Bulletin of the Royal Entomological Society Volume 44 (1) 2020

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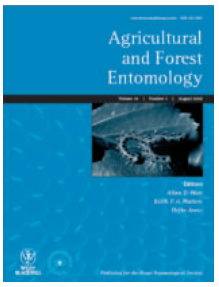

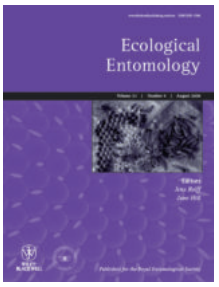

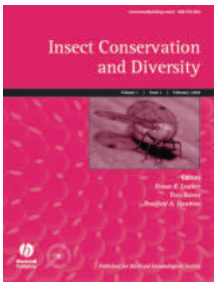

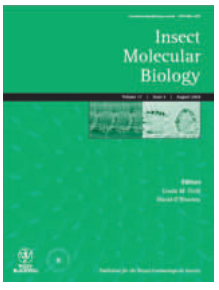

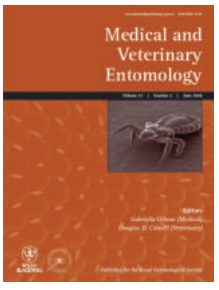

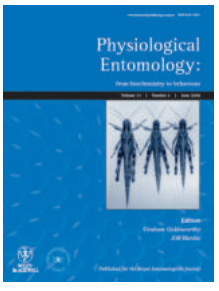

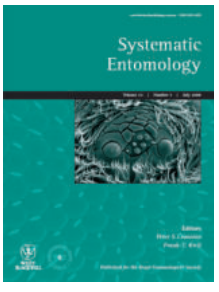

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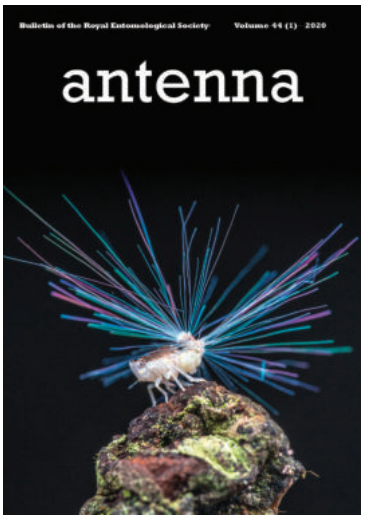

COVER PICTURE

NIW 2018 Photography Competition – Specially Commended:
Planthopper nymph with the 'fibre optic' tail, by Wexiang Lee

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Bulletin of the Royal Entomological Society

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EDITORIAL

"We have ten years to save our planet" said Prince William, backed by respected celebrities, on the first day of the new decade. Australia is ablaze, its people and wildlife under dire threat. This hit home even harder for me on discovering that one of our own, prominent Fellows has lost his home to the flames. Insects are, of course, impacted strongly by our way of life and that way of life is threatened in return by those impacts. It is clear that our ability to detect and understand insect population trends remains weak, and the report by Luke Tilley on the Royal Society of Biology's meeting on the subject alludes to this. Thus, it was exciting to learn a few months ago that Germany is taking significant steps to address the issue. Aletta Bonn and Jens Rolff provide insight into how the sea-change in the attitude of a national government came about and how the funding will be used. Simon Leather follows this up with a plea for other governments to follow this lead. Our Society may have somewhat limited influence on its own, but we must seek to use that influence. Combined with the influence of other organisations and individuals, scientifically-backed messages will get through and changes will occur – hopefully in time to prevent complete disaster. Cynicism and apathy are the enemies. It is to be hoped that the "Grand Challenges" initiative, outlined herein, will, in collaboration with other entomological societies, play a useful role. Against this background, the small step of switching to a paper envelope for *Antenna* and a cover with no plastic lamination seems, perhaps, trivial. Yet it illustrates the point that every small, local action contributes to big, worldwide needs.

Insects should not be declining in the Mansion House garden. The results are announced of the garden design competition, and it will be hugely exciting to see plans come to fruition to the benefit of insects and in line with the objectives of the RES.

I was very struck by Bryony Sands' article on her dung beetle research in Botswana: not only by her science but, especially, by her mettle. Be honest, would you have the bottle for this sort of work? I'm not sure that I would. All credit to those who have, now and in the past for, without them, our science would be applied mainly to the places where it is, perhaps, least essential.

At the Aphid Special Interest Group meeting in April 2019, Hugh Loxdale put the case that 'generalist' is a misnomer in its usual biological context. This generated much discussion and Hugh elaborates herein.

Simon Leather is mentioned above. He and his team often feature large in *Antenna* but rarely as large as in this issue. I enjoyed hugely my visit to research the ENTEAM article, and the 2019 Harper Adams RES Scholars are introduced in this issue, too.

It's been another good quarter for Society meetings, most of which are reported herein. The Orthoptera Special Interest Group met for the 40th time on the first Wednesday in November – as it does every year with utter reliability. Congratulations and thanks to all involved over the years, especially Judith Marshall and David Robinson. There will be an account of this significant anniversary meeting in the next issue.

The "Book Reviews" section has changed its name by dropping the word "Book". Craig Macadam reviews the apps that he uses most in his entomological pursuits and I very much hope that you will follow this up with a review of an app which you find useful. Why stop at books and apps? Are there any films, DVDs or other entomological content that you would like to draw to the attention of others?

Very many thanks to all contributors.

Richard Harrington

Guidelines for submitting photographs

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

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

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

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

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

300dpi

72dpi

Activists celebrating that their petition made it into the parliament of Bavaria. The banner reads: 'All of Bavaria can celebrate. Petition in parliament'. (Figure from: https://volksbegehren-artenvielfalt.de/ (Photo: © Uschi Anlauf))

RESEARCH SPOTLIGHT

Funding research on insect population changes: some hope

Editor's Introduction

On hearing the news that genuinely useful funding is to be put into entomological research in Germany, I asked RES Fellow Jens Rolff for a German perspective on how this came about and how the money is likely to be used. With Aletta Bonn, he kindly obliged – and it's fascinating reading. I asked Simon Leather for a UK perspective, and he has provided a revised version of a letter which he and others had published in *The Guardian*. **RH**

100 million Euros for insect conservation

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When Klaus Reinhardt, former Vice-President of the Royal Entomological Society, travelled to Bulgaria a few years ago, he noticed a significant number of insects on the windscreen of his hired car – an observation he last made as a child (this was when the Berlin wall was still up) and a very vivid sensory experience of decline in insects (Eisenhauer *et al.* 2019) as also noticed by many other people. The Hallman *et al.* (2017) study, work of entomological expert enthusiasts in a small natural history society in the far West of Germany, quantified this observation by showing a strong decline in insect biomass even in conservation areas. So, how did these observations of insect decline convince a government of an industrialized state such as Germany to put insect conservation into their coalition contract and earmark 100 million Euros for implementation in practice and associated research? And what is this money meant to achieve? These developments surely build on international concern over important drivers of insect declines, such as climate change

and range shifts (Chen *et al*. 2011), the international debate on global pollinator decline (Potts *et al*. 2010), the impact of neonicotinoids (Whitehorn *et al*. 2012) and potential knock-on effects across taxa, *e.g.* declines in insectivorous birds (Bowler *et al*. 2019).

Here, we address these questions by highlighting what we believe were specific factors at work in Germany. There are really two roads to Berlin, as it were, that explain the decision of the government to set up a program to spend 100 M Euros *per annum* on insect conservation and to promise specific insect conservation legislation. One, which we discuss first, is the growing public interest in insects in Germany, helped by specific political circumstances. The other is the work of the *Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* (IPBES). Both are reverberating strongly in the media and with policymakers.

The main interest of the general public in Germany and, we presume, in many other countries, started with reports on significant winter mortality of honeybee colonies about 10–15 years ago (Oldroyd 2007). While scientists and NGOs were trying to alert policy makers and the public, a grassroots organization, '*Berlin Summt*' ('Berlin is buzzing'), was founded in 2011 and soon expanded across Germany (https://www.deutschland-summt.de/). First, their focus was on fostering honeybees, which spawned a great interest in private beekeeping. Over the years, *Berlin Summt* became more and more interested also in the fate of wild bees and other pollinator insect taxa, as well as education programmes, events and insect-friendly gardening. This was in addition to the campaigns that the more established conservation NGOs such as BUND (Friends of the Earth Germany, https://www.bund.net/) and Naturschutzbund (https://en.nabu.de/) have carried out. In short, across Germany, the fate of insects became more and more known to the public, using bees as charismatic, strongly positively-associated flagship species.

This public awareness is also reflected in the coalition contract of the National Government: *"We will comprehensively combat insect decline. We want to improve the life conditions of insects with an 'Insect Conservation Action Programme'. We want to establish a scientific monitoring centre on biodiversity involving the Federal Ministry for the Environment and the Federal Ministry of Agriculture."*

(German coalition contract, 12 March 2018; CDU, CSU & SPD 2018; *own translation)*

Insect conservation is therefore now enshrined in the German coalition contract by the Conservative Parties and the Social Democrats (CDU, CSU & SPD 2018), surely building on constructive background work by environmental NGOs, a range of ongoing science developments and the overall public concern. It is important to note that accountability for the insect conservation programme and the monitoring centre was given to both the Ministry of Environment and the Ministry of Agriculture. While these two ministries have not always had a history of working smoothly together for conservation, cooperation is essential for achieving successful solutions across sectors.

This growing public interest and high-level political support, we believe, also gave momentum to the petition on insect diversity under the title 'Rettet die Bienen' ('Save the Bees') in Bavaria, one of the 16 federal states of Germany (https://volksbegehren-artenvielfalt.de/). This petition was started in May 2018 by a small party, the ÖDP (Ecological Democratic Party) and, after initial reluctance, carried forward also by the Green Party, the Landesbund für Vogelschutz (a conservation NGO) and the Gregor Louisoder Foundation for the Environment. It was supported by many NGOs and other parties. In Bavaria, the law about petitions is interesting: a successful petition will be enshrined in law, unless the Parliament of Bavaria opposes this. If the latter happens, another petition, called Volksentscheid, has to be organized within three months. In this case, the Parliament would have the option to present alternative plans, but the decision on this new petition would be legally binding. 1.75 M people, *i.e.* 18% of the population of Bavaria, signed the petition 'save the bees' in early 2019. In the current case, the petition was directly accepted as legislation, albeit a few problems remain, especially as regards policing of the new rules. Building on the successful petition in Bavaria, Svenja Schulze (SPD), the German national Minister for the Environment, Nature Conservation and Nuclear Safety, promised national legislation for insect conservation, resulting in the announcement of the 100 M Euro for insect conservation in autumn 2019 (see below).

The success of the petition and its straight acceptance by the Bavarian Parliament, as well as the announcement of the Minister for the Environment, were almost certainly driven by an additional factor: the surge of the Green Party, the only party in Parliament with widely accepted environmental credentials, first in national opinion polls (ongoing) and the Bavarian elections (17.6% as the second strongest party in Bavaria, thereby winning 18% of the seats in the Bavarian Parliament due to proportional representation of the electoral system in Germany). Current polls suggest that the party would win over 20% in a national election. This makes the notion of a green chancellor a real possibility (https://www.theguardian.com/world/2019/dec/27/robert-habeck-could-be-germany-first-green-chancellor) and has therefore significantly increased the pressure on the other parties to develop progressive environmental policies.

In summary, the four factors that contributed to the 100 M Euro plan were (i) a public that was alerted to the issue of insect declines, helped by (ii) innovative NGOs pushing for implementing insect conservation in the German coalition contract, (iii) the successful Bavarian petition, paired with the particular legal framework in the state of Bavaria, and (iv) the success of the Green Party, putting pressure on all other parties.

The development and activities discussed above have also got a sound scientific foundation. To support conservation policy development at global, regional and national scales and as a response to knowledge needs, the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES, https://ipbes.net/) was established in 2012 as a science–policy interface that supports governments and stakeholders in decision making. It is designed similarly to the IPCC, the Intergovernmental Panel on Climate Change, that was founded in 1988. Main outputs and deliverables of IPBES include assessments to provide policy-relevant and scientifically-credible information on the status and trends of biodiversity, ecosystem services and their impact on human wellbeing (UNEP 2012). Following UN regulations, a balanced representation of participation across regions, gender and disciplines is ensured, and IPBES is governed by 130 member states, and therefore attains legitimacy and broad ownership across nations. The global IPBES secretariat is hosted by Germany in Bonn, alongside an additional national IPBES coordination office that fosters

People queuing on the Marienplatz to sign the petition 'save the bees' in the town hall in Munich. (figure from: https://volksbegehren-artenvielfalt.de/ (Photo: © Tobias Hase)

implementation of IPBES findings into national policy decision making. Both are supported with significant funding provided by the German Government. Josef Settele, a well-known German entomologist, co-chaired the global assessment published this year, so IPBES reports are well received by the Government and incentivize action. Over the years, IPBES has brought together more than a thousand scientists and other knowledgeable people from across the world to synthesize scientific evidence in eight IPBES assessment reports: the global assessment, four regional assessments, two thematic assessments and one technical report (https:// ipbes.net/assessing-knowledge).

Among the first IPBES assessments commissioned, the IPBES pollination assessment (IPBES 2016; Potts *et al.* 2016) has received substantial media attention and made a significant global impact on policy development, as it provided a concise synthesis of the state of pollinators worldwide as well as the impacts on society and economy (> 75% of all crop species for human nutrition depend on animal pollination and the market value of pollination was estimated at 250–600 million Euro/year in 2015). Importantly, it included a best-practice 'toolkit' of approaches for management and policy by governments, the private sector and civil society. As such, the pollination assessment received high level formal endorsement by the Parties to the Convention on Biological Diversity (CBD) in Mexico in 2016 that encouraged nations to develop and use these practical tools and contribute to their further development (CBD 2016). Today, we see many national strategies and action plans on pollination emerging in *e.g.* Germany, England, Ireland and Northern Ireland, Scotland, Wales, Ireland, Belgium, Brazil, France, The Netherlands, The Republic of Korea and South Africa. These developments, paired with the fact that IPBES, due to Germany being host to the secretariat, receives considerable policy attention in Germany, surely contributed to laying the ground for the 100 M Euro insect conservation plan.

100 M Euro for what?

The announcement in September 2019 that the German Ministry for the Environment plans to spend 100 M Euro *per annum* on insect conservation, received immediate international attention (Vogel 2019). The whole sum is planned to be spent in three different areas. Twenty-five percent is to be spent on direct conservation measures, 25% on research and 50% is to be added to a programme under the title 'Gemeinschaftsaufgabe Agrarstruktur und Küstenschutz' ('Common Programme on Agricultural Landscapes and Coastal Protection, GAK') led by the Federal Ministry of Food and Agriculture. The latter programme is worth 1.5 billion Euros a year and follows the EU legislation on rural development (European Agricultural Fund for Rural Development (EAFRD), European Union 2019). Unfortunately, the majority of the large agricultural subsidies is still provided as direct payments that often fail to deliver on biodiversity, climate and social targets (Pe'er *et al.* 2019). This new programme, however, is a promising start. It is not yet entirely clear how the extra funding for insect conservation will be incorporated into this framework, while the insect conservation action plan not only seeks to protect insects but also to reverse the trend of decline in both biomass and diversity. The action plan includes nine major areas of action with 46 concrete action points (BMU 2019):

- Support of insect habitats and structural diversity in agricultural landscapes
- Restoration of insect habitats and increasing connectivity in non-agricultural landscapes
- Conservation area management in the light of insect conservation

- Reduction in pesticide usage
- Reduction of nutrients and pollutants in soils and water
- Reduction of light pollution
- Support of in-depth research on insect decline
- Increasing funding and setting incentives
- Encouragement and support of societal involvement.

