *Senecio doronicum*, octoploidy is much commoner than tetraploidy, tetraploids being confined to exposed rocky slopes. There is a slight overlap in space and in flowering time between the two forms, which also show small morphological differences. Rana revealed differences in the identity and behaviour of pollinators, and the frequency of their visits to the two forms.

The Rothamsted Insect Survey (RIS), led by James Bell (Rothamsted Research), has been providing UK-wide standardised data on insects sampled by suction-traps and light-traps since the 1960s. James highlighted the problems of introducing technological changes such as automated identification to such long-term networks, as these may bias results or even slow down the process of identification. He acknowledged that there are, in any case, too many technological challenges in automatic identification of aphids to make such likely in the foreseeable future. He did, though, show how developments in computing technology can improve delivery of data to users, and how deploying real-time meteorological, acoustic, pressure and light sensors by traps can add value to the insect data and aid their interpretation. In work unrelated to the UK trap networks, the RIS has developed digital pheromone traps to attract and identify *Spodoptera frugiperda* (fall armyworm) in Kenya. An app, *Nondo Africa*, can identify twenty species of moth pests of maize in both adult and larval forms. New systems are also being developed to identify multiple species in light-traps, although these will not be used by the RIS for the reasons stated above. Mark O'Neill suggested that, as these systems cannot deal with "unknown unknowns", effective anomaly detection will be required, but this is a huge challenge in machine vision/AI. Luca Pegoraro pointed out that standardised long-term data on pollinators are lacking. James said that any programme must take account of the fact that bees are only a part of the pollinator community and that all contributors to the service should be treated equally. He also highlighted the issue of distinguishing "absence" from "failure to capture".

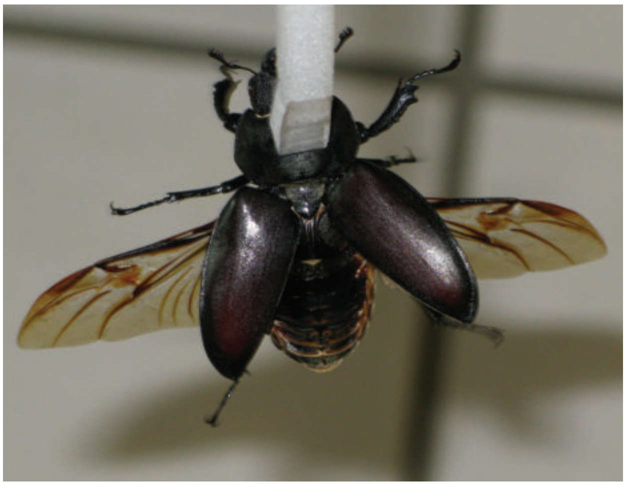


Figure 5. Stag beetle female on flight mill (Colin Hawes)

Colin Hawes (Royal Holloway, University of London) has been doing research on the stag beetle, *Lucanus cervus* (Figure 4), for thirty years. In the field, he has used mark-release-recapture techniques and radiotelemetry to study their flight capacity and dispersal, which are crucial for gene flow between populations and for colonisation of suitable habitat. These studies have been backed up by laboratory flight-mill (Figure 5) experiments. The field studies suggest that dispersal rates and ranges are low, especially in females, when there is a plentiful supply of rotting wood on which the larvae can feed, but the flight-mill experiments suggest that both males and females can sustain flight for an hour, making longer-range dispersal feasible when needed. The data inform conservation strategies.

Whilst technologies are advancing rapidly and will continue to enhance the collection of relevant data, these advances must be translated into policy and action to reduce biodiversity loss. Money talks, and Justin Sparks (The Merian Project; www.merianproject.org) is promoting a new technological approach that will make visible the true economic value of our natural resources, in a way that will ensure economic actors protect and invest in those resources out of financial self-interest. The Merian project is developing systems capable of calibrating and monitoring biodiversity in real time, and aims to transform both economic and social values to the long-term benefit of mankind.

In the general discussion, it was pointed out that no presentations covered molecular techniques for automated identification, either in the lab or field. Mark O'Neill suggested that nanopore technology is one way forward. This is already in use but, although it is relatively cheap compared to other molecular methods, it is still comparatively expensive and slow compared to other identification techniques. There is great potential to integrate such techniques with those covered by the speakers. There is no doubt that rapid advances will be forthcoming, and that e-ecology will become increasingly valuable in convincing people of the crucial need to protect our ecosystems, as well as providing evidence as to how this should be done.

More than forty delegates participated in this meeting. Many thanks to them all and to the convenors, speakers and their co-authors. Hopefully, the next meeting on the theme of real-time data will have the option of attending in real-person, with technology aiding participation by those unable, or not wanting, to travel.

Orthoptera Special Interest Group

Online Meeting, 11th November 2020

Convenors: Björn Beckmann (UK Centre for Ecology and Hydrology), Judith Marshall (Natural History Museum)

Report by Richard Harrington

Figure 1 Large marsh grasshopper (*Stethophyma grossum*) (© Philip Thorpe)

Last year, the Orthoptera SIG made history by holding its 40th meeting. This year it made history by holding its first virtual meeting, with a record attendance of 80.

Just two species dominated proceedings: Large marsh grasshopper (*Stethophyma grossum*) (Figure 1) and Roesel's bush-cricket (*Roeseliana r. roeselii*, but still widely recognised under its earlier name *Metrioptera roeselii*) (Figure 2). Stuart Green (formerly NRI, retrained and working as an Optometrist, but always an Orthopterist!) is lead entomologist in a project aiming to re-establish the former species in Norfolk and Cambridgeshire, where it was last seen in 1968 and in the 1860s, respectively. The Large marsh grasshopper is the largest, and one of the rarest, British grasshoppers, confined almost exclusively to the wettest of habitats in the New Forest and Dorset. It has an unusual stridulatory mechanism whereby the hind tibia repeatedly flicks out and kicks the tip of the forewing to make a series of clicks. It has the potential to fly long distances, but doesn't usually do so, as its habitat patches tend to be small. On the ground, it is cryptic, wary and elusive, which can make population monitoring problematic. Historical drainage and peat cutting at many former sphagnum bog and fen sites reduced its populations drastically but, at one site in Norfolk, habitat management over the last ten years or so has raised water levels by blocking drainage channels and clearing scrub to substantially restore the habitat. With necessary permissions, parent populations were translocated from the New Forest in July 2018. Thirty adults were released at two sub-sites and a further 18 adults were kept for a captive breeding programme, these being supplemented by 15 more collected in September. Breeding in captivity worked very well and 260 egg pods resulted. Most of these were passed on to a team of 11 volunteer "Citizen Keepers", who were trained in how to home-rear them through to adulthood and, although there were inevitable mortalities along the way, rearing success was generally very good. On turning adult, the grasshoppers were colour-marked with a spot on the thorax to facilitate dispersal studies, and about 900 were released in August 2019 at several predetermined sites (Figure 3). A further 1,000 were reared during Covid lockdown in 2020, and also released at the site. As yet, the level of success is unknown, although numerous unmarked, Norfolk-born adults were sighted in 2020, and this will be assessed through surveys in 2021, when there will be further releases. Work will also begin in the Cambridgeshire fens.

In discussion, it was pointed out that, in Germany and The Netherlands, the range of Large marsh grasshopper has expanded rapidly over the past 25 years, and that it is now frequenting moist meadows, which are far drier than the New Forest and Norfolk sites. Phil Thorpe (Natural England Reserves Manager, and University of the West of England Master's student) suggested that similar changes are occurring in England. The species was rediscovered in the Somerset Levels in 2019, following an absence since 1995 (but for a single record in 2006). The new records were from Brue Valley pastureland, with 115 sightings reported in 2019, and 250 from 19 fields in 2020. Phil investigated Large marsh grasshopper habitat preferences by searching 84 zigzag transects (25m x 5m) from seven mire (M) or meadow grassland (MG) plant-community types. The largest counts were made from a 2-hectare field of M23 (soft rush-dominant) and MG8c (black sedge/lesser spearwort) vegetation communities, grazed at low intensity and cut after egg-laying; there were so many animals within this field that the collective calls sounded like rain. Studies will continue as will, hopefully, range expansion.