These nine areas also specify the funding as described above (the details are available in the document cited above, albeit only in German). For scientists and citizen scientists alike, the programme is certainly very promising. One goal is to establish long-term monitoring programmes, which are much needed not only to assess ongoing trends but also the potential success of insect conservation measures. This will also entail a strengthening of taxonomic collections and joint work with museums. Action point 9 is also of great importance as it will support local conservation initiatives and provide for citizen science projects and thereby, hopefully, innovative avenues for both science, policy and practice (*e.g.* Hecker *et al*. 2018). Here, it will be important to harness the potential of citizen science for monitoring (Pocock *et al*. 2018; Kelling *et al*. 2019) and employ available statistical tools for data integration to combine different data sources (Isaac *et al*. 2020). It should also be noted that the Government is planning to involve stakeholders from science and society on a regular basis to develop this programme, and has already done so through a public consultation on developing the action points, started in autumn 2018, and a round table discussion with representatives of society and science in November 2019. The programme will be accompanied by changes in legislation affecting not only conservation measures but, importantly, also agriculture, including a ban on particular pesticides such as glyphosate. It will be very interesting to see in a few years, how this programme has been put into action and whether the measures provide an insect conservation benefit. It has also to be seen in the context of money spent on agriculture, forestry and fisheries, for example 1.5 billion Euro alone for the GAK (see above).

With this article we hope to have demonstrated how joined-up working of science, society and policy can arrive at bold moves towards insect conservation. While the implementation of the 100 M Euro insect conservation programme is on its way in Germany, we hope the German science–society–policy community can further support and foster its success, and that similar windows of opportunity can be productively utilized in other countries.

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A UK perspective

Simon Leather
Harper Adams University

Insects and their relatives comprise most of the world's macro-biodiversity and are key components of essential ecosystem services. Many are also important crop pests. About 40 per cent of world crops are lost to pests and diseases.

Last year a series of articles in the press and in the mainstream scientific literature drew attention to the state of health of wild nature. While headlines implying imminent total extinction are exaggerated, as an entomologist-cum-ecologist I agree that there is good evidence that insects are declining, and the ecological consequences may be serious. Insects massively outrank all other animals in diversity, numbers and biomass. Since insects underpin most non-marine food networks, serious declines would threaten the stability of wild nature, inevitably leading to reductions in numbers of insectivorous animals and those that eat them. Loss of pollinators would also adversely affect agriculture, since many crops depend on insects to set seed.

Similar reports in each of the last three years have provoked a brief flurry of media attention and expressions of concern followed by deafening silence. Most worrying of all, there has been no apparent reaction from science funding bodies or the UK government, despite the German and Danish governments setting an example and committing major funding towards understanding the crisis facing us. It is imperative that the UK research establishment enables intensive investigation of the real threat of ecological disruption caused by insect declines without delay.

I blame the UK government for the lack of action over the last few decades. The decline began with the merger of the Agricultural and Food Research Council (AFRC) and the biotechnology and biological sciences programs of the former Science and Engineering Research Council (SERC) to form the Biotechnology and Biological Sciences Research Council (BBSRC) in 1994. A direct result of this was the closure of major internationally recognised agricultural research centres in the UK. Successive governments have also failed to support agricultural research adequately, thus the number of entomological and crop protection posts in UK universities and research institutes has declined markedly since 1994.

There is very little sign of the Government or the Research Councils being willing to fund entomological research, let alone training in universities. There is now only one general entomology degree course in the UK, and that is at postgraduate level at Harper Adams University, although both Reading and Sheffield Universities have recently added M-Level entomological training to their portfolios, albeit in a more specialised format. Entomological teaching at undergraduate level is much reduced in extent, despite the recent addition of an undergraduate Zoology with Entomology degree at Harper Adams University. Applied entomology, including crop protection, is in even more dire straits; there are now fewer than ten pest management specialists teaching in all UK universities.

If we wish to maintain a functioning global ecosystem, the decline of entomologists and pest managers is not the way forward. Without teaching in this area, there will be no future generations of British entomologists, pest managers and insect taxonomists. Instead, we will have to rely on imported expertise, if indeed, any exists.

Without specialist entomological and pest management training at degree and postgraduate level, there will be no UK food security. We, as entomologists, need to call on the Government to ensure a future not only for formal entomological and pest management training and research, but also maintaining expertise in diagnosis, "whole organism" biology and a UK capacity to manage threats to food security.

Knowing about insects and their ways is not a luxury; the US entomologist Thomas Eisner said "Bugs are not going to inherit the Earth. They own it now." We dispossess them at our peril.

www.nationalinsectweek.co.uk

Kheper prodigiosus, a telocoprid dung beetle.

In search of dung beetles in Botswana: a journal of discovery

Bryony Sands
University of Bristol

Studying dung beetles in Africa was a dream come true for me. I had been awarded a PhD Scholarship at the University of Bristol, looking at the impacts of livestock parasiticides on dung beetles in agricultural ecosystems. Thirty years previously, my supervisor Professor Richard Wall had first found out that residues of macrocyclic lactones, commonly used to treat cattle for parasites, resulted in a failure of dung to degrade due to an absence of dung-colonising insects such as beetles and flies (Wall & Strong, 1987). Why was this so important? Most often it is bees that are heralded as the providers of ecosystem services in agriculture, which are at risk from our ever-increasing reliance on toxic pesticides, but there is another unsung hero busy, out of sight, which in my opinion deserves recognition.

Dung beetles are hugely important providers of ecosystem services such as nutrient cycling and soil fertilisation, biological pest control, and increased primary productivity in agricultural systems. By processing and burying dung, reducing pests and parasites on pastures, and returning important nutrients to soils, dung beetles have been estimated to save the UK cattle industry £367 million per year (Beynon *et al.*, 2015). However, it has now been well documented that current agricultural practices threaten to endanger their populations worldwide.

I wanted to find out whether a slightly different class of insecticide, synthetic pyrethroids, which are widely used in Africa to treat important pests and parasites of cattle, also had negative impacts on dung beetles. These compounds were often suggested as being safer for dung beetles, but it was not known whether that was truly the case, nor what happened to this contaminated dung after it had been buried unground by the large African species of dung beetle. On top of this, the ecosystem services provided by dung beetles are likely to be of great importance for small scale pastoralists in sub-Saharan Africa. So, I had the chance of a lifetime: to spend three months per year in a tent in the bush in Botswana with my local field assistant, Nelly, studying these fascinating insects.

On the hunt for dung

My field site was based in Khumaga, a village in north west Botswana. It lies on the western bank of the Boteti river, which borders the Makgadikgadi Pans National Park to the east. I was to carry out work in the village, where local subsistence farmers kept cattle and goats, as well as in the national park on the other side of the river. When I arrived in camp, I met Nelly, a Motswana student from the Botswana International University of Science and Technology (BIUST),

who would be my field assistant and work on the project with me, and her supervisor Casper. We hit it off straight away – she was great. First things first; we had to go and see the village chief – the 'Kgosi' – to get permission to do our work in the area. In order to address the Kgosi and enter the 'Kgotla' where he would see us, it was customary for women to wear skirts, and to address him in Tswana, the widespread language used in Botswana. The chief was magnificent – a tall elderly man dressed in a pure white suit, including white shoes and a white hat. Stern, but with an unmissably mischievous look in his eye. Nelly did the talking, and after a long conversation the Kgosi turned to me and smiled, saying welcome to the village, and that we were free to do our research here. A good start to the trip!

We wanted to start a pitfall trap survey to get an idea of which species of dung beetle were in the area – this had not been done here before so would be valuable information. We used cow dung-baited pitfall traps to collect beetles, which involved suspending freshly dropped cow dung in muslin over collecting cups which were buried in the sand. The beetles would be attracted and fly in, land nearby and walk towards the dung, falling into the cups below. We also set up a comparison survey of wild animal dung, including zebra, giraffe and elephant, compared to cow dung to see if there was any differential attraction of dung beetle species. This was important because species that could utilise a wide range of animal dung would be less at risk from insecticide residues in cattle dung.

We found a local farmer called Robert, who was happy to allow us access to his cattle early in the mornings to collect fresh cow dung. Collecting wild animal dung was slightly more of a challenge, and involved crossing the river into the national park. When the river was too high to drive across, the ferry man Oti would guide me with sporadic hand gestures as I held my breath and drove the Land Rover up the two long, narrow planks onto the makeshift ferry platform. Once safely inside the park, we began the hunt for dung. We needed fresh dung for the pitfall traps, since dung beetles prefer it fresh, and even dung a few hours old would already be colonised by beetles. There were hundreds of zebra here so that was not a problem. There were also a lot of elephants, which could usually be found at favourite spots along the river bank. It didn't take much waiting around for

Waiting to collect giraffe dung!

Me and my field assistant Nelly inspecting one of our experiments for dung beetle mortality.

one of them to lift its tail and deliver us our prize! Collecting fresh giraffe dung was not so straightforward, since their whereabouts (and bowel movements) were far less predictable. Many hours were spent pointing binoculars at an unsuspecting giraffe's behind, and we often left the park with our poo buckets full just as the sun was setting and just in time to make it back to camp by nightfall.

I was spending Christmas at our camp, but the season couldn't have felt less festive with the sun blazing down, and limited communication with my family and friends back home. My mum sent me a Christmas parcel well in advance, but had perhaps placed a little too much faith in the Botswana mail service (it did not arrive until mid-February!), and Nelly had gone back to her family for Christmas. So, although I was living my dream, it was the first time I had been alone on Christmas Eve, and I went to bed thinking about home. Some strange sounds woke me up during that night; swooshings and shufflings around my tent, and low quiet grumbles. Nightly noises were nothing new out here, so I dismissed them and went back to sleep. In the morning, on Christmas Day, I got out of my tent and stepped into the morning sunlight. I noticed tracks all around my tent… very big tracks. Then I noticed something that put a massive smile on my face – Santa had been after all. An elephant had broken into camp during the night and left me the best Christmas present ever. A huge pile of dung right outside my tent! I spent a happy Christmas Day watching the progress of beautiful large *Kheper* and *Scarabeaus* beetles as they worked in the dung, making their brood balls and rolling them away to safety, dodging greedy hornbills which were also getting an easy meal feeding on the beetles.

Waiting for the rains

The rainy season in Botswana is between November and March, and this is when dung beetles are at their most abundant. I had arrived in December hoping to be there for the initial emergence and glut of beetles that season. However, this year, the rains had not come. The crops for the villagers had not grown and the situation got so bad at one point that the government had to bring lorries of water to the village. Although I had been catching beetles in my pitfall traps, my main experiment was failing.

I had paid one of the villagers to help me bury 40 buckets so that they were level with the surface, and filled them back up with sand. We placed cow pats spiked with different concentrations of deltamethrin (a commonly used synthetic pyrethroid insecticide for treating cattle ectoparasites) on the sand in each bucket. I wanted to look at any differences in dung beetle colonisation, as well as brood ball production

Dung beetles soon colonised the artificial dung pats.

and larval development, due to negative effects of the insecticide residues.

In Africa, 70% of dung beetle species are paracoprids. This means that they colonise dung pats and then dig deep tunnels underneath, dragging dung down into the tunnels and forming 'brood balls', into which they lay their eggs. The other types of dung beetles are smaller, endocoprid beetles which live and breed within the pat itself, and those large charismatic ball-rollers, the telocoprids, which you can usually see on wildlife programmes rolling their brood balls across the savannah. I was focusing on the more common paracoprids, the idea being that they would colonise my pats and form their brood balls in tunnels beneath, but contained within the buried bucket. I could then lift out the bucket and sieve through the sand to find the brood balls. The problem was that there were not enough dung beetles around due to the drought. My pats were not adequately colonised; many had only one or two brood balls and some had none – certainly not enough to get any meaningful data. It was time for a re-think!

I decided to focus on adult mortality, as we could see clear effects with small endocoprid beetles being found dead around pats that had higher concentrations of deltamethrin in them. I was hoping that the rains would not fail next year so that I could attempt the brood ball and larval development experiment again when I returned. For now, I could also continue with the pitfall trapping – all I needed was one more repeat of the wild animal comparison survey. We woke up the following day, however, to find that the zebra had left. After a mild panic, and making a few calls, I heard from another researcher in the area that they had been spotted in the Makgadikgadi Pans, likely driven away from Khumaga back towards the northern deltas in search of water and grazing. Determined to complete at least this data set, I decided to set off in search of them and, more importantly, their dung.

There is no phone signal out in the salt pans, and we did not have a satellite phone with us, but the zebra had only been spotted a few hours' drive away. What could go wrong? We loaded our poo buckets, food and water, sun cream, spare fuel and tools into the Land Rover and set off into the vast flat pans. The sand was deep and dry on the track and it was hard to get traction; we were swerving about from one side to another. Suddenly, about an hour and a half into the journey, we swerved into a small tree stump, but seemed to bounce off and kept on going. Then I started hearing a strange noise coming from the vehicle. My heart sank. I stopped and got out, and my fears were realised – the tree stump had burst a tyre. So here we were, two young women alone in the middle of the Makgadikgadi Pans, no satellite phone and no hope of help until the following day (I had told my friends at a nearby camp to come and search for us if we did not return that night).

Luckily, although both small in stature, we were not so helpless – and were told early on in our trip that to survive in the bush we had to be able to fend for ourselves. So, we set about changing the tyre. The deep sand made it difficult to get the jack firmly in place, the wheel nuts were screwed

A healthy dung beetle larva inside a brood ball that we recovered from the buried buckets.

on so tightly that we had to jump up and down on the brace to loosen them, and the sun was beating down. But once we had successfully changed the tyre, we set off again and only had to drive for about thirty more minutes before we spotted a great herd of zebra in the distance. After filling our poo buckets, we stopped for lunch before driving back to camp; hot, tired but happy with our spoils! During my sleep that night I thought I heard a familiar high-pitched braying… and in the morning Nelly came towards me with a look of amused outrage on her face. We couldn't believe it. After all that, the zebra were back at camp!

Battling bureaucracy

My second visit to Botswana began with a somewhat bumpy landing. When I arrived at immigration, I was told that I had no days left on my visa and that I could not stay in Botswana. I was reeling… how could this be? Would I really have to go home, with no data, back to the cold, dark English winter? I had heard that the government was clamping down on granting research permits and residency to foreigners, even kicking out ex-pats running small businesses, who had been living there for 20 years. I tried explaining that I was entitled to 90 days per year, and that my year should have been refreshed, but I was given a mere five days and instructed to go to the immigration offices the following day. There was one highlight to this day though – on my way to bed there was a huge hippo in the river next to the tents, splashing around in the dark with its eyes shining in the torch light. It was good to be back, regardless.

Needless to say, I didn't sleep that night and waited impatiently for 6am when I got a taxi to the immigration offices, which opened at 7am. I sat waiting for half an hour until someone finally came and opened the door at 7.30am. I was second in the queue, and a man was just about to open his booth when one other member of staff suggested that we all have a 'wellness meeting' before starting. This consisted of everyone there, staff and customers alike, getting together in a circle, singing, dancing, clapping and praying for another half an hour. Despite pulling a brave face and doing my best to join in, I have to say it did little to quell my mounting anxiety and exasperation!

When I was finally seen, I was pleasantly surprised that the attendant agreed with my point about being entitled to 90 days in the country. However, he fired off a list of forms, letters and permits that I would need in order to 'apply' to have the days added to my visa. Luckily, it being my second time in Botswana, I was clued up enough to carry most of the paperwork I needed around with me at all times. All that was left was a signed headed letter from Casper at BIUST saying that I was indeed working with them on a project. I ran to the cell phone shop, bought a sim-card, called Casper who agreed to write the letter, ran to an internet café to download it, then to a print shop to print it, and ran all the way back to the immigration office by midday.

I think they were so taken aback that I managed to sort out all the documentation in time, that they just decided to issue me the permit. As I waited and the clock ticked closer to closing, I was getting less and less hopeful that it would be sorted out that day. Then, with five minutes left on the clock, a woman finally came out and handed me my papers. I could stay!

Searching through sand

When I got to camp this year, it had transformed. The rains had come with abundance. Where there had previously been bare sand and stunted vegetation, there were now tall grasses

and lush green. In some places the grass was taller than my head. This was wonderful news for me and my beetles, although the villagers had mixed feelings – the rain had been so torrential that some of their fields had flooded and ruined the crops for a second year. Nelly also had some good news – she was 17 weeks pregnant. Looking back, and having since been pregnant myself, I am in awe of her tenacity – camping in the bush for months, early mornings and getting stuck in to field work, often in intense heat, with barely a grumble. This year we were determined to get the main experiment working.

With help from my supervisor Richard, who had come to assist us for a week, we buried the 40 buckets, and went to Robert's corral to collect dung at 7am the following day. Robert was not there when we arrived, but a passer-by stopped and told us that there had been a lion in the village. He showed us lion tracks nearby and said they were hunting the cattle. This was bad news for the villagers, and for the lions. This type of human–wildlife conflict is common here. The lions are protected in the national park across the river, but when they start coming into the village for an easy meal it is a different story. Last year a lioness had been found dead, shot several times by local farmers. For the farmers it is an easy choice: their lives and livelihoods are at stake. However, solutions for these conflicts can be found, and 'lion guardians' have since been recruited from the local community to watch out for lions and use non-violent methods to scare them off. We collected the cow dung alone and returned back to camp.

The insecticide-spiked pats were left in place on the sand in the buckets for two weeks to allow dung beetle colonisation and brood ball production, and then we began sieving. It was arduous work. In between the rain it was hot – reaching 42°C, so we got up early to begin sieving at 6am. It took us five hours to sieve through just ten buckets! Other things had also made the buckets their home: scorpions and solifuges (also known as camel spiders or sun spiders). Anyone who has had a close encounter with a camel spider, as I had the previous year inside my tent, will probably not be keen to repeat the experience. Being an insect biologist, I make no bones about preferring not to be in the same room, or on the same continent, as these large arachnids – but I tried to maintain my composure as I searched through the sand. The experiment had been a success and there were many brood balls in the sand beneath the pats.

I had planned to store the brood balls for several weeks before opening them, to give the dung beetle larvae time to develop inside, but had not reckoned on the intense heat, which would likely kill them. With intermittent power and basic equipment, it was time to get creative. We developed a brood-ball cooling system which consisted of digging deep holes and filling the bottom with moist sand, before placing the brood balls in buckets at the bottom of the hole and making a watertight covering to protect them from the rain. When the time came to open the brood balls, we were delighted to find eggs and larvae inside. Interestingly, many of the brood balls that had been made from insecticide-contaminated dung contained unhatched eggs, whereas clean dung contained healthy larvae.

The results were in

When my time in Botswana came to an end, I had mixed emotions. I was pleased with my results and had achieved all the experiments that I had planned. I knew that this had been, and probably would be, one of the best experiences of my life and I was extremely grateful for it. I was also excited to return home to see my friends and family, but I was sad to be leaving and I knew that my life would never be same again. I promised myself I would return to Africa. I set off for the airport with one suitcase full of beetle specimens, one suitcase full of my belongings, and a hard-won biological samples export permit in hand.

Back in Bristol with my reference collection.

And what had my experiments revealed? We had found direct lethal effects of synthetic pyrethroid residues in cattle dung. There were significantly more dead dung beetles found around pats that contained deltamethrin compared to insecticide-free dung. There were also sublethal effects on dung beetle reproduction; brood ball production and larval survival were both significantly reduced in dung containing the insecticide residues – showing that contaminated dung buried by dung beetles retains insecticidal effects on larvae underground (Sands *et al.* 2018). We found no difference in the attractiveness of contaminated dung, leading to an ecological trap where beetles are attracted to a sub-optimal and potentially lethal environment. Dung decomposition rate was also significantly reduced even at the lowest concentration of insecticide, indicating impaired ecosystem functionality. There is clearly a cause for concern over continued reliance on the current agricultural pesticides, and with recent estimates suggesting that 40% of insects could be threatened with extinction (Sánchez-Bayo & Wyckhuys, 2019), we urgently need to find highly effective and environmentally sustainable solutions to agricultural pest and parasite management worldwide.

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ENTEAM

Richard Harrington

Harper Adams University

Take a look at the photo above. A typical conference photo? No, these are the entomological students and staff of Harper Adams University near Newport in Shropshire and I'm pretty sure that at no other UK university could you find so large a gathering of insectophiles. Even if you could, I'm certain that they would not match the energy and enthusiasm of these folk.

I'm biased but, when I was a lad, the place to study applied entomology was Imperial College. Now it is Harper Adams. Their master's courses have been running a while and, two years ago, these were complemented by a bachelor's course which, no doubt, will further boost the master's intake. Harper Adams as a whole comprises mainly undergraduates but the postgraduate sector, currently around 10% of the students, is growing fast. Here, following a day's visit, I outline the entomology courses and the research interests of the teaching staff. All this falls under the Department of Crop and Environment Sciences, headed by Dr Andy Wilcox.

Undergraduate course in Applied Zoology with Entomology

This is a four-year course leading to a BSc. The first two years are spent at Harper Adams, with entomology beginning in earnest in the second year. In the third year there will be an off-site placement, but the first to join the course have not yet reached that stage. The fourth year will comprise further on-site learning together with project work. There were three entomology students in the first intake, nine in the second, and enrolments are expected to increase gradually to 30 per year. Dr John Reade is in overall charge of the suite of Applied Zoology courses, with Dr Heather Campbell and Dr Simon Segar leading teaching of the entomological content in the second year. No other UK university has an undergraduate course majoring in entomology.

Master's course in Entomology

I was struck by the diversity of ages, ethnicities and walks of life on this course. Students included a local soon-to-be-retired GP, the managing director of a UK-wide pest-management company based in Lincolnshire and people with both science and arts backgrounds. Minimum entry requirements are a lower second-class degree or relevant experience. The oldest student to date was 68 with no qualifications beyond GCE. The flexibility of the course timetable facilitates this diversity. It comprises modules completed as blocks of one or two weeks. Whilst the course is one-year full-time, students may complete modules over a three-year period, allowing them to mesh their studies with other commitments. There are nine modules in the entomology stream (Research and Information Skills, Experimental Design and Analysis, Biology and Taxonomy of Insects, Diversity and Evolution of Insects, Commercial and

Visible entomological enthusiasm.

Coffee-time conversation enhances the atmosphere at Harper Adams.

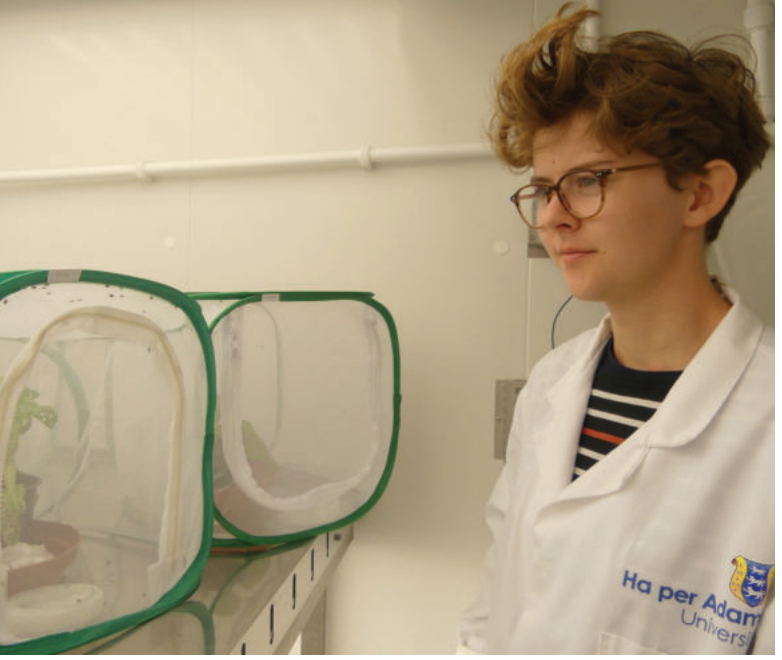
Practical Biological Control, Insect Physiology and Behaviour, Pesticide Technology, Biodiversity and Ecosystem Services and Ecological Entomology). Many of the modules are shared with students on related courses (Integrated Pest and Disease Management, Ecological Applications, Conservation and Forest Protection, Forest Management, Agroecology, Plant Pathology, Plant Health and Biosecurity). Professor of Entomology, Simon Leather, is Programme Manager for all but the Forest Management and Agroecology courses, and each module has its own leader. Respected academics and practitioners from many universities, institutes and companies are involved in the teaching. Eight modules plus a research project are required for an MSc, eight modules without a research project for a Postgraduate Diploma (PgD) and six modules for a Postgraduate Certificate (PgC). Flexibility is further enhanced by the possibility of enrolling for a PgC and upgrading later if desired. Modules typically have 20 to 25 students, with an annual intake across these courses of around 45. Assessment is through essays, scientific papers, exams and a project running from Easter to mid-August for the MSc option. The project may be within Harper Adams or off site in the UK or overseas.

Research

Keith Walters is Professor of Invertebrate Biology and Integrated Pest Management (IPM), as well as Director of the Centre for Integrated Pest Management (CIPM), a virtual Centre at the university that brings together the multidisciplinary aspects of IPM and other aspects of crop protection. As such, the Centre provides a focus for all research into sustainable pest management at Harper Adams. All of this research is rooted in the needs of industry and environmental awareness, and the Centre is involved in many projects, including collaborators from other UK universities and institutes as well as those from Indonesia (whitefly control), Brazil (stingless bees), Canada (non-target impacts on bees), Kenya (thrips control) and Rwanda (coffee pests). A UK-based example is an Agriculture and Horticulture Development Board (AHDB)-funded project on the precision application of molluscicides. This involves detailed monitoring of the behaviour of grey field slug (*Deroceras reticulatum*), including through radio frequency identification (RFID) tagging (developed in collaboration with Dr Tom Pope, who has previously used this approach to monitor the behaviour of vine weevil adults), which has shown that most slugs don't move far, and tend to return regularly to the same general area (within 1.0–1.5m) after foraging, leading to patches that are fairly stable in space and time. If they venture out to attack your hostas, they return home. The few (10–15%) that move further afield tend to find other hot-spots. Eight factors, mainly relating to physical and chemical soil conditions, have been found to be important in determining hot-spots of slug activity. The research, which involves collaboration with mathematicians, GPS software developers, consultants, machinery manufacturers and others, has revealed that farmers who think they know their slug hot-spots are missing around 60% of them. The Centre has also recognised that introduction of more sustainable pest management approaches will affect other aspects of farming and has broadened its remit to take account of this. So, work on conservation biocontrol has been expanded to include studies of wild bee (bumblebee and solitary bee) nutrition, leading to provision of multiple ecosystem services from the same habitats. The Centre links to teaching through research projects undertaken by the students.

Insect Chemical Ecology Research Associate, Dr Joe Roberts, is involved in a project led by the University of Warwick and funded through the BBSRC's Sustainable Agricultural Research and Innovation Club (SARIC) looking at partial resistance to the peach–potato aphid (*Myzus persicae*) in *Brassica oleracea* and *B. napus*. Such resistance may improve the efficacy of biopesticides as well as biological controls, such as parasitoids. Joe's research also includes AHDB-funded work to find a new tool to inform decisions on vine weevil (*Otiorhynchus sulcatus*) control. Traps with and without plant-volatile lures are being trialled. Vine weevils are active at night and hide in dark places during the day. Some of the entomology students taught by Dr Nicky Randall have helped with trap design ideas, Pringles containers forming the basis of a particularly successful unit.

Claire Hoarau is only two-weeks into her PhD but has a clear vision for its progress. She is investigating the potential of biopesticides as controls for cabbage stem flea beetle (*Psylliodes chrysocephalus*) (CSFB). Adults cause the well-known shot-holing of leaves but larvae can also cause problems in spring as they develop inside the leaf petioles and stems of plants. Initially, Claire is trying to develop a method of rearing CSFB so that she has a continuous supply of insects for experimental work. In the next stage of the project Claire plans to screen potential botanical and entomopathogenic biopesticides and will then look for synergistic and antagonistic interactions between these and pyrethroids. The importance of Claire's research is illustrated



Claire Hoarau.

Dr Joe Robers.

by the fact that, in oilseed rape crops grown close to the university, 90% of CSFB individuals are resistant to pyrethroids meaning that these populations cannot currently be controlled with available synthetic insecticides. The situation is made worse by the fact that use of pyrethroids, as well as being ineffective in controlling this pest, is likely to be harmful to natural enemies within oilseed rape crops.

There seems to be a profusion of entomological Simons at Harper Adams. I met three. Dr Simon Segar has been there for a year and is a Lecturer in Entomology, with a particular interest in tropical insect and plant diversity. Simon is a research-active lecturer who sees the benefit of integrating research and teaching activities. As part of Operation Wallacea's work in Honduras, he is studying insects on the super-diverse genus *Psychotria* of the coffee family (Rubiaceae). These plants deploy defensive alkaloids (including dimethyltryptamine) and Simon is interested in molecular aspects of the evolutionary dynamics of the plants and insects, with the aim of being able to predict which insects are likely to be pests of coffee grown under various conditions. He has broad interests in the field of insect–plant interactions and is director of studies for a PhD student, Cindayniah Godfrey, who is studying resistance in woolly apple aphids (*Eriosoma lanigerum*) in collaboration with researchers at NIAB EMR.

Dr Heather Campbell is also a Lecturer in Entomology and has been at Harper Adams for two years. She has a particular interest in the community ecology of ants with respect to anthropogenic disturbance, on which she has worked in Australia, Namibia and South Africa. She is co-supervisor of Claire's PhD (above) and has a PhD student in Vietnam working on dragonfly responses to pesticides in rice paddies and the impact on their abundance in neighbouring national parks. She is applying for a grant to set up a research project in the Gorongosa National Park in Mozambique to study interactions between people and environmental management. Heather also curates the insect collection at Harper Adams, and teaches curation techniques. The collection is a valuable teaching resource and comprises mainly insects from the UK.