Over to Roesel's bush-cricket. Karim Vahed and Oliver Tomlinson (University of Derby) are studying its recent establishment at relatively high altitudes in Derbyshire and Staffordshire. Prior to the 1980s it was associated with the sea, being found by the Thames, Solent and Humber estuaries. In Austria, France and Switzerland, though, it can be found up to 2,500m asl, although most records are from lower down. Over the last few decades, large range expansions have been seen in the UK and it has reached Derbyshire and Wales. With climate change, upland areas have become more suitable, and this may continue. Roesel's bush-cricket is

Figure 2 Roesel's bush cricket (*Roeseliana r. roeselii*) (© Karim Vahed)

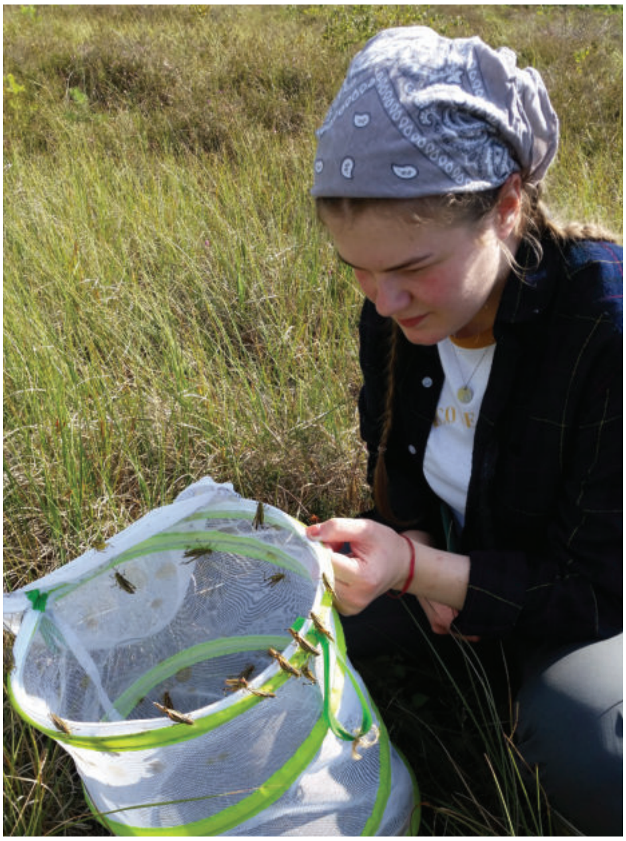


Figure 3 The big day has arrived, and a Citizen Keeper releases her grasshoppers (© S. Green)

generally brachypterous, macropterous specimens resulting from high density or stress. In some years there are large numbers of the macropterous form, and these are associated with dispersal events. They can fly at least 19 km. In Derbyshire and Staffordshire, Karim reported a northwards and westwards range expansion over the last few years. Populations have now been found at the edge of the Peak District National Park, and the presence of nymphs and brachypterous adults in 2020 suggests that they have become established at altitudes up to 300m. Elaine Wright reported that the species is rapidly spreading in Wales, with hills being no barrier, and it will be interesting to see whether other upland areas (e.g. North Pennines, Dartmoor and Exmoor) will be colonised.

The meeting ended with Ted Benton (University of Essex) talking about a planned survey and book on the Orthoptera of Essex, and Steve Banner showing a wonderful film called "We don't like crickets". Steve's PhD was on the gut pharmacology of the Desert locust, *Schistocerca gregaria*, but he left the orthopterists' fold until his son, aged 9, got interested. Lockdown was a great opportunity to take up filming, and the result was a feast of long antennae (Figure 4), huge leaps, bucolic scenery and stirring music. It was particularly nice to be joined at the meeting by Steve's son and daughter, perhaps the youngest ever participants in a SIG, and to see the next generation of orthopterists in action. Incidentally, "We don't like crickets" is a parody of the lyrics of 10cc's "Dreadlock Holiday", in which the words "I don't like cricket, oh no", are followed by "I love it", and Steve's full title was "We don't like crickets...oh no…We love them!".

Many thanks to all presenters and their co-authors, and to Fran Sconce (RES) for handling the technical side, which included the facilitation of break-out groups, and a "virtual pub session" at the end, sadly without Judith's usual wonderful catering.

Like Large marsh grasshopper and Roesel's bush-cricket, Björn is moving north. He is handing over the convening of the group to Darron Cullen (University of Lincoln). Huge thanks are due to Björn for the fantastic work he has done over the years, and a warm and grateful welcome to Darron. 3rd November 2021 is firmly in the calendar.

Figure 4 Nymph of *Conocephalus fuscus* in early June, frame taken from the film (© Dr Steve Banner)

Scottish Regional Meeting

The Role of Insects in Plant Health

4th November 2020 – Online

Convenors: Fiona Highet (SASA), Katy Dainton (Forest Research)

Report by Richard Harrington

Figure 1. *Nasonovia ribisnigri*; © Rosemary Collier, University of Warwick

The United Nations General Assembly declared 2020 as the International Year of Plant Health (IYPH), aimed at raising awareness as to how protecting plant health can help reduce poverty and hunger, and protect the environment. FAO estimates that up to 40% of food crops are lost to pests, diseases and weeds. Such problems are worsening as a result of human activity resulting in climate change, reduced biodiversity, and the spread of pests, diseases and weeds beyond their natural range. Protecting plants is far more cost effective than dealing with a full-blown emergency. This meeting was convened to contribute to IYPH, with ten excellent presenters speaking on the role insects play in crop loss, and what needs to be done in mitigation.

Gerry Sadler (SASA), Chief Plant Health Officer for Scotland, introduced the meeting and outlined SASA's role in keeping exotic pests out, developing contingency plans for dealing with those that get in, and managing those that are already established.

Whilst most talks had a Scottish flavour to them, the first keynote, from Sean T. Murphy (CABI), examined the impact of insects on smallholder cropping systems in eastern sub-Saharan Africa. 70% of the world's poor live in rural regions and most are smallholders. CABI's emphasis is on major pests, common to particular smallholder groups. CABI has undertaken a meta-analysis to assess the current (and likely future) economic impacts of five major pests of mixed maize cropping systems, and a socio-economic study to assess how smallholders perceive pests compared with other major threats to their livelihoods. This was done just prior to the invasion of the fall armyworm, *Spodoptera frugiperda*, a New World species which entered west Africa in 2016 and has attacked maize. The combined annual economic losses due to the five pests in Ethiopia, Kenya, Malawi, Rwanda, Tanzania and Uganda are estimated to be around 1 billion dollars, 2% of GDP, with *Chilo partellus* (spotted stem borer) being the most destructive insect. Increased losses are expected as pests spread to other countries. In addition, problems are becoming greatly exacerbated by the fall armyworm as it has now spread to 44 countries in sub-Saharan Africa. The socioeconomic study was done in Mwea, central Kenya. All farmers in the region grow maize, with banana and tomato being the other major cash crops. Insects and diseases are recognised as the most important constraints, then weeds, drought, lack of market and lack of capital. Smallholders generally only make a profit if they grow two or more cash crops. CABI's work draws the attention of donor countries to the importance of supporting monitoring and control programmes.

Insecticide resistance is an increasing problem which, together with the loss of many active ingredients, and ecological damage associated with some synthetic insecticides, emphasizes the need for alternative,

Figure 2. *Tetropium fuscum* adult; SASA © Crown Copyright

Figure 3. *Tetropium fuscum*; historical specimen Glasgow Huntarian Museum © Fiona Highet

environmentally-friendly control methods. Rosie Mangan (University of Stirling) is keen to see wider use of fungal biopesticides and is investigating ways to reduce the risk of insects becoming resistant to these. The risk of resistance is greatest in uniform landscapes. Rosie's experiments with *Helicoverpa armigera* (cotton bollworm) showed that making the pest's environment more complex, by increasing crop variability and by using a variety of biopesticides, should drive down this risk. Heterogeneity can be on a coarse scale, such that individual farms may be able to adopt reasonably uniform approaches to cropping and pest control provided that neighbouring farms are using different systems.