I spoke with all the above researchers but others were not available during my brief visit. Tom Pope filled me in. Dr Andy Cherrill, Senior Lecturer in Applied Ecology and Entomology, has a particular interest in the ecology and conservation of leafhoppers and Orthoptera. Recent projects include investigation of leafhoppers of newly created heathland and the efficacies of various vacuum-traps for monitoring different insect orders in a range of habitats. Dr Nicky Randall, Principal Lecturer in Agroecology, has a background in insect ecology and is interested in enhancing ecosystem services such as pollination and natural pest control on farmland. She has PhD students investigating habitat provision for farmland invertebrates, and an MRes student investigating the nectar preferences of *Bombus terrestris*. She also works in evidence-based agriculture. Dr Laura Vickers is Senior Lecturer in Plant Biology, with a particular interest in aphid adaption to environmental stress, insect osmoregulation and insect behaviour in novel growing systems such as "vertical farming" which involves growing crops in stacked environmentally-controlled chambers under LED lighting, often in urban settings. Dr Lucy Crockford is Senior Lecturer in Soil and Water Management, with an interest in the ecology of aquatic invertebrates in relation to nutrient flows in water courses, as affected by agricultural practices which influence run-off, such as minimum tillage and cover cropping.

I am particularly grateful to my host, Dr Tom Pope, Reader in Entomology, whose own research focuses on biopesticides and more generally integrated pest management. This focus is reflected in the work being undertaken by the PhD students Tom supervises, such as Claire (see above). As well as pioneering the use of RFID tags to track the movement of slugs, he is developing integrated plant protection strategies in ornamentals where the focus is the control of vine weevil and in strawberry where the target is the potato aphid (*Macrosiphum euphorbiae*).

Over lunch I chatted with many of the students, all of whom were engaging in their conversation. The undergraduates, it seemed, were generally more inclined towards conservation than control, with this being reversed in the postgraduate community. Many said that, having been somewhat out on a limb in their entomological interest at school, they were relieved to find their soulmates at Harper Adams and to learn so much from each other. After the group photograph at the top of this article had been taken, many students headed straight for a hedge, armed with paint brushes and collecting tubes: true entomologists if ever there were. Such enthusiasm, which is innate but fostered effectively by that of the staff under the pioneering leadership of Simon Leather, is reflected in the students' regular contributions to *Antenna*, including their domination of the student essay competition. It seems entirely appropriate that the Royal Entomological Society supports five of the students each year through MSc Fellowships. Their application essays feature in this issue.

Why humans and aphids don't always like their greens: is there such a thing as a generalist?

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Fig. 1. The author learning to prepare a spicy Thai curry dish with hot chillis, *Capsicum annuum*, which contains the mammalian antifeedant Capsaicin (8-methyl-N-vanillyl-6-nonenamide). Photo: Phuket Island, Thailand, October, 2019, Nicola von Mende-Loxdale.

When I was a young child in the mid to late 1950s, I remember having battles with my father at the lunch table over eating green beans and Brussels sprouts in particular; he relished them and thought they would do me good, I loathed them. I also remember my teacher at infant school standing behind me at meal times to make sure that I ate every last morsel of the stewed rhubarb with custard or baked apple put in front of me, food still being in relatively short supply in those far off, post-war days. Of course, what I didn't realise then was that sprouts, for instance, are protected with nasty tasting phytochemical antifeedants (isothiocyanates and sulforaphane; Griffiths, 2014; https://en.wikipedia.org/wiki/Brussels_sprout), whilst rhubarb is defended by oxalic acid (Sebastian *et al.*, 2007) and apple by malic acid and especially polyphenols (Purrington, 2017). These have been produced during the age-old co-evolutionary struggle of plants (which of course cannot run away when under attack, unlike most terrestrial animals), and the plethora of herbivores that attack them, everything from spider mites and insects to birds and mammals, including humans (Fig. 1).

Having watched many cooking programmes on the TV in recent years, one gets the impression that we humans eat a large range of plant material. Is this view correct? I think not: it is just another of the many myths that we daily imbibe as part of the 'diet' fed to us by social media and widely-held social beliefs. In fact, of the ~ 391,000 vascular plant species known world-wide, some 5,400 are edible to humans (Dasgupta, 2016), yet only 15 species (the so-called staples: wheat, barley, oats, maize, potatoes, rice, cassava, *etc.*) now provide 90% of human food (en.wikipedia.org/wiki/Staple_food). Hence, ~ 1.4% of the total are edible to humans and, if you include only the 15 species, just ~ 0.004%! So, we humans eat a very small fraction of the plant material available globally and are essentially highly specialised in our plant diet. In this light, even some of the apparently edible common staples contain antifeedant toxins. Potatoes and cassava, for example contain alkaloids and hydrogen cyanide (HCN)-producing cyanogenic glucosides, respectively and have to be treated with caution before consumption (peeled in the case of the humble spud, more especially when the peel is green, and soaked in water in the case of cassava flour to allow fermentation. This allows ~ 80% of the cyanogenic glycosides to be broken down by a naturally-occurring enzyme, linamarase, the HCN so produced escaping into the atmosphere and making the flour safe for consumption; en.wikipedia.org/wiki/Cassava).

As mammals, we are of course not alone in such dietary specialisations. Besides the well-known predilection of the

Fig. 2. The tansy aphid, *Metopeurum fuscoviride* Stroyan, a monophagous, ant-attended species, a highly co-evolved specialist feeder on the tansy plant *Tanacetum vulgare* L., a host that is chemically-defended against insect attack with terpenes/terpenoids. Using microsatellite markers, the aphid has been shown to display genetically-related inter-plant preferences dependent upon the cocktail of terpenes/terpenoids present (Benedek *et al.*, 2015), the composition and titre of which also affects the intra-plant positioning of colonies at a micro-ecological level (mainly, but not exclusively, on the stem). (cf. Jakobs & Müller, 2019, for details).
Photo: Mohsen Mehrparvar. Reproduced with permission.

giant panda bear, *Ailuropoda melanoleuca* David for bamboo (comprising ~ 99% of its diet) in its home range, the forests of south central China, it has evolved from a previously carnivorous antecedent, still has the genes to prove it (Li *et al.*, 2010; Jin *et al.*, 2011), and indeed does occasionally eat other plants as well as birds' eggs, fish and small mammals to supplement its rigid, not-very-nutritious diet (en.wikipedia.org/wiki/Giant_panda). Other, even stricter, mammalian herbivores can be surprisingly choosy in what they eat. For example, the Okapi, *Okapia johnstoni* (P.L. Sclater) of the forests of Central Africa, whilst being known to browse over 100 types of leaf, some poisonous to humans and other animals, is nevertheless selective in what it consumes, such that no particular leaf dominates its diet, presumably because of the levels of toxins these contain (en.wikipedia.org/wiki/Okapi). Even the koala, *Phascolarctos cinereus* (Goldfuss) of eastern Australia, a highly specialised marsupial eucalyptus leaf feeder, preferentially eats the leaves of certain species of gum tree with lower levels of antifeedant toxins, *i.e.* formylated phloroglucinol compounds (FPCs) (Moore *et al.*, 2010).

I provide these examples to show that over the spectrum from extreme monophagy to high levels of polyphagy, the exact nature of the phagy involved is often not as clear cut as once assumed, and that there are degrees to these extremes and presumably all the stages in-between. Such levels of phagy cannot be easily divorced from the various factors governing them, principally anatomy-morphology, genetics-chemistry-biochemistry, chemical ecology and behaviour (Loxdale & Harvey, 2016). That animals can display specialisms down to a very fine-grained level, including the koala, as cited above, and aphids such as tansy-feeding species (Jakobs & Muller, 2019) (Fig. 2), is a very exciting discovery, truly the cutting edge of ecological-evolutionary population divergence.

On the flip side of this scenario, so-called polyphages (equated by some with 'generalism') may be much less so than believed. In this light, whatever the published literature may have us believe, there is clearly no substitute for experimental research to ascertain the true diet preferences and breadth of animals, including insects, and of particular interest to me, aphids. With predatory invertebrates, this could be done via direct feeding experiments, preferably in the true wild habitat rather than a laboratory context where the animals in question may be in a sensory-deprived arena and thereby consume food items offered to them that they would not normally encounter (Finlay-Doney & Walter, 2012). Nowadays, DNA markers, including sequencing, are employed to resolve the diet of animals, including invertebrates like molluscs, spiders and insects (Pompanon *et al.*, 2012), and within the last group, predators, parasitoids, herbivores and detritivores (Rietsma *et al.*, 1982), all of which potentially display food preferences.

In the case of insects, many species *appear* to be polyphagous, but there could be cryptic species within apparent genetically-homogenous populations, or lower levels of evolutionary divergence, largely morphologically similar entities masquerading (to us and excluding mimicry) as the target species in question (Loxdale *et al.*, 2016; Loxdale, 2018). Again, only direct feeding experiments (*e.g.* Lepidopteran caterpillars, especially in relation to allelochemicals in the diet and plant nutritional quality; Scriber, 1981) or DNA studies can ultimately resolve what eats what, how many and when. My guess is that for the majority of extant species, and especially extinct species, we haven't a clue. Even the relatively recently extinct (mid-1930s) Tasmanian wolf or thylacine, *Thylacinus cynocephalus* (Harris) may not have eaten what we previously thought it did, *i.e.* it ate smaller prey relative to its size rather than larger animals (Attard *et al.*, 2011).

Which brings me inexorably to the topic of my favourite group of insects, the aphids. According to the late Victor Eastop (1924–2012) of the Natural History Museum, London, some 4,000 species are known worldwide, of which 99% are specialist to a greater or lesser extent, usually feeding on closely-related plants within the same family or specialised on single species (Eastop, 1986). The remaining ~ 1% are apparently more polyphagous but, if you re-examine data collected by the Rothamsted Insect Survey (RIS) for the ten major pest species trapped by their UK nationwide network of 12.2 m. high suction-traps over many years (Tatchell *et al.*, 1983) (some notoriously polyphagous like the peach–potato aphid, *Myzus persicae* (Sulzer); Fig. 3), which reputedly feeds on plants in 40+ families; Blackman, 2010), even these may not be as polyphagous as once assumed, attacking on average around 4 plant species per family (Tatchell *et al.*, 1983; Loxdale *et al.*, 2019; see Table 1 in the latter paper).

One often reads that aphids are highly polyphagous, as I have recently done when perusing papers on the genome

Fig. 3. The peach–potato aphid, *Myzus persicae*; parthenogenetic mother with nymphs. In colder climates, it is heteroecious and holocyclic, host alternating between its primary host, predominantly peach, *Prunus persica* and many secondary herbaceous hosts, reputedly in 40+ plant families (Blackman, 2010). In warmer climes, it is predominantly anholocyclic (Blackman, 2010). It is possible that globally, populations may comprise an array of host-adapted, morphologically-similar cryptic species or biotypes/subspp.

sequencing of global pest species like *M. persicae* and *Aphis gossypii* Glover, for example (Mathers *et al.*, 2017, Quan *et al.*, 2019). These papers cite large – but anecdotal – values for their respective levels of polyphagy, *i.e.* hundreds of host plants (Fig. 4). But from where, one might reasonably ask, do these data originate? True, some aphid experts can of course identify aphids prepared on slides for microscopic examination down to the species level with a high degree of confidence and maybe, in collaboration with field data, even to biotype level (Eastop, 1973). The members of the RIS, to which I once belonged, identify a range of at least 30 pest species caught in the suction-traps to produce data for the weekly *Aphid Bulletin* sent out to plant growers and their advisers (Harrington, 2014). But what about other less well-trained entomologists-ecologists? Can they really tell a *Myzus persicae* from other closely-related and morphologically-similar *Myzus* species with confidence? I personally have my doubts. And even if it is true that, for example, the grain aphid, *Sitobion avenae* (F.) (Fig. 5.), has occasionally been found on hosts such as shepherd's purse, *Capsella bursa-pastoris* (L.) Medik. (Family Brassicaceae) (Blackman, 2010), this is not its normal host, the aphid being typically oligophagous on members of the Poaceae, more especially cultivated cereals (Loxdale & Brookes, 1990). What is the incidence of such rogue attacks on non-typical host plants? Whatever the truth, it is known that aphid species transferred to non-natal host plants have fitness costs in terms of development and reproductive rate and are hence not as ecologically adapted as when on their normal long co-evolved natal host (McLean *et al.* 2009). In this sense, they are likely to be negatively selected against in the longer term. There is also now evidence that secondary (facultative) bacterial symbionts are involved in the adaptation of aphids to novel hosts, especially within the same plant family, *e.g.* the pea aphid *Acyrthosiphon pisum* (Harris) (Fig. 6) (Tsuchida *et al.*, 2004), although this is disputed by others (McLean *et al.*, 2011).

Whilst aphids are clearly highly constrained by long-co-evolved ecological factors from host shifting, especially by the nature and titre of chemical antifeedants (Koul, 2008) and antagonists of one form or another (predators, parasitoids and pathogens, especially entomophthoralean fungi), perhaps they can more readily transfer from one host to another in the cossetted agroecosystem. Here selection, especially biotic via antagonists, is likely to be relaxed and the titre of plant antifeedant lower than in wild forms of the plant (Loxdale *et al.*, 2019). But one assumes this is not likely to be a long-term co-evolution continued over millions of years under the unerring glare and force of selection, including on fecundity (number and rate of offspring), although who exactly is to say? Maybe this is indeed the shape of things to come. But having said that, the agroecosystem is not the 'real world' in

Fig. 4. Cotton–melon aphid, *Aphis gossypii*. Adult virginopara with nymphs. A heteroecious, holocyclic species north of Arkansas (~ 35°N) in the USA, anholocyclic below this latitude. Uses *Catalpa*, *Rhamnus* or *Hibiscus* as the primary host. In Europe, it is totally asexual and 'can produce nearly fifty generations a year under favourable conditions'. Apparently, highly polymorphic, infesting 'at least 60 host plants being known in Florida and perhaps 700 worldwide', especially cotton, cucurbits, citrus, eggplant, okra, asparagus and peppers. (https://en.wikipedia.org/wiki/Aphis_gossypii) Photo: influentialpoints.com; Reproduced with permission.

Fig. 5. The grain aphid, *Sitobion avenae;* winged migrant with nymphs. In the U.K., predominantly anholocyclic on members of the Poaceae, especially cultivated cereals. Occasionally found on other herbaceous plants (Blackman, 2010).

Photo: influentialpoints.com; Reproduced with permission.

an evolutionary context, only an annexe of it, a short-term one in the sense that it has only been around for about 8,000–9,000 years BP, as far as we can judge, certainly in the Americas (Piperno *et al.*, 2009). And even whilst it is true that aphids, including *M. persicae*, have adapted to the agroecosystem, including evolving a range of insecticide-resistant genotypes under the current intensive regimes of cultivation involving widespread prophylactic pesticide spraying over the past 50 years or so, these genotypes themselves are not necessary very robust in a genetic sense; they often have pleiotropic fitness costs, including negative effects on behaviour and hence survival, such that they are relatively quickly selected against, especially over the wintertime when the level of spraying is relaxed (Foster *et al.*, 2017).

Returning to the problems of semi-skilled recorders recording species in the natural world, be they aphids, birds or butterflies, this is not always an easy task. I still cannot tell with any degree of confidence a willow tit from a marsh tit, yet skilled birders claim they can, and indeed, can identify these species with some degree of confidence, along with many of the 'little brown jobs' LBJs, *e.g.* warblers that regularly invade these shores.