I used to work on monitoring, forecasting and control of aphid pests of agriculture. I retired five years ago and was astonished to learn from Andy Evans (SRUC), that almost all the insecticides that were relied on in my time to control aphids, and hence the diseases they spread, have since been withdrawn, with virtually no alternatives coming on the market. Andy is looking at the impact of these withdrawals in Scotland. In a worse-case scenario, the loss of insecticides is expected to reduce cereal profits by 2% (£7 million) in Scotland as a result of increased problems from aphids and the viruses they transmit, wheat bulb fly, leatherjackets, and grain-store pests. Pest problems in oilseed rape in south-east England are not yet important in Scotland, but Scotland's seed potato industry is likely to suffer from increased problems from aphid-borne viruses. Field brassicas and carrots are expected to be severely impacted, with excess losses of 26% (£19 million) due to aphid-borne viruses, cabbage root fly, diamondback moth and other caterpillars, flea beetles and carrot fly. Greatest excess losses (55%, £60 million) are expected in soft fruit from raspberry beetle, clay-coloured weevil, vine weevil, raspberry cane midge, aphids and mites. Some insecticide withdrawals are due to EU regulations, and it is possible that Brexit will facilitate the return of certain active ingredients. There are alternative control measures but these are often expensive and short-term. IPM's time really has come.

Bacterial associations with aphids are well-known but, as pointed out by Pilar Morera-Margarit (James Hutton Institute), they are far less well-known in weevils, which form the largest beetle family and include many pests, and in which bacteria are involved in cuticle formation, flight activity, reproduction, speciation and, the subject of her presentation, detoxification of plant metabolites. In *Hypothenemus hampei* (coffee berry borer), gut microbiota detoxify caffeine. Treat weevils with antibiotics, and caffeine appears in their faeces. Reintroduce the bacterium *Pseudomonas fulva* to the gut and, hey presto, the caffeine disappears. There is a similar story with *Hylobius abietis* (pine weevil) and terpenes. It turns out that bacterial genes are involved in terpene degradation and that, as a result, terpenes may be a source of nutrients to the weevils, rather than being toxic. Pilar says that these findings should be combined with knowledge of weevil ecology, physiology and genetics, and applied in an agricultural setting to develop innovate IPM programmes.

Much has already been said about IPM. Rosemary Collier (University of Warwick), in the second keynote talk, asked whether IPM has lived up to its promise. In greenhouses she concluded that it has. Inundative and inoculative control are well-developed, especially in tomatoes. Sometimes, however, the biocontrol agent itself can need controlling! IPM in soft fruit also got a good report, growers largely relying on predators and parasitoids for control of thrips, mites and aphids, although some aphicides are still used. Biocontrol agents are rarely introduced to orchard fruits because they are long-term perennials and beneficials such as earwigs, anthocorids, lacewings and hoverflies build up naturally. In field vegetables and salad crops, apart from *Bacillus thuringiensis* for caterpillar control, there has been minimal biocontrol. Physical barriers have been of use, as has host-plant resistance, but this can break down, for example in about ten years in the case of lettuce completely resistant to the aphid *Nasonovia ribisnigri* (Figure 1). No biocontrol agents have been successfully introduced to arable crops on a commercial scale and there is limited host-plant resistance. Conservation headlands have played a useful role, however. Factors favouring deployment of IPM include the presence of valuable non-target organisms, a contained crop, a high-value crop, insecticide resistance, and the loss or lack of

Figure 4. *Hylobius abietis* feeding on Scots pine; © Ainoa Pravia, Forest Research

Figure 5. *Philaneus spumarius* adult; SASA © Crown Copyright

insecticides. New biopesticides and physical barriers could provide a quick fix, but renewed focus should, according to Rosemary, be put on crop rotation (at a landscape scale, as suggested by Rosie, above), resistant varieties (Genetic Improvement Networks could be tapped into here, and partial resistance should be considered as it can't so readily be broken down), polyculture (growing more than one species in a field) and conservation biocontrol.

Tetropium fuscum (brown spruce longhorn beetle) (Figure 2) has recently been recorded in Scotland, and Scottish Forestry (with the help of SASA) wants to know if it poses a risk. It is a native of continental Europe, where it is a secondary pest, feeding largely on dead or already stressed spruce and pine. It is more aggressive in Canada, however, where it has become established on red spruce. Larvae cause damage and pupate in the xylem, causing blockages and tree death. Lure traps and billet traps (fresh-cut log) have been used to monitor it in Scotland since its arrival in 2015. The larvae are similar to those of *Tetropium castaneum* (black spruce beetle) and molecular taxonomy is required to separate them. In the process, Rebecca Cairns (SASA) has discovered that *T. fuscum* numbers are relatively low. *Tetropium castaneum* is far commoner, but not a pest, and Rebecca may have uncovered a molecularly-distinct species or subspecies. There was a surprise discovery of a museum specimen of *T. fuscum* collected in 1986 from Roslin (Figure 3), suggesting that it has been present in Scotland for several decades. Rebecca concludes that it is probably not a threat to Scotland's spruce and pine due to the low numbers observed, offering reassurance to the forestry industry, and demonstrating the importance of traditional and molecular taxonomic techniques.

Staying with beetles on pine, *Hylobius abietis* (large pine weevil) (Figure 4) causes £5 million damage annually in the UK and €140 million in Europe. Ainoa Pravia (Forest Research) is studying its locomotor dynamics. Chemicals for its control are being phased out and an IPM approach is required, with fungal and nematode biopesticides seemingly having potential. The insect mainly walks rather than flying and has a strong aggregation behaviour which may be pheromone-mediated. Ainoa has explored its behaviour in relation to billet traps and has found that it shows a directed, rather than random, walk to traps, suggesting that it may think that they are host plants. It prefers the higher entrances in traps and shows great variation in the time spent in traps. Ainoa hopes to improve trap design and efficiency as a result of her work.

It's not present in the UK, but the bacterial pathogen *Xylella fastidiosa* is causing great concern, as it is the cause of disease in a huge variety of crops and trees, and is spreading rapidly through Europe (now in Italy, Spain, Portugal and France). *Xylella* lives in, and blocks, the xylem of a plant and is vectored by xylem-feeding insects such as *Philaenus spumarius* (meadow spittlebug or common froghopper) (Figure 5) as well as other leafhoppers found in the UK. Katherine Lester (SASA) is working on several collaborative projects aimed at improving testing for the bacterium in plants and raising awareness of the disease. An important part of this work is to build on previous knowledge of vector biology, behaviour, distribution and abundance in the UK. *Philaenus spumarius* is common and abundant in numerous habitats in Scotland, and the insects are polyphagous, feeding on a wide variety of plants, including trees. Within gardens, nymphs feed particularly on lavender and rose, and in natural areas on bird's foot trefoil, creeping thistle and grasses. Work continues to improve our understanding of its spatial abundance, particularly in woodlands and within arable, horticultural and urban habitats. If *Xylella* does arrive, Scotland is well-prepared.

Co-convenor Katy Dainton (Forest Research) explained how to become engaged with tree and plant health. Introduced species are a threat to biodiversity, and climate change, the gardening boom resulting from Covid-19, and increased global trade are increasing the risk. The Conservative Party has pledged to plant 30,000 ha of trees per year, approximately 120 million trees, and over 80% of these are being planted in Scotland. 609 out of 1,240 pests on the plant health register are insects. Katy makes a plea for vigilance and reporting, as early detection leads to less intervention. She thinks that the next invasion of insect pests might be found via social media and urges people to visit www.observeatree.org.uk and www.forestry.gov.uk/treealert to get involved.

Many thanks to the convenors, presenters and their co-authors, and Fran at the RES, for putting together and supporting an excellent meeting, attended by around 50 people and making a great contribution to the International Year of Plant Health by highlighting valuable research.

Outreach Special Interest Group

Online Meeting, 10th December 2020

Convenor: Ashleigh Whiffin (National Museums Scotland)

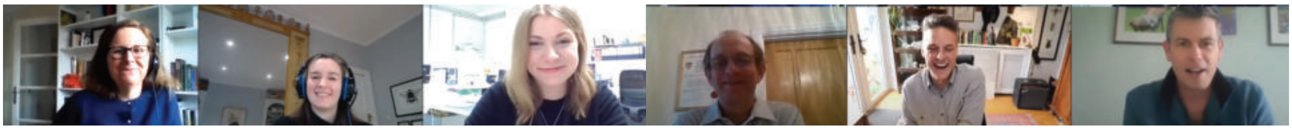
Report by Richard Harrington

Perhaps the Outreach SIG should be at the vanguard of finding new formats for engagement. This meeting certainly was. The idea was simple – an informal, short event to discuss how to enthuse the public, and it worked a treat. Eighty-five people attended and, from their "chat" posts, I noticed that they came from far and wide, including India, Pakistan and the USA.