In recent years, citizen science has become popular, employed by large organisations like the RSPB and *Butterfly Conservation* to record the demography of species in the U.K. (Fox *et al.*, 2019). As Fox *et al.* state, many of these people are professional, trained recorders and thus their data are sound. But what of people with limited skills and/or experience, whose ranks are daily growing in terms of these tasks? Yes, it is good that they take part in such important surveys, but can their data be trusted? Certainly, there is doubt that the data they collect are always accurate (Fox *et al.*, 2019). If this is true, what about the polyphagous nature of aphids? Can we trust such data? Up to a point probably but only when taken with a 'large pinch of salt'. Humans are

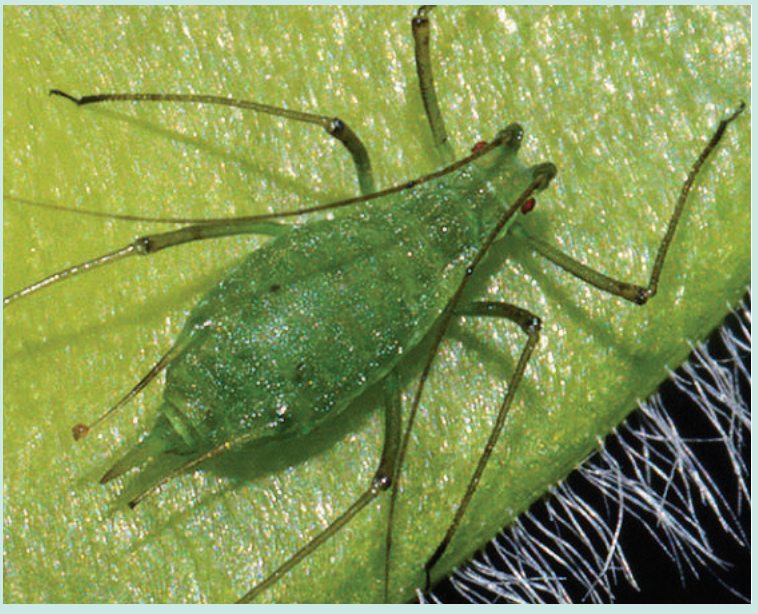

Fig. 6. The pea aphid, *Acyrthosiphon pisum*. (Biotype A on Broom, *Cytisus* (= *Sarothamnus*) *scoparius* (L.) Link). Specialises on members of the Leguminosae (Fabaceae). Reproduces mainly sexually (Blackman, 2010). Known to display a range of ecologically specialised, host-adapted races-biotypes-subspp., hence in reality it is a species complex (Peccoud & Simon, 2010). Photo: influentialpoints.com; Reproduced with permission.

notoriously bad at identifying faces, *e.g.*, in criminal identity line-ups of suspects (Forsyth, 2010), let alone very small, phloem-feeding plant parasitic insects, so we have to be careful at taking people's word for what they claim to have observed and where and when. Hundreds of folk claim to have seen the thylacine in Tasmania and mainland Western Australia since its demise 84 years ago (*e.g.* Heberle, 2004). But where, one might reasonably ask, is the empirical proof in terms of a living or recently dead animal (*e.g.* road kill), or even its hair snagged on barbed wire, its scat, or a decent photograph or video footage that indisputably proves its continuing existence? There I rest my case and, along with this, I suggest that claims about the diet breadth of this or that animal must be treated circumspectly, unless supported by hard empirical evidence.

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Society News

News from Council

RES Grand Challenges in Entomology

Luke Tilley
Chief Executive

For the last few years The Royal Entomological Society has been collaborating with other entomological societies from around the world to discuss and offer mechanisms to address future *grand challenges* in entomological research and communication. For those who attend RES Ento conferences, ESA Entomology conferences or international congresses (e.g. ICE and ECE) *A Grand Challenge: an Agenda for Entomology* will be familiar from the last four years. The programme was instigated by the Entomological Society of America (ESA) and is now supported and led by several entomological societies, including the RES. The broad aim of the initiative is to improve the human condition through insect science. Initial efforts have focused on summits and workshops of leading researchers, dedicated to both broad and specific topics within entomology. Here, I briefly explain the rationale for this collaborative approach and introduce a specific project funded by the RES to 'scan the horizons' of entomology.

The motivation

Insects include arguably the most beneficial and also some of the most dangerous organisms on the planet. Certain insects are responsible for spreading diseases and reducing global crop yield, others are providers of myriad ecosystem services, from pollination to decomposition. Entomologists have a unique set of skills to enhance the quality of human life by mitigating the negative effects of insects whilst protecting the many positive effects of entomological diversity.

Medical entomologists are researching ways to control mosquitoes that spread diseases such as malaria, which is still responsible for the death of one child each minute according to the World Health Organization. Other entomologists improve food security by protecting crops through the study of interactions between insects and plants, evaluate the impacts of invasive species, or identify priorities for biodiversity conservation around the world.

Therefore, entomologists can positively impact the future of mankind and life on Earth. Since insects do not respect national borders, the best approach for addressing insect-related challenges is through collaborative, international efforts. There is now a global initiative to empower the members of entomological societies, joining together, to engage with global public and private bodies, to highlight and advance entomological research. The aim is to bring together top scientists, policymakers, industry groups, NGOs, funders and other organisations to create coalitions to implement sustainable solutions to some of the world's insect-based problems.

So far

So far, there have been several meetings that form part of the Grand Challenges initiative, including:

Grand Challenges: Vectors and Beyond – Ento 19, London, UK, *August 2019*

Addressing the North American and Pacific Rim Invasive Insect and Arthropod Species Challenge – Vancouver, Canada, *November 2018*

Grand Challenges in Entomology in South America – Gramado, Brazil, *September 2018*

International Entomology Leadership Summit: Improving the Human Condition through Insect Science – International Congress of Entomology, Orlando, Florida, USA**,** *September 2016*

Integrated Tick Management Symposium: Solving America's Tick-Borne Disease Problem – Washington DC, USA**,** *May 2016*

Summit on the *Aedes aegypti* Crisis in the Americas – Maceió, Alagoas, Brazil**,** *March 2016*

Grand Challenges Leaders' Meeting – Minneapolis, Minnesota, *November 2015*

As the above list of conferences and meetings highlights, the subject matters vary from individual species or focussed topics to broader communication and leadership priorities. The aim from here on is to establish a robust set of specific and broader questions to identify priorities for future insect research and its applications.

What next?

The Royal Entomological Society has the most international membership of any entomological society and members

work on almost every insect-related topic imaginable. With this in mind, the RES trustees have agreed to fund and oversee an ambitious project in collaboration with the whole RES membership that will culminate in a "state of entomology" paper to outline the major challenges ahead in entomology. These will then be unpacked to reveal specific research questions related to each wider challenge. Dr Lynn Dicks FRES (University of Cambridge) will be the lead researcher on a survey of the RES membership. The aim is to use the wealth of experience and knowledge of the Society to inform policymakers, funding bodies and the public about the challenges ahead and how entomology might offer solutions. To achieve this, Dr Dicks' project will run from January to September 2020 and every Member, Fellow and Honorary Fellow will receive a survey in order to take part in this exciting initiative. The information gathered will then be synthesised and summarised using workshops and global experts to compile a report.

I sincerely hope that you will choose to participate and help to create a valuable "state of entomology" paper that will act as a manifesto for the future of global insect science. You should expect to hear from Dr Dicks in the near future. Please add your experience to the project.

Journals and Library

New ways for old specimens – museomics is transforming the field of systematic entomology

Christiane Weirauch, Peter S. Cranston, Thomas J. Simonsen and Shaun L. Winterton

Editors of *Systematic Entomology*

Natural history collections have preserved and housed natural objects since the "cabinets of curiosities" of the Renaissance period. Still, only a minute proportion of their vast holdings is on display in the public galleries of these natural history museums. The remaining billions of biological specimens worldwide are archived behind the scenes, in what might be envisioned as dusty and dark vaults reluctant to reveal their treasures. Until the second half of the 20th century, these collections have almost exclusively served as resource for the cataloguing and classifying of past and present biodiversity including the discovery and documentation of taxa so far unknown to science. This started to change before the turn of the millennium, when scientists launched the first large initiatives to "unlock the vault" and bring the vast biodiversity data harboured in biological collections out into the open by creating digital records of the metadata associated with a specimen (locality, date, collector, host plant, etc.), imaging of specimens, and by making these data freely available online. This biodiversity informatics revolution was spearheaded initially by museum scientists and curators focussed on vertebrates and plants, because of the larger size, greater public interest, more manageable number of specimens, and the 2D quality of herbarium specimens that facilitate workflows. Although more challenging because of the enormous number of specimens, comparatively small size, diversity of preservation techniques, and position of metadata on a label underneath the specimen, a growing number of specimens in entomological collections worldwide have been, or are currently being, digitized[1,2]. By documenting past and present and predicting future species distribution ranges, these museum-derived datasets have enabled research on areas including biodiversity change in relation to climate change, biological invasions, and arthropod vectors of public and veterinary health concerns, impacting fields far beyond systematic entomology[3,4].

Fig. 1. Samantha Smith (Weirauch lab, UC Riverside) collecting emesine assassin bugs for phylogenomic projects on Barro Colorado Island, Panama.

We are now at a point where an on-going revolution in DNA-sequencing techniques and bioinformatics methodology allows us to unlock this vault of treasures even further[5]. Starting in the mid-2000s, advances in sequencing technology have launched research that is now referred to as "museomics", a legacy approach to genetic sequencing of specimens from museum collections. In contrast to more

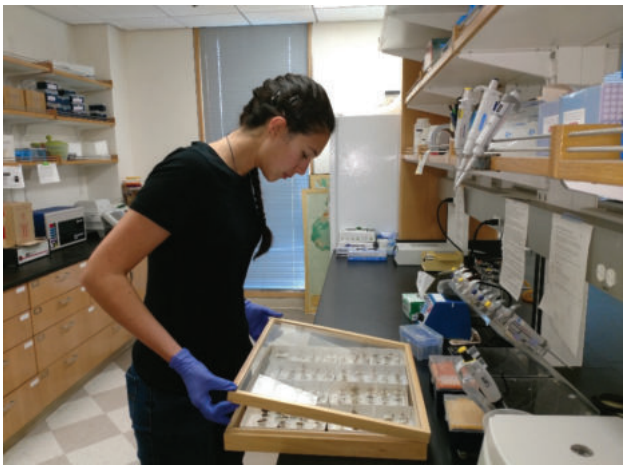

Fig. 2. Madison Hernandez (Weirauch lab, UC Riverside) preparing assassin bug museum specimens for next-generation sequencing.

traditional molecular systematics projects that required targeted field-work (Fig. 1) and careful preservation of tissues to ensure that DNA remains largely intact, these new approaches take advantage of the billions of specimens that are already deposited in natural history collections (Fig. 2). Using genetic material and data from specimens in natural history collections, scientists can now trace evolutionary origins, model past and future spread of pests and diseases, offer insights into the evolution of insecticide resistance, and revolutionize our understanding of human evolution using ancient DNA.

Similar to the biodiversity informatics revolution, museomics was spearheaded initially by the vertebrate and botanical communities, but despite the unique set of challenges when applied to small, dry biological specimens, insect scientists have made great strides towards embracing and advancing this field [6–8]. Studies range from targeting relatively few genes to entire mitochondrial and/or nuclear genomes. Entomologists have explored the feasibility of extracting and amplifying DNA from pinned insect specimens with fragmented and degraded DNA and subsequent Sanger sequencing for more than two decades[9]. However, only the use of next-generation sequencing (NGS) protocols that has increased substantially during recent years has started to make museomics in the entomological field a cost-effective and more widely used alternative to traditional approaches. This is largely due to the fact that NGS protocols involve steps that "shear" or fragment intact DNA, so using already fragmented DNA from pinned insect specimens should not pose a problem - at least theoretically. In the real world, entomological museomics offers great opportunities, but also significant challenges, in particular for pinned, dry museum specimens that represent the bulk of entomological collections.

Due to centuries of field expeditions to all corners of the world, natural history collections are the most comprehensive and accessible representation of biodiversity, offering a tremendous opportunity for scientific discovery. They also house rare species that even targeted expeditions frequently fail to find again; these are often represented only by the original type specimens. Another great benefit of using museum specimens for genetic research is that generations of taxonomists may have worked on a given collection and the proportion of specimens authoritatively identified to species level is consequently high. Given that NGS approaches have recovered sequence data for insect specimens that were collected more than a century ago, museomics also has the potential to uncover historical signatures in genetic sequences, allowing, e.g., an improved understanding of the evolution of insecticide resistance[10] and similar phenomena such as cryptic (genomic) changes within, and between, populations due to well-documented environmental and anthropogenic changes. Generating and making publicly available genetic resources is also a key element of the Nagoya Protocol on Access to Genetic Resources, a supplementary agreement to the Convention on Biological Diversity. Furthermore, in the face of the current biodiversity extinction crisis, museum specimens including bulk samples from large survey and passive trapping projects may be the only specimens remaining after the site surveyed is no longer intact. Museomics may thus be the only way to acquire unique genomic insights into the biological, evolutionary and biogeographical importance of now extinct populations.

Despite these overwhelming benefits, there are still challenges to applying museomic approaches to insect specimens. The number of insect species, both known to science and remaining undescribed, is staggering and the number of insect specimens in collections is overwhelming (300 million in North American collections alone[2]); the availability of genome-scale datasets for all, or even just the majority of, insect species is therefore a distant dream. In addition, many insects are small and the amount of DNA that can be retrieved from a single specimen may be too little for reliable sequencing without destruction of the entire specimen. Depending on collecting methods and preservation conditions, pinned insect specimens can be heavily degraded and even overgrown by fungi, posing additional challenges to both the wet lab protocols and bioinformatics procedures required to sort useful sequence data from potential contaminants. Additionally, primary types are the only known specimens for many species, making the advancement of protocols for largely non-destructive sampling imperative in like manner as currently employed for procedures such as genitalic dissections.

Although NGS approaches are now cost-effective compared to Sanger-sequencing projects, sampling of a large number of individuals for relatively low-profile projects such as genus-level taxonomic revisions will benefit from further refining protocols for maximal effectiveness. On-going research is further adapting and optimizing NGS methods for pinned museum specimens in an attempt to make them affordable and widely used[11,12]. The challenge for museomics will be how to integrate with the rapidly growing field of environmental DNA that reveals almost inconceivable diversity in terrestrial and especially freshwater aquatic systems, with much deriving from insects[13]. While NGS barcoding allows rapid and low-cost association of insect life stages[14] allowing identifications against well-populated 'libraries' of organisms, the data produced in such studies already seem likely to overwhelm even the most dedicated museomic practitioners. Yet, without such connections with historic named specimens, we can ask what value such metagenomic revelation of diversity can have in a world of biodiversity losses.

A conclusion might seem to be that field expeditions and the collection of large-scale specimens are things of the past. This is, however, far from the truth. Not only is field-work necessary to study and document the biology, ecology and behaviour that museomics may allow us to put into an

evolutionary context, but also continuous collecting activities aimed at building collections for the future are essential to document and explore both spatial and temporal cryptic changes in molecular diversity – changes that are often preceding more obvious phenological, phenotypic or ecological changes. In fact, this makes collecting activities even more important in the current age of accelerating biodiversity changes. Indeed, museomics simply provides an opportunity to exploit the vast wealth of legacy genetic information already available in present collections, to then use this data source to strategize future research efforts, including field-work. We argue that any decrease in collecting activities (among both professional and amateurs), or funding for collecting and collection maintenance, threatens to deprive future researchers of the opportunity to study and publish research on our biodiversity in the Society's journals in the same way that we have benefited from the collecting activities of past generations.