In science, some of the most important discoveries are made by accident. Nick Baker (freelance naturalist) similarly discovered by accident that Instagram is a fantastic way to engage. On the day lockdown began, Nick's diary for the year emptied, and he felt bereft. Then his daughter showed him how to go live on Instagram, and he hasn't looked back. (This, surely, is what having children is for!) He was now a free agent, not hamstrung by the vagaries of TV companies but, instead, fully in control of live broadcasts. Soon he had a large and appreciative following and made new friends, whilst enjoying himself at a level not experienced since he was ten. "Nick's Instagram broadcasts were the perfect medicine." "Because of Nick, I have a keen interest in entomology and have started a diploma in this subject." Just two of the plaudits which Ashleigh flagged up. Nick, incidentally, was co-founder of the RES "Bug Club" with Clive Betts in the early nineties. This is now with the AES, but Nick hopes to become more involved with our own Society again, which is great news.

RES President, Helen Roy (UK Centre for Ecology & Hydrology), reprised accounts of the inspiring discussions she had during National Insect Week with female entomologists from around the world. You can read more on this in *Antenna* 44(3) 101–105. Helen pointed out that not everybody is empowered to have their entomological voice amplified, and that it is part of her mission as President to improve such opportunities for everybody. She also related how she has been able to engage with diverse groups during lockdown, including a Zoom meeting with her local Brownies, in which hawkmoths were the stars. The Pollinator Monitoring Scheme coordinates FIT (Flower–Insect Timed) counts, whereby people watch a flower for ten minutes and record species which come to it. Almost certainly as a result of lockdown, 1,838 people participated in 2020, double the number in 2019. Some of the positive aspects of lockdown will be a legacy going forward.

The Big Wasp Survey (BWS) was launched in 2017. Adam Hart (University of Gloucestershire) related how 1,500 "super engagists" put out traps, presenting a potential



problem with tens of thousands of wasps needing to be posted, then identified. He needn't have worried. Within an hour of circulating a message asking whether these people might be willing to try learning how to do the identifications themselves, half had enthusiastically replied in the affirmative. Jess Perry, an Applied Ecology Master's student, prepared videos, photos, an identification flow chart and a step-by-step guide. The result was phenomenal, with 96% accuracy being achieved. The BWS badly needs records from urban areas and national parks – see bigwaspsurvey.org.

You can read more about National Insect Week and other RES Outreach activities on pages 44–51, but Fran Sconce (RES) outlined the very successful "Entomology at Home" campaign, which included 50 virtual events, the production of new on-line resources, the photographic competition and a large volume of social media activity. A poll conducted during the meeting revealed that 89% of respondents would like there to be an NIW every year, whilst 68% would favour it being combined with the Insect Festival. A small majority would prefer dropping "National" from the event title.

Questions poured in, and the one-hour discussion session could potentially have doubled in length. Topics covered included: how to run virtual workshops and show specimens under microscopes; how to get the reluctant interested in insects; how to generate press opportunities; the potential for hybrid in-person cum virtual meetings; platforms for citizen science; the role of museums in outreach; identification apps, and much more.

The palpable enthusiasm to spread the word bodes well. Many thanks to Ashleigh and all the panellists for an inspiration-packed two hours – perhaps the shortest SIG ever, but certainly an event with impact.

SCHEDULE OF NEW FELLOWS AND MEMBERS

as at 29th October 2020

New Fellows (2nd Announcement and Election)

Dr Jenan Salem Alharbi (as at 7.10.20)
Dr Pierfilippo Cerretti
Dr Laurel Haavik
Dr Gadi V.P. Reddy
Dr Philip Barton
Dr Polura Venkata Rami Reddy
Prof. Ramaiyer Varatharajan
Dr Amr Ahmed Mohamed
Dr Akkati Venkat Reddy
Mr Stuart Paul Masson Roberts
Dr Srinivasa Murthy Kotilingam
Dr Angeliki-Kelly Martinou

Upgrade to Fellowship (2nd Announcement and Election)

Dr Joe Roberts

New Members Admitted

Dr Jesamine Bartlett (as at 7.10.20)
Miss Jen Thomas (as at 7.10.20)
Miss Melanie Jane Wainwright (as at 7.10 20)
Dr Rathinam Balasubramanian

New Student Members Admitted

Miss Rita Roma Morais

Deaths

Mr Tony Johnson Wilkes, 1962, UK

as at 2nd December 2020

New Fellows (1st Announcement)

Dr Simon Hellemans
Prof. Tong-Xian Liu

Upgrade To Fellowship (2nd Announcement and Election)

Dr Sagadai Manickavasagam

New Members Admitted

Mr Henk Ten Holt
Dr Philip William Brighton
Mr Damian De Marzo
Miss Rachel Sarah Inhester
Mr Harold Jack Russell Stone
Dr Neha Pandey
Miss Victoria Rose

New Student Members Admitted

Miss Aimee Tonks
Miss Emma Jayne Taylor

Deaths

Prof. Alan Clements Hon. FRES, 1950, UK
Prof. Walter McAllister Blaney, 1979, UK
Mr Michael Stephen Harvey, 1982, UK

Honorary Fellow Interviews

Helen Roy

From Wild to Beguiled: a Life with Ladybirds

by Peter Smithers

Helen Roy needs no introduction. Anyone with even the vaguest interest in the natural world will be aware of her books on ladybirds and will probably own at least one of them. She is a champion of the colourful beetles that have stolen the hearts of the British people, beetles which are now seen as icons of our countryside. As a recently-appointed Honorary Fellow, Helen was high on my list of potential interviewees, and when she accepted the role as the Society's President this interview, via Zoom, became imperative and took place in June at the end of her first week in office.

How has your first week as President of the RES gone?

"It has been very busy. There are exciting things happening, such as planning the Grand Challenges project, which will be looking at the big questions in entomology. We will be asking all members for ideas very soon and setting up workshops to discuss them. National Insect Week is also coming up, so there will be many online events to get involved in. I have recently given a few webinars on ladybirds alongside Peter Brown (Anglia Ruskin University), something we would not have thought of doing before lockdown. We had 250 participants for the one on garden ladybirds and 80 for the one on ladybird larvae. These webinars have worked really well, so I am sure we will be doing more of them."

Early life

"My mother was Cornish, but I was born in Plymouth, Devon. When I was eight-months old, my parents moved to Uganda. My father was teaching maths and my mum was a nurse. It was a really remarkable journey as neither of my parents had ever flown before. We were there for almost three years, but I have no memories of this time. However, I grew up seeing many photographs of the family in Uganda and my parents often told stories of the local wildlife, including naked mole rats and snakes in the larder. Apparently, after having eaten fried termites in the local market, I sat by a termite mound and ate them live. There are photographs of me running into swamps and charging around in the bush. I have been back to Uganda as a teacher with the Tropical Biology Association and it was really magical. I love the sense of the wild that I experienced while there."

The Isle of Wight

"On our return from Africa, we lived in Surrey but soon moved to the Isle of Wight where my father had elderly relatives. Almost as soon as we arrived, my parents separated. Despite this, I had a charmed childhood. The Isle of Wight was a fantastic place to grow up; it is much quieter than the mainland and as a child it felt a safe haven. My mum was my inspiration. She was a remarkable woman. Finding herself on her own with two young daughters far from her own home, she simply dedicated her time to making the world a magical place for us to grow up in. We lived in a small house on the edge of an estate, but I remember it as if it was a palace. The small garden was full of excitement for me – including a rat I befriended that lived on the compost heap.

My mum worked full-time as a nurse tutor, which was unusual back then, but at the end of her working day we would all wander up onto the chalk downs or along the beach with a flask of hot chocolate. We all loved the outside and not much has changed – my sister (and now also nieces and daughters) and I are always sharing stories of the wildlife we see. My mum encouraged our love of all things wild; she knew the names of all the local wildflowers and taught us many of them. I remember 1976 – the year of the ladybirds. I was six years old and captivated by the adult 7-spots emerging – bright yellow and without spots. My mum died two years ago and I miss her very much, but her legacy is continuing, as her granddaughters, inspired by their granny, continue on their journeys, sharing photos of bees and butterflies as they go."

School

"Each year, a biology teacher in my school organised a camping trip to a nature reserve on the Isle of Wight, called Newtown, which was a peninsula cut off by a firing range. I attended this camp every summer from age 13 until I left school, and indeed after I left school. The teacher had lots of friends who were experts in various fields of natural history. I remember being in awe of their knowledge. I recall sitting around a quadrat with a botanist and realising how many plants were within it; it was not just a patch of grass. All our findings were written up in the Isle of Wight Natural History Society journal. Even then I found sharing wildlife observations exhilarating. Entomologists have a fondness for poking around in things that most people would rather not, and my early experiences at these camps introduced me to this pastime. Recently, when walking with my daughter, we would walk pass a dead deer and each day I would say I was going to look under it, but my daughter suggested it was not acceptable behaviour. I eventually did turn it over, but only found a single dermestid beetle. On checking with Steve Lane, the volunteer recording scheme organiser for Histeridae beetles, it became apparent that this was the nationally scarce *Dermestes murinus*."

Cornwall

"Cornwall is also very important to me, as from age seven, my sister and I were dispatched to our grandparents in west Cornwall for the summer while both our parents worked. Prussia Cove is near Penzance, and next to Prussia is the lesser known Piskies Cove. We would spend day after day exploring Piskies and the cliffs above. We loved swimming, and my sister and I once swam from Piskies Cove, around the headland back to the beach at Prussia Cove, while our grandma followed nervously on the cliff path to present us with doughnuts once we made landfall. My family were an inspiration to me. Their encouragement and joy at the wildlife that so fascinated me was so enriching. I remember being fascinated by the mysterious papery cocoons of the burnet moth pupae on the clifftop grasses. My grandma and I investigated and discovered what they were. So many memories of long summer days in west Cornwall – I still think of it as home. One summer, my grandma allowed me to set up a museum in her bedroom and my mum tolerated many creatures being brought into the house, including dead bats in the freezer. Before we arrived in the summer, my grandfather would put a corrugated iron sheet on the ground in his back garden so we could see what would appear under

it during our stay – slowworms and small mice usually but, of course, slugs, spiders and other invertebrates too."

Undergraduate years

"I first went to Oxford to study medicine but quickly realised that medicine was not what I wanted to do. I had spent my teenage years bat watching and mammal trapping and was not quite sure why I chose medicine. I think there was probably an expectation that someone who was enjoying science should study medicine. So, having made up my mind to leave, getting out of Oxford proved to be much harder than getting in! I was offered a place on their zoology course but I knew that Southampton University had a fantastic reputation for ecology and felt this was more in line with what I wanted to do. So, I went to see the Principal to discuss this and was told to go and return wearing my gown. If I had needed confirmation that Oxford was not for me, this was it. I returned, compliantly with my gown, to politely notify the Principal that I was going to leave. I then spent the summer working in a bar, and teaching English as a foreign language, but most enjoyably also as a volunteer with the National Trust completing chalk grassland surveys on the Isle of Wight.

I loved Southampton. John Allen was one of my lecturers and I found his ecology lectures simply incredible. We went on a residential field trip to Zahara de los Atunes in Andalusia. It was amazing – there was so much to see and the bombardier beetles in the dunes were stunning. My undergraduate project was on the social behaviour of dogs and while I still have a great fondness for dogs it did convince me that mammals were not the group I wanted to work with."

Life after graduation

"I then undertook a Master's at Nottingham University. It was titled 'Environmental Science: Measurement, Modelling and Analysis'. As an undergraduate I lacked confidence in statistics, so I thought this was an opportunity to increase my quantitative skills. The project was studying the ecology of a farmland pond struggling with eutrophication, so there was lots of freshwater invertebrate sampling of the pond and the stream that fed into it. The study had a whole-system approach, which I thoroughly enjoyed.

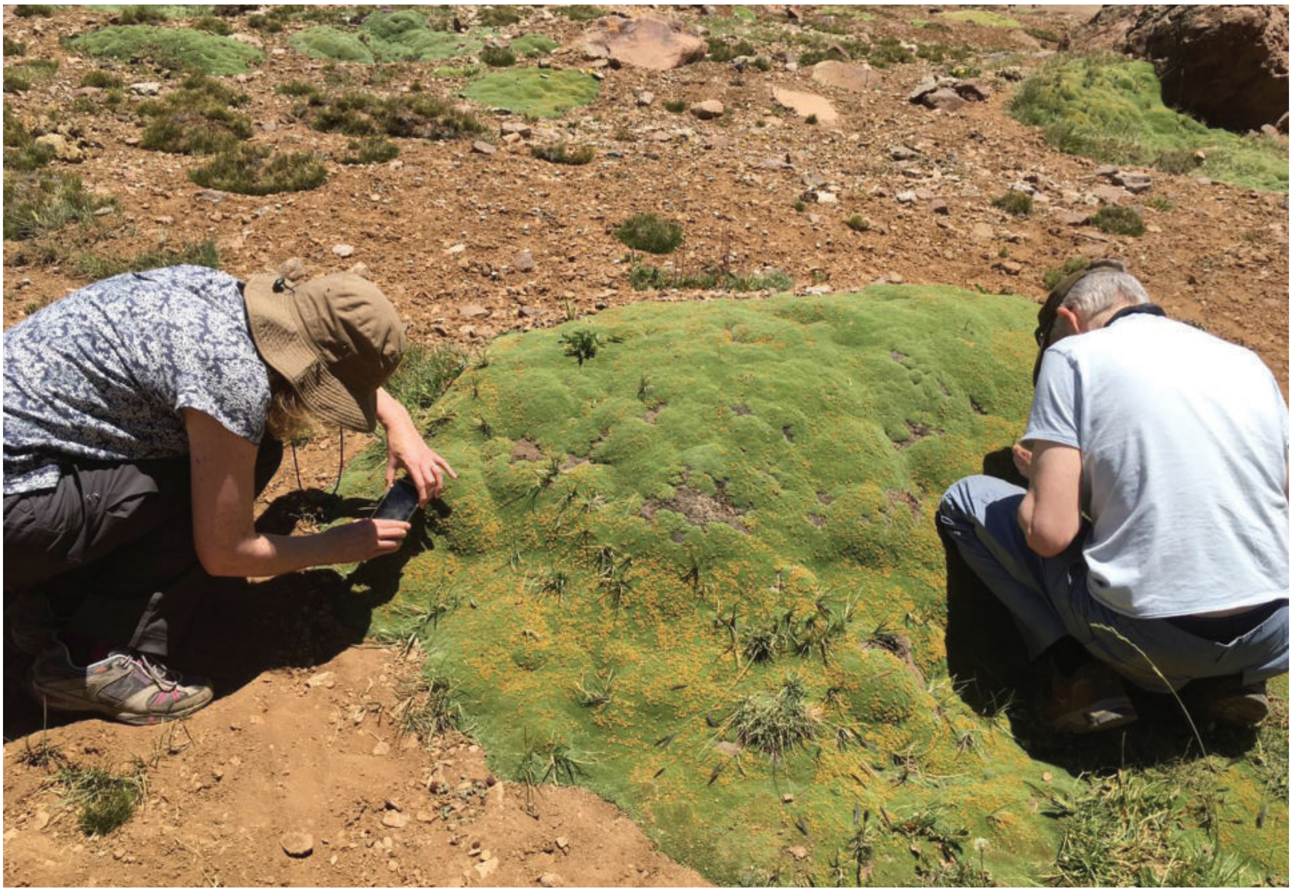
After that, I applied for a number of PhDs and obtained one at Nottingham University in collaboration with Rothamsted Research, where I was based for three years. It was a study of community ecology; interactions between aphid natural enemies, mainly ladybirds, and aphid pathogenic fungi. An amazing three years, under the wonderful guidance of Judith Pell. I was looking at the way aphid predators interacted with the aphids and so increased the transmission of the pathogenic fungus. I loved the opportunity to delve into so much detail, and exploring the interactions. Sometimes when I am talking at engagement events, I get carried away and forget that not everyone wants that level of detail!

It was during my PhD that I realised ladybirds were the insect group for me. I was totally captivated by them. Throughout my childhood I had a broad range of interests, but through higher education I had been slowly narrowing the field. I just like the small things in life. I had also enjoyed the opportunities to get involved with undergraduate teaching through my PhD. Working at Rothamsted was also my introduction to the RES. Groups of us would travel from Harpenden to meetings in London. The Society was a great influence in my early career. My very first presentation was at a postgraduate forum.