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New publication announcement

Handbooks for the Identification of British Insects
Vol 2. Part 8
Aphids – Anoeciinae, Lachninae, Eriosomatinae, Phloeomyzinae, Thelaxinae, Hormaphidinae, Mindarinae

By Roger L. Blackman, Robert D. Dransfield and Robert Brightwell

This is the fourth Royal Entomological Society handbook on aphids, and completes the coverage of the British species. It covers seven subfamilies, represented in Britain by 105 species in 35 genera. They encompass a great diversity of life-styles, ranging from the Eulachnini with Cinara and other major pests of conifers, to the Eriosomatini and Pemphigini, which induce galls on elms and poplars and then migrate to colonise the roots of various herbaceous plants. For each subfamily there are keys for the identification of tribes, genera and species, and also for morphs within species. The systematic account includes biological information and photomicrographs of each species. Wherever possible distinguishing characters are provided that are amenable to the non-specialist, including field keys to aphids on conifers and plant roots.

£35.00 plus postage and packaging; Members/Fellows receive 30% discount.

Sir Charles Godfray's ideas about RES handbooks – a response

Andrew Polaszek (RES Handbooks Editor)
and Lin Field (Chair, RES Publications Committee)

In an interview with Hon. Fellow Sir Charles Godfray (*Antenna* 43(3) 144–146), Charles laments what he regards as the excessive price of new RES handbooks. In our defence, RES handbooks are currently produced in collaboration with the Field Studies Council, whose dedicated staff require financial support for this undertaking. Prices are calculated to just cover production costs, and income generated is of course put back into the RES. At the same time, the cost of preparing drawings and, increasingly, other kinds of images, are often met directly by the RES during production. In that same issue (pp 126–127; Farley-Brown *et al.*), several new and innovative formats for handbooks currently in preparation were presented, including pictorial and multiple entry keys. Undoubtedly these will meet with Charles's approval. We wholeheartedly support his advocacy of an extensive RES website, where online versions of each handbook could be available for annotation, obviously not by anyone, but after some agreed system of individual certification. While such a move is likely to impact to some extent on sales, most current purchasers of handbooks are either scientific libraries, or individuals who want to have a physical copy, regardless of online availability. Any minor decline in handbook sales income would be more than offset by the enormous benefit to users and consequent prestige to the RES.

Meetings

Ento '19: Vectors of Diseases

International Symposium and Annual Science Meeting

London School of Hygiene & Tropical Medicine, 20th – 22nd August 2019

Mary Cameron and James Logan

Photo 1: Attendees at the *What works for networks?* workshop. Photo courtesy of Frederik Seelig, LSHTM.

It was a great honour to host Ento' 19 at the London School of Hygiene & Tropical Medicine (LSHTM) last summer; coinciding with LSHTM celebrating its 120th anniversary of innovative scientific research in global and public health. We are particularly delighted that the 163 delegates who registered, an average of 150 attending for each of the three days, represented international entomologists from five continents: N. America (several US institutes, including Puerto Rico), S. America (Brazil, Chile), Asia (Bangladesh, India, Japan, Korea), Africa (Burkino Faso, Cote d'Ivoire, Kenya, South Africa, Tanzania), Europe (France, Greece, Netherlands, Switzerland) and Australia. Nationally, delegates came from more than 25 academic institutes across England, N. Ireland, Scotland and Wales.

Photo 2: Ento '19 teams "hard at work" during the pub quiz. Photo courtesy of Frederik Seelig, LSHTM.

The meeting consisted of three plenary sessions in the International Symposium, which were held at the start of each day. The plenary sessions, each with an associated theme, explored important challenges to the control of vector-borne diseases: *evaluation*, *innovation and implementation*. The plenary sessions were followed by 12 parallel sessions in the National Science Meeting. In total, there were 17 invited speakers in the plenary or parallel sessions, 10 female and 7 male, as well as 75 delegates, including 15 students, who delivered oral presentations.

Seven of the parallel sessions were themed, six of which concerned vectors of diseases (human, animal or plant): *Insecticide resistance management*, *Innovative tools for vector control*, *Transmission of vector-borne diseases*, *Vector/host/pathogen interactions*, *The role of mathematical modelling in vector-borne disease research* and *Integrated vector/pest management*. The other themed session focused on the decline of insects. The remaining five sessions were open to a variety of subject areas to widen the scope of interest and attract entomologists from a range of research fields. In addition to delivering oral presentations, 25 delegates, including 11 students, presented their work as posters.

We were delighted to have Brian Marsh from the Marsh Christian Trust to present Jessica Gillung (Cornell University) with her certificate as recipient of the Marsh Early Career Award, and for Shaun Winterton, RES Editor in Chief of Systematic Entomology and lead judge on the Westwood panel, to announce Jason Hall as the winner of the Westwood Medal and Marsh Prize. Brian Marsh presented Jason Hall with his well-deserved medal in honour of his career devoted to insect taxonomy.

The programme also included four workshops, which were very well attended (Photo 1). The themes for each workshop were: *Partnering with industry*, Chairs: Chris Rice and Sarah Dewhirst (ARCTEC), *What works for networks?*, Chairs: Frederik Seelig (Global Vector Hub) and Emma Howson (BBSRC GCRF Gnatwork Network), *International collaboration: perspectives from the CONNECTED Network*, Chair: Harriet Mills, and *Knowledge translation*, Chairs: Victor Brugman (Vecotech Ltd) and Emma Fadlon (Innovate UK).

Unfortunately, due to planned renovation works at LSHTM, it was not possible to hold a traditional conference dinner or ceilidh at the meeting. Nevertheless, given LSHTM's central location, with eating and drinking establishments on every street corner, there were plenty of opportunities to network and socialise. For example, an entomologically-focused pub quiz was held at the nearby College Arms pub (Photo 2).

No doubt, our President, Professor Chris Thomas, would like us to point out that his team (situated at the table on the left at the back of the room) won the pub quiz (by a very small margin, we should add)!

The symposium finished with awards presented to students for the best oral and poster presentations and a session introducing the RES Grand Challenges in Entomology initiative chaired by Luke Tilley. You will hear more from Luke concerning the important role that RES is playing with respect to identifying grand challenges and supporting entomologists to address them (see pages 21-22).

Since then, we have received numerous positive responses from those who attended Ento '19 regarding how much they enjoyed the meeting, both socially and scientifically, which makes the efforts made by everyone involved worthwhile. We would like to thank Kirsty Whiteford, Luke Tilley and all the staff at RES who provided great support. We are also grateful to Prof. Anne Mills, Deputy Director and Provost of LSHTM, for delivering her welcoming address, and Azimah Said, our Events Manager at LSHTM, who worked very hard behind the scenes. We also thank the session chairs, workshop chairs, presenters, student helpers and everyone who attended to make it an enjoyable and successful meeting.

Outreach Special Interest Group

Hyde Park, 28th November 2019

Richard Harrington

I think this might be the most unusual entomological meeting I have been to – hugely inspiring and, at times, quite surreal. The venue fitted both these categories. Our host was The Royal Parks and the meeting was held at its LookOut Discovery Centre in Hyde Park. How often can one fight through the hubbub to attend a meeting in Central London and then emerge for (a delicious and entirely vegetarian) lunch into the middle of the capital's greatest outdoor space?

Not everybody is into communicating their science to the public, but those who are comprise a wildly enthusiastic breed. I have never before been to a scientific meeting where delegates have been asked to sing and dance (if you can call the hokey-cokey a dance). Professional story teller, Olivia Armstrong, had us doing both, and a few "lucky" people even got to dress up. The Royal Parks' *Mission: Invertebrate* project had commissioned a 20-minute story to explain to visitors what invertebrates are and why they are so important. Olivia, using a range of everyday visual and audio aids, told of a tree, struck by lightning, that dreaded the foresters coming to chop it up and take it away. Instead, a myriad of grateful invertebrates colonised it. Such a tree features in the ground of the Discovery Centre and was seen by those

A hoverfly lagoon (© Ellen Rotheray)

who joined Richard Pering of *The Royal Parks* for a lunchtime look around the grounds. I don't think I've heard a professional storyteller since my *Jackanory* days, and it was clear how Olivia could captivate the young. I loved her comment "Storytelling makes the magical seem real and the real seem magical". That was not the only singing of the day. Even our own Chief Executive, whilst describing the Society's progress with production of resources for primary schools, had us on our tarsi performing "Head, Thorax, Abdomen, Abdomen".

Continuing her mission to persuade people to love flies, Erica McAlister (Natural History Museum, London), using some truly magnificent photos, ably and amusingly flagged up the virtues of these much-maligned creatures. Biting midges pollinate chocolate, Black soldier flies are rich in omega 3 oils and, of course, many flies are pollinators and decomposers. Several have the most amazing morphologies and revolting behaviours, which can't fail to fascinate when put under the spell of Erica's pen or Powerpoint. As for *Anopheles*: "It's not their fault, they are just unwitting vectors and, in any case, males can be pollinators. Furthermore, we don't know enough about their taxonomy and ecology to make it sensible to try to eliminate the whole genus". I was rather amused by the clip shown from *University Challenge* in which Jeremy Paxman, citing Erica's book, asked how many individual flies there are in the world for every human "answers to the nearest three million will be accepted". "Six million" came the response. With a withering look as if to say "surely you can do better than that" Paxo gave the answer as "seventeen million". Well, I wouldn't have got it, but I confess to not having read Erica's book.

Given the venue, it was appropriate to have a presentation on insects in inner cities. May Webber (Butterfly Conservation) is managing the Heritage Lottery-funded *Big City Butterflies* project to raise awareness amongst Londoners of the butterflies and other insects under their noses. Moth traps have a huge impact on those who are lucky enough to view their contents but they are often problematic for people to set up because of the nuisance they can cause to neighbours. Nonetheless, May gave examples of children and adults who have had their eyes opened to the wonders of their surroundings, some of whom have even been lured off their *iPads* as a result.

Also introducing people to the insects on their doorsteps was Ellen Rotheray (University of Sussex) through the *Buzz Club*, a citizen science organisation aiming to increase habitat for wildlife, particularly pollinators. In Brighton and Hove, the Tesco-sponsored *Buzzing Balconies* project has demonstrated the potential of said architectural features to host window boxes and grow-bags planted with pollinators in mind, whilst the *Hoverfly Lagoons* project has had people UK-wide and beyond supporting these vital pollinators (see www.thebuzzclub.uk/hoverfly-lagoons).

Staying with pollinators, Louise Williams (Defra) outlined the priorities of the National Pollinator Strategy and simple actions that the public can take in its support. She introduced delegates to the Bumblebee Conservation Trust's *Bees' Needs Week*, during which events take place in London's renamed Carnabee Street and awards are given to organisations which have been especially successful in supporting bees. For more details, see www.bumblebeeconservation.org/bees-needs.

For *Antenna* 43(3) I visited the Royal Horticultural Society's entomologists at Wisley where, amongst others, I met Hayley Jones and Imogen Cavadino, who are involving the public in mapping cellar slugs in UK gardens. Read that article for details, but Hayley gave an update showing that 217 records, representing good coverage of the UK, had been received. Eighteen months of the project remain and Hayley is hoping for 1,000 records. She said that most people engaged in the project had not previously realised that the majority of slug species are not pests.

Former entomologist Julie Clark is now a student of landscape architecture. She believes that conventional resources such as journals and official "green guidance" rarely meet the criteria of being understandable, meaningful and engaging. Julie is exploring, graphically and in words, how ecologists and landscape architects think, and believes that insects, because they are keystones of ecological systems, can bring the two together to the benefit of biodiversity in urban landscape design.

Art has a role in invertebrate conservation through accessibly supporting scientific understanding, helping with learning, and showcasing diversity. Charlie Linton, one of our hosts from *The Royal Parks*, showed examples of the work of influential entomological artists with a varied range of styles. German-born naturalist Maria Sibylla Merian (1647 to 1717) was one of the first to observe and illustrate insect life-cycles. Carim Nahaboo is an artist of our time, whose work featured in the 2018 *National Insect Week* and will be familiar to many readers. David Measures (1937 to 2011) was the first to paint butterflies in flight. His remarkable works were produced not with a brush and water, but with his fingertips and spit, necessary to record quickly but accurately what he was seeing. Remarkable in a very different way are the knitted moth sculptures of Max Alexander. Finally, Charlie recognised the influence of street artist, ATM.

We were very fortunate to benefit from the wisdom of Emily Beament, PA Media (formerly The Press Association) Environment Correspondent. Her top tips on selling a story

The meeting being entertained by (and participating in) a story by Olivia Armstrong.

were: i) be passionate; ii) ensure that the title is brief but catchy; iii) provide excellent pictures; iv) be completely jargon-free; v) highlight the involvement of volunteers so that readers can envisage themselves taking part and vi) be available following a press release. With an ever-growing interest in the environment and climate change, Emily assured us that there is plenty of space in the media for engaging stories.

The Society is preparing a guide to entomological outreach, which Fran Sconce introduced. A discussion on future meetings led to the notion of a two-day city centre event with a SIG meeting followed by a public event, perhaps at a shopping centre. Can't wait! In the meantime, huge thanks to Alice Laughton, her colleagues at The Royal Parks and all the speakers for an unforgettable day.

Lunch alfresco at the LookOut Discovery Centre, Hyde Park.

Aquatic Insects Special Interest Group

Climate Change Impacts on Aquatic Insects

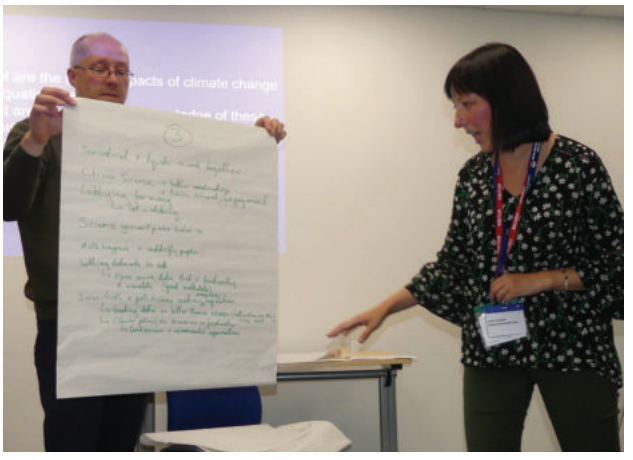
Centre for Ecology and Hydrology, Lancaster, 1st October 2019

Richard Harrington

As the train whizzed me past waterlogged fields and my brolly failed miserably to protect me from Storm Lorenzo on the ten-minute walk from Lancaster Station to the Travel Lodge, it seemed highly appropriate that I was heading for a meeting on climate change impacts on aquatic insects. And yet, as pointed out by co-convenor Craig Macadam, nobody was speaking about the impacts of floods, only the impacts of droughts.

In 1981, Steve Ormerod (University of Cardiff) started a long-term experiment at the Llyn Brianne reservoir in Carmarthenshire. The experiment is still running. Biological and physicochemical data are collected from a series of replicate streams in different habitats (coniferous forest, deciduous forest and moorland), some being unmanipulated controls, some manipulated. Such long-term data enable correlations to be made between the biological data and potential explanatory variables, giving insights leading to hypotheses as to the reasons for biological changes, which can then be tested experimentally. For example, insect abundance is negatively associated with Hurrell's North Atlantic Oscillation Index for winter – a positive index (warmer, wetter winters) being associated with insect decline. Moorland streams have warmed in winter by 1.7°C since 2010 and forest streams by 1.4°C. Invertebrate abundance has dropped on average by 21% for each 1°C rise in temperature, although community composition has not been greatly affected. A deciduous buffer helps to mitigate the changes, as leaves falling into streams encourage invertebrates, but there has been a progressive loss of specialist traits. Away from Llyn Brianne, in urban situations, major improvements in the water quality of rivers may be offsetting some negative effects of climate change, as reducing organic pollution increases insect resilience to temperature rises. On a different issue, of the 8 to 12 million tonnes of plastics entering the oceans annually, at least 4 million tonnes arrive via rivers. Steve and his colleagues have found plastic fibres in half the insect specimens studied and these fibres are working their way through aquatic food-webs and turning up in birds such as the Dipper.