I finished my PhD with two months of my grant to go. I just really enjoyed writing my thesis and working with Judy. But finishing early meant it had all come to an end and I just wanted to start all over again."

Career

"I obtained a lectureship at Anglia Ruskin University immediately after my PhD. The first term was tough; going from a cosy research laboratory to a lecture theatre of 140 students was quite a change! The only way I could do research was to get up early in the morning and work before the student day began. However, I was there for 10 years and after the first term loved every moment. I particularly enjoyed teaching in the field. Every year we would head to a holiday park in Coombe Martin in Devon with 80 students. I often felt sorry for the families on holiday at the same time, who patiently tolerated the antics of us all tramping through the site at the beginning and end of each day with bat detectors and binoculars, sweep nets and sampling trays. I enjoyed field work so much that I would volunteer for any trips I could get on. I even learnt to dive in the Red Sea. The department wanted someone who couldn't already dive to learn alongside the students. What a privilege! I also went to Poland where we roamed the Bialowieza Forest with local



field guides. That was incredible, the wildlife was so rich, and the rare 5-spot ladybird was widespread there.

By that time my research programme was beginning to get very busy. I was on sabbatical with Mike Majerus when the Harlequin ladybird arrived in the UK. I was working on the pathogenic fungi of ladybirds and Mike found it very entertaining that I was so captivated by these quirky microbes. We had agreed strict boundaries in the lab in the interests of biosecurity! While working with Mike, I began to get involved with the Ladybird Survey and we jointly established a citizen science project to map the spread of the Harlequin ladybird – an idea inspired by the wonderful Trevor James FRES.

Soon we heard the news that the Centre for Ecology & Hydrology at Monks Wood was going to close and my husband, who worked there, would be relocated. So, when a position became vacant at the Biological Records Centre for someone to lead the Zoology work, it seemed a dream opportunity for me – but I was very sad to leave Anglia Ruskin University and Cambridge."

Citizen Science

"Science communication has always gone hand in hand with my research, so citizen science was a natural progression. I love to be in the field with other people, sharing the excitement of the natural world. Mike Majerus taught me so much about public engagement. He was another incredible mentor. The UK Ladybird Survey (formally the Coccinellidae Recording Scheme) is now coordinated by Peter Brown and myself.

Active engagement with the natural world is so important; it is vital that people are informed about the natural world so that they, as an example, can contribute to conservation decision-making. Volunteering and engaging is a great way to gain this appreciation. Connecting with nature is also important for general well-being; it is so therapeutic to become lost in nature, which reminds me of a time when I did just that. Peter Brown and I had taken a journalist from *The Times*, who wanted to write about ladybirds, to the Surrey heaths; an amazing place for ladybirds. I had said to him, "Once I am looking for ladybirds, other aspects of practical life get lost sometimes". We had been recording ladybirds for several hours; Peter and I were in our element, and I thought the journalist was also having fun when he said, "Could we go somewhere and have a cup of tea now?". Admittedly, it was raining and becoming a bit cold, so we agreed. Unfortunately, we couldn't find where we had parked the cars and spent quite some time trying to retrace our very convoluted path. He wrote in the article that "he had been lost with two entomologists on the Surrey heaths".

I really enjoy opportunities to work with the media. I particularly enjoy radio interviews, but I have also been involved with a number of television programmes, for example Springwatch, including highlights of being interviewed by Brett Westwood. We are so lucky to have such a rich culture of natural history programmes on both television and radio. I also enjoy being invited to write for the BBC Wildlife magazine every so often.

While natural history programmes often focused on the charismatic vertebrates, it now seems that they are embracing invertebrates. I am impressed by Chris Packham's breadth of knowledge on some of the invertebrate groups. I met Chris when I was at an undergraduate at Southampton University. It was in his days on The Really Wild Show. I was writing articles for the student newspaper and I had arranged for

Chris to give a talk to the Biology Society, and he agreed to be interviewed afterwards. The editors of the paper were very excited and impressed that I had organised an interview with Chris. "How did you manage that?" they said. But when I handed the article in, it transpired they had thought I was talking about Chris Patten (British politician at the time)."

UK Overseas Territories

"Recently I have been working on making predictions about which invasive non-native species could potentially arrive and establish on the UK Overseas Territories and pose a threat to their unique wildlife. It has been so exciting working with people from all over the world with such incredible and diverse expertise – all of whom have different perspectives. By working together, we have been able to produce lists of species which can inform biosecurity going forward. I can see that this collaborative approach involving expert-elicitation is a great way to contribute to the evidence needed to understand such complex systems.

I have visited three of the Caribbean overseas territories, the Cyprus Sovereign Base Areas, Gibraltar and St Helena. All are amazing and unique places and I am looking forward to working with the many people who contribute so much to ensuring the future of these special places."

Invasive non-native Species

"Not all non-native species are problematic, but the 10-15% that cause problems can cause really dramatic problems. Predicting and assessing which species are going to be a problem is the critical, but difficult, thing.

The cloud forest on St Helena has been invaded by New Zealand flax. It has rampaged through the island, altering the landscape and ecosystems. The 455 endemic invertebrate species on St Helena are threatened by these dramatic changes. We are responsible for the movement of many of the invasive non-native species that go on to compromise the functioning of our natural world, and we have a responsibility to ensure the future of our natural world for both people and nature."

Helen's great passion and drive are surely rooted in the wonderful freedoms that she had as a child. Those wild, carefree days have kindled and incubated an energy and curiosity that has forged a unique career. Her immersion in the natural world at an early age, unfettered by academic restraints, has nurtured a deep appreciation of that world and a calm confidence in her role as observer, interpreter, educator and custodian of it. Her voyage through academia has slowly focused her interests on to the insect world, then to ladybirds, and on to a wide range of invasive organisms. Her journey has provided opportunities to explore and to become fascinated by the fine detail of the interactions she was investigating, a fascination that still underpins everything she undertakes. Those early experiences have also prepared Helen to see the bigger picture, so her love of ladybirds has neatly morphed into a holistic perspective of invasive non-native species.

But it is as a communicator that she is widely known. Helen's more general articles, plus radio, internet and television appearances, are the activities that generate her public profile, a profile that she utilises with untamed enthusiasm and enjoyment in order to promote a better public understanding of natural environments. We hope that her time as President will offer her many such opportunities.

At several points in our conversation Helen said, "It is writing that I really enjoy", and enjoyment is what Helen does best. She is passionate about everything, but first and foremost she enjoys the things that she does. Long may our new President enjoy the natural world, and long may she continue to inspire so many people to join her in enjoying the world around us.

(Virtual) National Insect Week 2020 – thank you all

Fran Sconce
Outreach and Engagement Executive, Royal Entomological Society
fran@royensoc.co.uk

Lots of things were different in 2020. National Insect Week ran from 22nd to 28th June and became a successful online campaign. We want to thank everyone who took part and contributed.

Our message was that everyone can learn something new and exciting about insects, wherever and whoever they are, regardless of age, circumstances, background and how they feel about insects. We promoted this via online channels and the National Insect Week website.

Society President Helen Roy (UK CEH) kicked off the week with a launch video filmed in her home garden. It was viewed by over 9,000 people on social media on the day, and she encouraged us all to get involved in celebrating the wonderful insects that run our world.

Helen Roy launched the week with a live video from her garden.

Live chats online helped connect our community of entomologists. Ashleigh Whiffin (National Museums Scotland) and Katy Dainton (Forest Research) introduced some of the 50 virtual events in an *Instagram live* and UK CEH did a *Facebook live* with their scientists. Entomologist and biological recorder, Martin Harvey, ecologist and pathogen specialist Beth Purse, lake ecologist and freshwater minibeast expert Steve Thackeray, and ecologist and invasive species expert Helen Roy answered questions from the public. Several Society Members and Fellows signed up to take part in online text chats with *I'm a Scientist*, a platform which connects school classes and youth groups with scientists. Neil Phillips (UK Wildlife Blog) ran a *Facebook live* about 'Interesting Insects'.

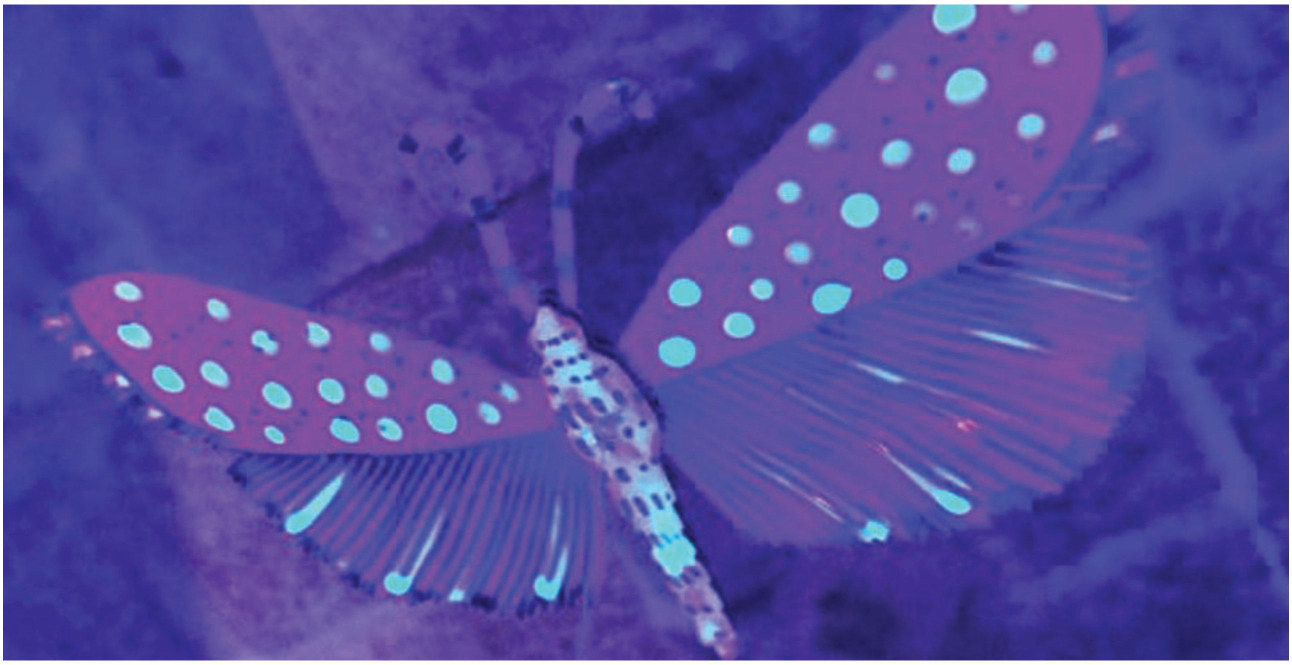
Science talks covered a wide range of entomological topics. The Field Studies Council Biolinks project ran a *virtual meetup* with Jennifer Gilbert (Butterfly Conservation and Back From the Brink) talking about the Rugged oil beetle and a project exploring it in Gloucestershire. Eleanor Drinkwater gave a talk with the Royal Society of Biology Wales branch on 'Wallace and the Caterpillars - A Colourful History of Discovery', about how prey can use colour to frighten predators. The Natural History Museum ran several insect-related *Nature Live* events: 'The Beauty of Butterflies', with Blanca Huertas, and 'Beetles!', with Max Barclay. The University of Cambridge's Museum of Zoology ran its *Zoology Live* with two days themed on minibeasts.

Biological recording and citizen science were promoted as a way for the public to take part in insect science, and a new National Insect Week webpage introduced this. The Society worked with the Field Studies Council to prepare new resources on garden beetles and pollinators and the 'Garden Entomology' booklet was made available digitally for the first time. The Society's Director of Science, Jim Hardie, prepared a leaflet on 'Intriguing Insects', featuring the most common insect species that appear in public enquiries to the Society, alongside answering thousands of insect enquiries during the whole summer. RECORD Local Records Centre ran a webinar on a general introduction to the importance of recording invertebrates for their conservation; the Tanyptera Trust had a 'Cuckoo bees of the North West' webinar, with Tony Park (World Museum Liverpool) talking about their ecology and behaviour and how to identify them.

In North-East Scotland, Leanne Fernandez and Jack Elphinstone, students at the University of Aberdeen, ran a whole North-East National Insect Week; a fantastic effort with daily podcasts, activities, an art competition and an interview with young conservationist 'Ant-boy' Xander Johnston.

In the media, BBC Radio Wales covered the week on their *Science Café* programme, including interviews with Society Chief Executive, Luke Tilley, Buglife Cymru Conservation Officer, Liam Olds, on colliery sites, Michael Wilson, curator at Cardiff Museum, and Sarah Beynon on her Bug Farm. On BBC Radio 4 *The Curious Cases of Rutherford and Fry* programme broadcast an episode 'The Sting in the Tail', where Adam Hart (University of Gloucestershire) and Seirian Sumner (University College London) helped to answer a listener question of 'What's the point of wasps?'

The week also had lots of creative activities such as a *Facebook live* dance session with Anna Outdoors, a primary school outdoor learning expert, themed on watery wildlife. Activities included dancing like water boatman! For their



Moths to a Flame by the Art and Energy Collective from Cornwall.

weekly nature drawing club the Natural History Museum picked hexapods as the theme, and lots of beetles, moths, bees, flies and more were shared online. Art Sippers, who run virtual art workshops, ran an evening session with the NHM to 'Learn to Paint a Bee-Utiful Bee', whilst sipping a drink of one's choice. The Art and Energy Collective in Cornwall timed several of their 'Moths to a Flame' project events in the week, with local moth experts and live moth-trap opening over Zoom, and preparing a moth-themed artwork to be displayed at Glasgow's Botanic Gardens for COP26. Arron Watson held a 'Meet the Maker' Instagram live event about his 'Invertebrate Kingdom' game of which he launched a digital version on *Tabletopia* during the week. The game is described as being of survival, strategy and a bit of luck, and Arron has included facts on different invertebrate physical and behavioural adaptations. There was a Zoom streaming discussion of Asher Flatt's documentary 'Stuck on a Rock', about the rediscovery of and conservation efforts for the Lord Howe Island stick insect.

During the week the Society launched the National Insect Week Photography Competition, with Tim Cockerill heading up the judging panel. Helen Roy hosted the popular Sharing Stories panel event as reported in *Antenna* **44**(3).

Thank you again from the Society to all who contributed to the week, a success even though many plans for events and gatherings in 2020 had to be rather swiftly cancelled and reimagined online.

We look forward to future online National Insect Week activities, mindful that new and international audiences can be reached in this form. Please get in touch with Fran Sconce fran@royensoc.co.uk if you have ideas and would like to be involved.

1st (adult): Alan Clark, German wasps drinking, UK.

1st (U18): Jamie Spensley (age 17), Marmalade hoverfly on a pink flower, UK.

NATIONAL INSECT WEEK 2020 PHOTOGRAPHY COMPETITION

There is little doubt that the prize for 2020's Adjective of the Year Award should go to the word *unprecedented*. I am glad to report that the superlative applies in a very positive sense to this year's National Insect Week Photography Competition. With a record 2,443 entries (2,095 from 72 countries in the over-18s' category and 348 from nine countries in the under-18s' category) and a brilliantly high standard overall, choosing a winner was a challenging affair, but it was approached with great gusto by our capable judging panel.

The winner in the over-18s' category, *German wasps drinking* by Alan Clark, features a group of German wasps (*Vespula germanica*). It struck the judges as a brilliantly captured, dramatic image showing an often-maligned insect in a creative and sympathetic light. Its composition, reminiscent of archetypal shots of African antelope and zebra drinking at the water's edge, brings techniques used in classical wildlife photography to the realm of macro images.

In the under-18s' category, the winning photograph is *Marmalade hoverfly on a pink flower* by Jamie Spensley, a bold and striking composition featuring a hoverfly (*Episyrphus balteatus*) nestled within a flower. The judges considered it a highly engaging image showing great technical and creative execution – impressive indeed for a young wildlife photographer.

The winning and runner-up photographs across both categories are all superb examples of the power that photography can have to create engagement with insects. Perhaps more importantly though, the competition entries represent 2,443 instances where amateur photographers from an amazing 72 countries have engaged with nature, connected with insects, and taken a closer look at "The Little Things That Run The World".

Many thanks go to our judges: Nick Baker, Naturalist and TV Presenter; Lucia Chmurová, Conservationist at Plantlife, formerly Natural History Museum (London) Coleoptera; Ashleigh Whiffin, Assistant Curator, Entomology, National Museums Scotland.