Specialising in terrestrial pests, I was possibly the only "non-swimmer" (literally as well, as it happens) in the audience and so greatly appreciated Rachel Stubbington's (Nottingham Trent University) introduction to temporary streams. These range from near-permanent flow to episodic, flowing only after heavy rain. Temporary streams dominate global river networks, especially in warmer, dryer regions but are also common in cooler, wetter regions. Rachel is studying communities in the different phases of stream drying. I needed reminding that lotic communities are those of flowing water and lentic communities are those of still water. Many aquatic invertebrates also often have terrestrial stages. Perhaps unsurprisingly, lotic community diversity increases with the duration of the flowing phase and lentic community diversity with the duration of the pool phase. Aquatic communities can be very resilient to drying but are often not resistant. Resistance increases in specialists of dry sediment, which need rehydration to activate dormant stages. Dry-phase communities are the invertebrate "seed banks". On average 12 taxa are found in these "seed banks", richness decreasing as harshness increases. Dormant eggs are the primary persistent stage, with true flies, caddisflies and beetles dominating. Terrestrial dry-phase communities are attracted by food, water and competitor-free habitat, with springtails and beetles dominating. Rachel presented a conceptual model of the impacts of various drivers on alpha, beta and gamma diversity in the different stream phases. The impacts of climate change are difficult to separate out from the impacts of changes in flow permanence, but it is assumed that climate change will lead to reduced flow permanence, more frequent and longer dry phases, shorter longevity and poorer water quality of pools, and drier sediments. These interactions mean that innovative approaches are needed to underpin effective temporary-stream monitoring and management. In a changing climate, temporary-stream biodiversity can be protected by revegetation of riparian zones to provide shade, restoration of sediments to promote vertical connectivity, creation of pathways to enhance catchment-wide connectivity, removal of barriers to increase longitudinal connectivity and sensitive management of surface and groundwater abstraction.



Jenni and Craig poring over the flip-chart and leading the workshop discussions

A large-scale mesocosm experiment in Candover Brook, Hampshire, to study non-linear community responses to drought was described by Kieran Khamis (University of Birmingham). Twenty-one flumes provided a replicated drought intensity gradient and both taxonomic and trait responses of macroinvertebrates ("seeded" from a local brook) were studied. Threshold responses (step changes) in abundance and taxonomic richness over an 18-month period

Ameletus inopinatus (photo by Stuart Crofts)

were detected for around two thirds of the most abundant genera, especially under moderate drought conditions. There were also significant responses in 12 of the 16 pre-selected traits recorded. Behavioural traits (dispersal, locomotion and feeding method) were sensitive to moderate-intensity drought as channels fragmented into isolated pools, but morphological and physiological traits (body size, respiration mode and thermal tolerance) only responded when surface water was lost. The results showed that small changes in drought intensity can lead to abrupt functional shifts in stream communities, suggesting that traits-based approaches could be particularly useful for diagnosing catastrophic ecological responses to drought. The flume facility has now been moved to the University of Birmingham campus with plans to explore climate–pollution interactions.

A traits-based approach was also adopted by Craig Macadam (Buglife) to predict the vulnerability of invertebrates to climate change. Craig drew attention to an excellent website for obtaining data on freshwater organisms: www.freshwaterecology.info. The introduction on the homepage of this site reads: "Here you can find autecological characteristics, ecological preferences and biological traits as well as distribution patterns of more than 20,000 European freshwater organisms belonging to fish, macro-invertebrates, macrophytes, diatoms and phytoplankton. The ecology data feature distributional parameters (e.g. ecoregional distribution or endemism, etc.), regional parameters (e.g. stream zonation or altitudinal preference, etc.), habitat parameters (e.g. temperature or substrate preference, etc.) or life-related parameters (e.g. feeding type or life duration, etc.) and others. All ecological parameters can be individually combined and queried." Using trait data from this site, Craig identified traits relating to vulnerability: i) predominantly found in headwaters; ii) predominantly found above 450m altitude; iii) cold-adapted; iv) flight period less than two months; v) univoltine, semivoltine or living for more than a year and vi) found in less than 15 hectads in the UK. From this he identified one vulnerable mayfly, five caddisflies and ten stoneflies, and mapped the number of vulnerable species per hydrobasin throughout the UK, and vulnerability to climate change. Northern England had more vulnerable species than Scotland, but this may be an artefact of insufficient sampling at high altitude. The work is at an early stage and Craig pointed out that more sampling is needed and that vulnerable species are likely to have been lost already.

Arron Watson (Environment Agency) has big ideas on big data. Concerned and inspired at an early age by Al Gore's film "An inconvenient truth", he wants to see more collaboration between organisations to put public data to better use in ensuring action on conserving aquatic invertebrates in the face of climate change. Huge obstacles relating to funding and data compatibility remain and there have been many previous attempts to bring organisations with long-term data together in pursuit of similar goals. Few, if any, of these efforts have stood the test of time. Maybe Arron's youth and huge enthusiasm will combine with age and experience to produce useful results, and Arron was pointed in the direction of the Society's Insect Data Special Interest Group which shares this dream.

In the afternoon, participants considered three questions as follows.

i) What other impacts of climate change on aquatic insects are likely?

Responses included: phenological changes; physiological changes including adaptation; disrupted food webs; disrupted life-cycles; changes in microhabitat and loss of refuges; increased risks from invasive species; isolation in species; range contraction and expansion; changes in community composition.

ii) What are the gaps in our knowledge of these impacts?

Responses included: abundance of taxa as opposed to presence; population genetics in relation to the environment; impacts of extreme events and interactions between them; interactions with other stressors; impacts on water habitats other than streams, such as head waters, reservoirs, lakes and ponds; impacts of flooding.

iii) What partnerships (people/data/research) do we need to tackle these gaps?

Responses included: potential for more citizen science; increasing skills gap in taxonomy; need to have clear messages for policymakers; join forces with those looking at similar issues in terrestrial invertebrates; involve data providers as interpretation is otherwise likely to be erroneous.

Many thanks to Jenni Stockan (James Hutton Institute, RES Secretary) and Craig Macadam for organising an excellent meeting, and to CEH for their hospitality.

Insect Declines in the Headlights

Royal Society of Biology *Policy Lates* Meeting

Royal College of Physicians, London, 7th October 2019

Luke Tilley

During Biology Week 2019, the RES supported a Royal Society of Biology *Policy Lates* event, attended by about 90 people, on insect declines. *Policy Lates* is a series of meetings bringing a panel of experts together for an informal debate on a contemporary science policy topic. In this case, the panel comprised Dr Nick Isaac (Centre for Ecology & Hydrology), Dr Larissa Collins FRES (Fera Science Ltd), Dr Lynn Dicks FRES (University of East Anglia) and our own President, Professor Chris Thomas FRS FRES (University of York). It was chaired by Professor of Science Communication Adam Hart FRES (University of Gloucestershire).

Prof. Hart started the discussion with some of the eye-catching news headlines regarding insect declines. However, as panellists talked through their research and datasets, it was demonstrated that insect decline is not as clearly defined as the headlines implied.

Dr Isaac presented long-term trends in UK insect populations, using data collected from the volunteer-led UK Butterfly Monitoring Scheme. The datasets showed that, whilst for some butterfly species numbers were decreasing, several moth species were increasing. Dominant crop pollinators were increasing in occupancy, but bees were declining overall. Dr Isaac highlighted the different conclusions that can be drawn from datasets, separately and in combination. He concluded: "We should be worried, but don't believe all the hype."

Prof. Thomas discussed his research on the biomass dynamics of British moths. He appealed for more long-term and widespread ecological data on insect abundance to understand trends.

Dr Collins highlighted the use of real-time, online technology such as *Crop Monitor* to increase our understanding of crops and their pests and to balance the need to conserve insect populations and protect crops.

Dr Dicks restated that insect decline is very complex and that more data are needed. She offered practical solutions for anyone to increase insect abundance in their community, including growing more flowers and shrubs, cutting grass less frequently, avoiding disturbing nests and hibernation spots, and using pesticides sparingly and with care.

There followed an energetic Q&A session, covering topics such as potential policy changes, future long-term monitoring, the importance of volunteers and citizen scientists, and the need for more insect taxonomists. The take home message from this productive evening was that insects are, indeed, under threat, but more data are needed to unpick the complexity and to understand the mechanisms.

From left to right: Professor Adam Hart, University of Gloucestershire - Panel Chair; Dr Nick Isaac, Centre for Ecology & Hydrology; Dr Lynn Dicks, University of East Anglia; Dr Larissa Collins, Fera Science Ltd; Professor Chris Thomas, Royal Entomological Society and University of York (image:RSB)

Honorary Fellow Interviews

Roger and Rosy Key
Two Boldy Go

by Peter Smithers

Roger Key is very well-known in the field of entomology and conservation. Indeed, it is not stretching the facts to say he has legendary status. His contribution has been enormous both in its scope and innovation. He has helped to improve the way the British countryside is managed and protected and, using his encyclopaedic knowledge of invertebrates, he has helped us to gain a better understanding of the natural world. However, what is not immediately apparent is that Roger is half of a team, his wife Rosy being the other half of a dynamic partnership. While they have, as individuals, made significant contributions to both entomology and conservation, it is as a team that they are at their most accomplished.

Finding a slot in the Keys' hectic schedule had been a challenge. On the day I caught up with them they were in a wildflower meadow near York, owned by the *Woodmeadow Trust* and full of families and excited children. Roger and Rosy were running a series of their famous bug hunts and I had arrived just in time for the last of the day. Roger gave an animated demonstration of how to use the gear, Rosy handed it out, and a wave of enthusiasm and curiosity was released to sweep across the meadow. Roger and Rosy fielded a host of questions about the catch and natural history in general. Questions were fired rapidly from both children and parents, a storm of "what's this" and "how does it do that?". It was finally time to go, so we packed up and adjourned to the *Old Black Bull* where, sitting in the garden in the shade of a plum tree, we drank beer, ate Rosy's homemade medlar fudge and began to discuss their lives in entomology.

Roger, Early Life

"I'm originally from Crosby, on the edge of Scunthorpe in the Coversands heathland area of North Lincolnshire and was fossicking for bugs as soon as I was up on two legs. Though I've no recollection of it, I was apparently bitten by

a devil's coach horse beetle at the age of two, which resulted in many tears, the temporary loss of a fingernail, and a permanently distorted fingerprint".

(All is revealed, I hear those fans of DC comics proclaiming!)

"I can't recall a time when I wasn't fascinated by everything that crawled with six or more (or no) legs. My parents thought I might grow out of it but, once I reached the age of 12, they accepted defeat and began to encourage me. *Brooke Bond* tea cards and the *Observer's Books* played an important role; before these there were white butterflies – and the rest. The tea cards opened the door to the world of insects. My Gran drank vast quantities of tea so I always had a steady supply. A couple of other adults took me under their wing, first the local lepidopterist, Joe Duddington, and the then-new curator of natural history at Doncaster Museum, Peter Skidmore, who became a major mentor, friend and eventually work contact for the next 32 years."

"I took zoology and botany A-levels, then a BSc in Zoology at Nottingham followed by a PhD in estuarine benthic ecology at Hull, which is where I first came into contact with Rosy."

(For a full account of the influences on Roger's early life, see his article *Another Generation of Entomologists?* in *Antenna* 31(2)).

Rosy, Early Life

"My twin sister and I were into nature from an early age but nobody in the family could understand this. At primary school. we had a nature table and nature walks, which we loved but, despite our enthusiasm, our parents discouraged us from this path, which was odd as our Mum knew the names of all the local wild flowers. However, we saved our pocket money in order to buy natural history books. We saved up thirty shillings each and I bought the *Hamlyn Animal Encyclopaedia* and my sister bought the one on birds. We also had a magazine called *Treasure*, which had a nature page in each edition."

Roger and Rosy above Manti Bay, on St Helena.

"As my parents moved around, we'd attended four schools before being sent to a girls' boarding school in North Wales to study for our O-levels. This was amazing: there were six science labs, two for each science, and all girls were encouraged to do sciences. After this we moved to a large comprehensive school to do our A-levels and we were the only girls studying the sciences in the two years of sixth form. This was in the bad old days – there was a residential field course but, with only one dorm, no girls were allowed. The field project, however, counted towards the exams so we had to do one on our own with no guidance or help."

"After A-levels I took a BSc in Zoology at Hull. It was a traditional course that introduced us to the animal kingdom, where we drew specimens of all the major taxa and dissected many of them; bee, rat, cockroach, dogfish and snake. Roger was a demonstrator on some of these courses but I did not really know him at that point."

"Hull University leased an old P.O.W. camp Nissan Hut (called Birch Hall after a nearby cottage) at Langdale End in the North York Moors as a residential field centre. Providing there was a 'trustworthy' post-grad student along, the university's student BiolSoc was entrusted with keys of both the centre and the departmental minibus to take students to the moors for a 'wild weekend'. 'Wild', in the sense that these were weekends where we could investigate the local natural history in more relaxed fashion. I became a regular on these trips. Roger was the usual minibus driver and I soon gained more experience in field biology. It was on these trips that I came to know Roger and Steve Compton (now reader in Entomology at Leeds University) a little better, and made many other friends who had their own success in ecology and conservation. One was Mike Cripps (sadly no longer with us), who also became an FRES and whose enthusiasm for working with children and nature as a science teacher in Norfolk still greatly inspires our work with kids today."

Norway

In the summer of 1979, Roger and Steve had organised an expedition to Jostedalen in Norway to study the influence of altitude and glaciation on animal and plant distribution. Roger was looking at dung beetles and Steve was studying chalcidoid parasitic wasps, which continues to be his research interest today. Roger takes up the story.

"Not long before we were due to leave, one of the team dropped out and we needed a replacement. Rosy was the unanimous choice but we couldn't get in touch with her (it turned out she was on holiday in the USA). Time became tight and we decided to ring just one more time and Rosy answered, having arrived home just half an hour earlier. So Rosy joined us and looked at wood-ants' nesting behaviour in relation to microclimate near a glacier. It was on this expedition that we became 'an item' and team Key was formed."

"On our return to the UK it was a time of job cuts and organisations closing down. Prospects for new graduates and PhDs were very poor. Rosy took up a traineeship in accountancy in London and stuck at it for six months before getting an MSc Research Assistantship at Cardiff with Mike Claridge, working on the ecotaxonomy of Southeast Asian delphacid hopper rice pests, while I was writing up my PhD and looking for employment. It was to be two years and 198 applications before my first real job."

Mid Wales

"That successful 198th job application was for a combined development officer and habitat surveyor for the Herefordshire and Radnorshire Trust, hosted by the University of Wales. It was just a Job Creation Scheme; a one year, non-renewable contract, but Rosy took over for a second year extension, after which I was eligible to apply for its third year and so the Trust had the pair of us, working as a team, for the whole three years for one salary. Projects we hosted included the informal UK Coleopterists' Group at the University's Llysdinam Field Centre and running a weekend-long course in invertebrate conservation there, which was well-attended by conservationists from around the country."