Dr Tim Cockerill FRES, Trustee

Head of the judging panel, and Senior Lecturer in Natural History at Falmouth University's Institute of Photography.

2nd (adult): Petar Sabol, Aphid family, Croatia.

2nd (U18): Jamie Spensley (age 17), An *Epeolus* spp. bee on common ragwort, UK.

Specially commended (adult): Phooi Leng Ho, A mother's love, Malaysia.

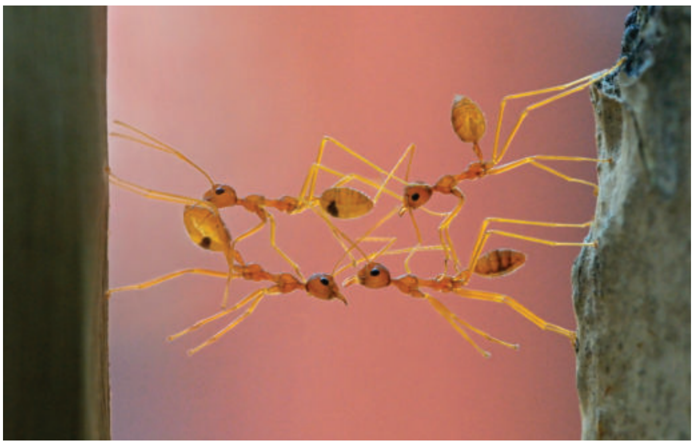
Specially commended (adult): João Petronilho, Conehead mantis, Portugal.

Specially commended (adult): Andrew Murray, Gnat ogre robber fly, USA.

Specially commended (adult): Phooi Leng Ho, Ready for the party, Malaysia.

Specially commended (adult): Tim Crabb, Rose aphid on a rose blossom, UK.

Specially commended (adult): Petar Sabol, Southern festoon, Croatia.



Highly commended (adult): Karunakaran Parameswaran Pillai, Bridging weaver ants, India.

Highly commended (adult): Elizabeth Cooksey, Walking through time, UK.

Highly commended (adult): Kit Chang, Ovipositing, Macao S.A.R.

Highly commended (adult): Pascal Grüner, European paper wasp, Germany.

Highly commended (adult): Beverley Brouwer, Wasp on mushroom, Netherlands.

Commended (adult): Louis Nicholls, Ghost waits in the dark for prey, UK.

Commended (adult): Simon Carder, Here comes the sun, UK.

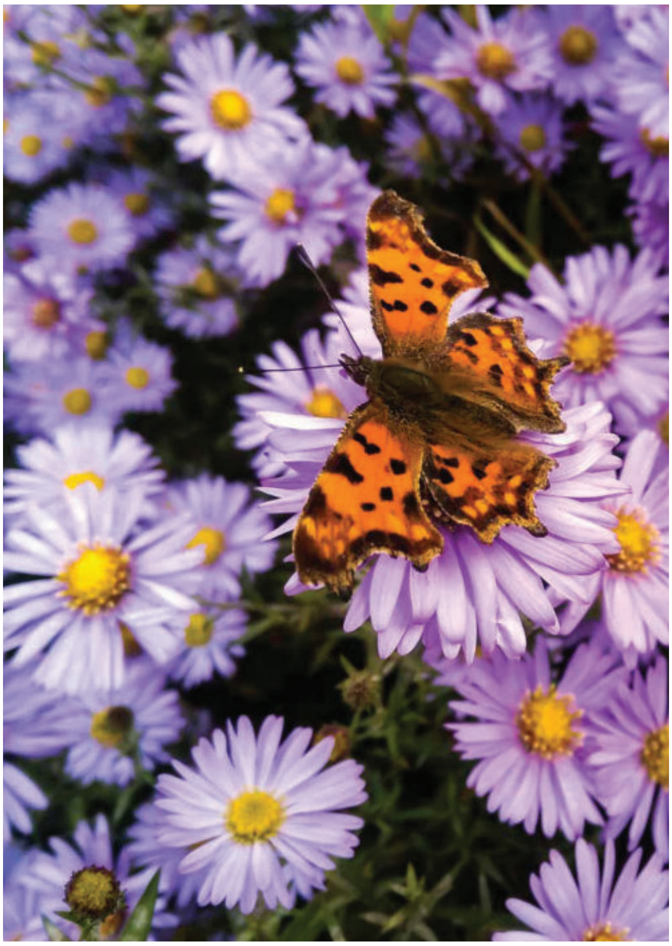
Commended (adult): Simon Carder, Butterfly meadow, UK.

Commended (adult): Ching-Shan Lin, Mother caring for her fungus garden, Taiwan.

Commended (adult): Liesbeth Ploeg, Just jaw dropping, Netherlands.

Specially commended (U18): Jamie Spensley (age 17), Carder bee in Cornwall, UK.

Specially commended (U18): Sruthi Parupudi (age 15), Common chaser dragonfly, India.



Highly commended (U18): Emily Davies (age 12), A summer's walk, UK.

Highly commended (U18): Kirsty Eykyn (age 17), Natural beauty, UK.

Highly commended (U18): James Murphy (age 13), Emperor dragonfly, UK.

Highly commended (U18): Will Lawson (age 17), Ants, UK.

Highly commended (U18): Will Lawson (age 17), Super strength, UK.

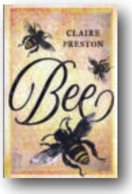
NATIONAL insect WEEK

All winning entries can be viewed at:
www.nationalinsectweek.co.uk/photography

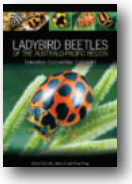
Reviews

The following reviews have been added to the Publications website:
www.royensoc.co.uk/publications/reviews

A Naturalist's Guide to the Insects of Australia
by Peter Rowland & Rachel Whitlock.
John Beaufoy Publishing. ISBN 978-1-912081-80-6. £9.00.
Reviewed by Peter Smithers.



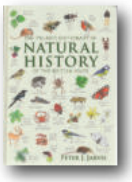
Bee
by Claire Preston.
Reaktion Books. ISBN 978-1-78914-048-4. £9.99.
Reviewed by Peter Smithers.



Ladybird Beetles of the Australo-Pacific Region (Coleoptera: Coccinellidae: Coccinellini)
by Stanisław Adam Ślipiński, Jiahui Li & Hong Pang.
CSIRO Publishing. ISBN 978-1-4863-0387-8. AU$220.00.
Reviewed by Peter Brown.

Atlas of Water Beetles of Britain and Ireland – smaller families of polyphaga
by G.N. Foster, D.T. Bilton, M. Hammond & B.H. Nelson.
F.S.C. Publications. ISBN 978-1-906-69869-0. £24.99.
Reviewed by John Walters.

Britain's Butterflies: A Field Guide to the Butterflies of Great Britain and Ireland (4th edition)
by David Newland, Robert Still, Andy Swash & David Tomlinson.
WILDGuides. ISBN 978-0-691205-44-1. £17.99.
Reviewed by Peter Smithers.



The Pelagic Dictionary of Natural History of the British Isles
by Peter J. Jarvis.
Pelagic Publishing. ISBN 978-1-78427-194-7. £35.
Reviewed by 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

(at the time of writing)

We are following the latest UK government advice and working from home as much as possible.

You can still apply for Membership and Fellowship, our journals are still open for submissions, the insect identification service is still operating and our events are now online with free registration.

Our Mansion House headquarters are not open every day, but our online shop is still open, though deliveries may be subject to some delays. The Librarian will not have access to our collections from home, but will be happy to try to locate material online.

We hope that everyone stays safe and well.

Student & Early-Career Entomologist event 'Ento Careers' (online)
17 March, 2021

Aphid Special Interest Group meeting (online)
15–16 April, 2021

Insects as Food & Feed (IAFF) conference (online)
20–22 April, 2021

EntoSci20
29 April, 2021

Sustainable Agriculture Special Interest Group (online)
12 May, 2021

Ento’21 (online)
23–27 August, 2021

Orthoptera Special Interest Group meeting
3 November, 2021

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

RES STUDENT AWARD 2021

Write an entomological article and WIN!

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 info@royensoc.co.uk

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. scan of student I.D. card

THE JUDGES
The judging 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 2021. The winner will be announced in the Spring 2022 edition of *Antenna* and on our website.

ROYAL ENTOMOLOGICAL SOCIETY · FOUNDED 1833

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