It was while working for the Trust, which shared an office with the Nature Conservancy Council (forerunner of all of today's government conservation agencies), that Roger and Rosy first met the great Alan Stubbs, at that time the only entomologist employed as such by the NCC. They took Alan on a tour around the Trust's various reserves and Roger was dismayed when Alan quickly dismissed what Roger had thought was one of the more promising reserves with: "I don't think very much of this place, show me somewhere better". It took Roger three more years of visits to come to just the same conclusion – that that reserve didn't harbour much of note entomologically. "Alan taught me a very valuable lesson – the importance of experience".

Not long after this Roger was taken on by Alan Stubbs and Ian McLean in the Chief Scientist's Team at the NCC in its new HQ at Peterborough. He was to work on the *Invertebrate Site Register* – a database of important sites for the conservation of invertebrates, with a hidden agenda of building a 'shopping list' of new SSSIs.

"I was responsible for Yorkshire and my own north Lincolnshire home patch. It was a brilliant era. I was part of a vibrant team of young entomologists – we eventually totalled eleven – working in all parts of the country on the invertebrate *Red Data Books* and species group reviews. We spent a huge amount of time together in the field. Everyone was learning from each other and we were continuously in contact with, and picking the brains of, nearly all of the most prominent professional and amateur entomologists of the day."

"One of the things I was able to instigate was an 'Invertebrate Conservation Roadshow', where three members of the team would visit conservation land management organizations around the country to give a one- or two-day workshop on the subject. We eventually ran over 100 of these events over six years, covering all sorts of land managers, including every County Wildlife Trust (but one!) in the UK. The interplay and questioning from the participants gave us real insight into the practicality of what we were suggesting people should do and we modified accordingly. The roadshow led directly to the production of Peter Kirby's excellent RSPB/JNCC book *Habitat Management for Invertebrates: A Practical Handbook*."

"Something the Invertebrate Team quickly learned was the need to influence general habitat management to take into account the needs of invertebrates for structural heterogeneity in their habitats. One thing that I felt that I added was the importance of conserving wild sites valued by local people, not because they were home to rare plants, animals or special plant communities, but because they were the places where local people, in particular children, could interact with, learn about and come to love and value the wildlife – just nice bits of accessible countryside in which to build dens, explore and learn."

Eventually NCC became *English Nature*, Alan Stubbs retired and Ian McLean moved to JNCC. In 1991 Roger became Head of the Invertebrate Unit, much involved with their Species Recovery Programme and projects on ancient trees. He continued in this post until 2007.

Back to Rosy

"At the time Roger moved to NCC, I was also unemployed, but I obtained a two-year contract as 'Entomological Bibliographer' in the NCC's library. The project was to produce a database of papers from the entomological journals they kept. It was supposed to take two years but we did it all in just seven months and so moved on to other journals. In the end, my contract was extended. In the meantime, a job came up in the Invertebrate Section but, under NCC rules, I was not eligible as I was married to a member of the Science Team. So, I went into admin and over the years have worked for very many teams including working on CITES, the Advisory Committee on Science, and the Advisory Committee on Birds. When the NCC was split up I went into JNCC's International Branch, working with the IUCN and parliamentary work and, after two years, joined *English Nature* working on policy on SSSIs and SPA and Ramsar sites. I was also involved in the *Recorder* biological recording programme (as was Roger)."

"In 1997, I became involved with the *Tomorrow's Heathland Heritage* project, with £14 million from a Heritage Lottery Grant and another £16 million from other partners, and with 25 projects all across the UK restoring and recreating lowland heathland. I had to visit each project at least once a year and was back in the field again for a lot of the time. After that I became *English Nature*'s lead on *Local Nature Reserves*, one task of which was liaising with BBC filming at a number of LNRs in the first *Springwatch* series."

"When we became *Natural England*, I worked on monitoring rare species on NNRs and produced the standard techniques to be tailored to each species and was involved in long-term vegetation monitoring of permanent quadrats right across the country. All in all, I must have done more different jobs than almost anyone else in the organisations."

Lundy cabbage beetle Project

In 1993, Roger and Rosy's 26-year long association with the island of Lundy and its endemic plants and beetles began.

"Lundy cabbage was listed on the UK's *Biodiversity Action Plan*, but we knew almost nothing about it. Our old friend Steve Compton had recently returned from working in South Africa and was looking for a research project either on island insects, or plant–insect interactions. The Lundy cabbage beetles seemed perfect and we accompanied him on his first visit. We needed to dissect about a dozen of the plants of this protected species to ascertain where the beetle's mining larvae were, so we applied for permission and were allowed ten".

"Owing to the concentration of sulphurous glucosinolates in the plants' tissues, dissecting them was 'aromatically challenging' and best done out of doors. We were left with a pile of cabbage leaves. What better to do than cook the leaves up in butter and see what they tasted like? Triple-distilled essence of Brussels sprouts from the sulphurous glucosinolates: no-one took a second mouthful. Nonetheless we had developed a taste – for islands."

Anak from Rakata.

SE Asia

"In 1996 we joined Steve Compton on an expedition to Krakatau, led by Prof. Ian Thornton of La Trobe University, Melbourne, in our case to look at fig wasp colonisation after the catastrophic 1883 eruption. We camped on Rakata, part of the remains of the original caldera, where our campsite stores were persistently raided by huge monitor lizards, which even invaded our tents at night. We paid visits to the other island remnants, including the developing new young cone of Anak Krakatau, which was intermittently putting out the odd puff of ash. All was well until after we'd departed Anak at dusk and were 15 minutes back towards Rakata when Anak went up in what turned out to be one of its biggest eruptions for a long time. An ash cloud rose kilometres into the air, interlaced with a Venus' flower basket network of bright blue lightening and there were new lava flows and showers of volcanic bombs. There we were, speeding away in a small boat with the most spectacular view imaginable, but far too much in motion with the swell for any decent photography."

"After Krakatau we moved on to Mount Kinabalu on Borneo, again to look at fig wasps with Steve. The hostel at the base of the mountain had an outside light, which swarmed with exotic insect life. We ended up running a continual bug hunt for the tourists, lasting late into the night and, on retiring to bed, were repeatedly woken by knocks on the bedroom door by tourists who'd found yet more exotic creatures for us to try to identify."

BBC

In the nineties and early noughties, Roger became the BBC's regular TV and radio 'Bug Man' on *Countryfile*, *The Really Wild Show*, *etc*. and especially *Countryside Hour* and *Langley Country*, as well as being a general advisor on all things insect.

"*English Nature* 'hired me out' to the BBC for around a fortnight each year, with the proviso that I wore a brightly coloured EN sweatshirt when on camera. At long last Mum came to accept that insect conservation was a worthwhile career when I managed to infiltrate a stag beetle conservation project into *The Archers* on *Radio 4*."

Roger's media career considerably slowed when the BBC's Pebble Mill Studios closed, along with its Countryside Unit, which produced most of the programmes on which he worked. This was a great disappointment to Roger "because we were at the 'advanced concept stage' of a series whose working title was 'Bugg(er)ing around Britain', which would have highlighted what was special about the bugs in different parts of the country. It was designed to involve the amateur specialist entomologists who contribute so much to our knowledge of our fauna."

Children's Bug Safaris and Education

"Our kids' bug hunts which, these days, most people know us for, began at the Rutland Bird Fair in the late 90s. *English Nature* always had a stand there and our role was to take children and their Mums and Dads to a nearby meadow to see what insects we could find and chat about. These were a great success so, when *English Nature* ceased to attend the Fair in 1999, the RSPB asked if we would continue doing them for them, and EN 'loaned us out' for four days each year for 18 years. That's a grand total of 216 individual bug safaris, many attended by celebrity naturalists like Nick Baker, Mike Dilger, Johnny Kingdom and David Lindo. We've probably done twice as many again with other organizations and we've now got a 'family' of enthusiastic kids and their parents, whom we initially met on the events and have maintained contact with since. Some are now parents themselves and we've hosted safaris for their children."

"Invertebrates and education became the major part of my work. I became a taxonomy, ecology and conservation representative on one of the boards for the A-level and GCSE syllabuses, and was able, through *English Nature*, to support a total of 11 PhDs and 7 'MSc by thesis' projects on the conservation of invertebrates at four universities. I also became a regular or occasional external lecturer on invertebrate conservation at 13 universities, particularly at Leeds, Reading, London, Birkbeck and Anglia Ruskin, and with Oxford, developing on-line courses in wildlife surveying – all with EN's blessing. I also coordinated the invertebrate teams at *English Nature* and the *Countryside Council for Wales* to run 5-day-long courses in invertebrate conservation at the Snowdonia National Park study centre at Maentwrog for 18 years."

"When *English Nature* became *Natural England* I helped put together the role of Education Officer for the new organisation, my plan being to build on the work I had been doing and forge more links with universities and schools at both national and local levels, helping to put conservation at the heart of the education system. I became that Education Officer but, from day one, I found that my ideas clashed with those of *Natural England*'s CEO and the Director of Communications, both of whom wanted a Policy Officer for education rather than for NE to involve itself directly with the educational world. So, I was to become a grey suit, liaising with other grey suits at the *Department of Education* in London. Not for me. Eighteen months later, when the 2008 financial crisis necessitated 600 staff cuts at *Natural England*, I took a generous voluntary severance, intending to set up my own environmental education consultancy – perhaps not the wisest of choices in a major downturn."

South Georgia

"On my last day at NE I had a call from *Buglife* asking if I was interested in tendering for some survey work. As I really wanted my work to continue in entomological/

environmental education, I was about to decline when they added the magic words "in the Antarctic". An Overseas Territory Environment Project, looking for alien invasive invertebrates on South Georgia, within the Antarctic Convergence. My eventual tender included Rosy acting as unpaid assistant – the work could not be completed by just one person – and I got the contract."

"*SV Seal* was a yacht designed for high latitude sailing, which was chartered to take us and four botanists from Kew Gardens from the Falklands to South Georgia. We were well-prepared for very cold conditions, which we often encountered, but to our surprise the temperature sometimes rose almost to 30°C, a record high for South Georgia, and we observed much evidence of global warming in retreating glaciers and the spread of temperate European insects and plants. We set up Malaise, water-pan and pitfall traps, all of which were highly successful, although our moth trap was destroyed on its first night of use either by snowy sheathbills or Antarctic brown skuas, both highly intelligent, inquisitive and destructive pirates."

"While there, we charted the spread of an invasive carabid beetle which was predating endemic invertebrates and found a number of new European and South American invertebrates, including the first ever Antarctic breeding hoverfly, that had obviously made it to the island with assistance from human agency."

St. Andrew's Bay, South Georgia.

St Helena

"Three years after South Georgia, in 2011, we got a similar request to help set up a *Darwin* invertebrate conservation project for the multitude of endemic insects and spiders on St Helena in the tropical mid-Atlantic, the island with the biggest earwig the world has ever known. We jumped at it and again got the contract. This began a connection with the island which continues to this day. Initially it was a three-week scoping study, followed by briefly joining the newly-established project team of David Pryce, an entomologist from the UK, and Liza Fowler, an islander 'Saint' and self-taught entomologist, for six weeks in 2013. I returned in 2018 to participate in a workshop on management of the remaining cloud forest and its numerous endemic invertebrates and at last got to see the island's most famous living endemic species, the spiky yellow woodlouse."

Part of the already heavily-loaded project was to produce a guide to the island's endemics and it proved just too much. Roger volunteered to take it over and just over four years on *The Terrestrial and Freshwater Invertebrates on St Helena* is about ready to go to the printers. In 2016, another bout of financial cuts hit *Natural England* and more jobs had to go. Rosy joined Roger in 'early severance'. Since then they've worked together and are planning a 2020s programme of bug safaris, training events and maybe a return visit to Norway with Steve, 41 years on, to see if the insect fauna has changed with global warming.

If the Keys ever write their memoirs, they will make fascinating reading. Roger and Rosy are wildly enthusiastic ambassadors for the natural world; their drive and energy have been involved in many of the initiatives that now safeguard the British countryside. But their commitment to making a future generation aware of challenges and opportunities that they will have to face is possibly their greatest achievement. Long may excited questions continue to sweep through our meadows and woodland and long may this dynamic partnership continue to inspire both this and future generations to care for and enjoy what remains of this green and pleasant land.

Grant Reports

The Royal Entomological Society MSc Scholars 2019

Simon Leather

Professor of Entomology, Harper Adams University

The Royal Entomological Society has for many years provided scholarships to aid aspiring entomologists wishing to study the MSc in Entomology, first at Silwood Park and since 2012 at Harper Adams University. Thanks to its generosity, the number of students applying and taking up a place on the course has increased year on year. This year was no exception and we welcomed a bumper number of students to the University in September 2019. We are incredibly grateful to the Society for its support and it is an indisputable fact that the availability of these scholarships has helped swell the numbers of entomologists graduating in the UK. It becomes harder and harder to arrive at our decision, as the quality and number of the applicants increases every year. This year it was more a matter of deciding which of the excellent applicants to leave off our short-list. After much soul searching we picked the following from the very competitive field.

Here they are in their own words.

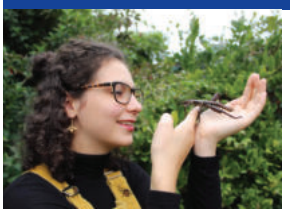
Guthrie Allen

I've had a life-long passion for science, evolution, wildlife and conservation which, over the years, has informed my choice of hobbies, the voluntary work I have done, the studies I have undertaken and even the food that I eat. Throughout that time, entomology has jostled for my attention along with botany, ornithology, mammalogy and general studies of ecology and evolution. However, entomology has always had the advantage of accessibility – insects literally fly and crawl into our lives. This I used to my advantage in fuelling the imaginations of children during my time as a wildlife club leader, many years ago (there's nothing quite like a menacing Devil's coach-horse up close). Even in my last job as a waiter in a Cornish beach café, I was able to show those around me the insects that flew through – the moths were a favourite: Rosy Footman, Scarlet Tiger and Hummingbird Hawkmoth. Entomology played a regular part during my undergraduate studies at the University of East Anglia. In Soil Sciences, I learnt of the key roles of insects and other invertebrates in facilitating soil metabolism. Throughout, I gained an appreciation of the power of insects, such as *Drosophila* and *Tribolium*, as model organisms in elucidating the workings of evolution. The needs of specialist insects in Europe became my focus whilst studying for *Biodiversity Conservation*. In *Community Ecology*, I developed a keen interest in the role that insects can play in agricultural environments as I researched the issue of feeding a growing global human population, whilst safeguarding the maximum biodiversity.

On finishing my undergraduate studies in 2016, I knew that I wanted to develop my skills in field surveying and species identification. My focus was still broad – I joined several societies, and assisted the Sussex Wildlife Trust's senior ecologist, together leading to surveys covering plants and animals – both vertebrate and invertebrate. It was clear that my insect identification skills needed work, so I also conducted my own survey of pond invertebrates. I identified them to family level, using a borrowed microscope, and developed an appreciation of insect anatomy along the way. Soon afterwards, in Cornwall, I became heavily involved in biological recording, starting first with plants and birds across the Land's End peninsula. However, it wasn't until reading the June 2018 issue of *British Wildlife* (Vol. 29, 321 – 327) that I realised I should make entomology my primary focus. In it, Patrick Saunders reports on his work to identify the conservation needs of the locally threatened Long-horned Bee, *Eucera longicornis*. To see that the work of one scientist could significantly impact the conservation of this species (and others) was inspiring to me and seemed only possible given that the species in question is small and has correspondingly local-scale conservation needs. After that moment, I put all my focus into developing my entomological skills. I invested in a x45 microscope and collected specimens across a range of habitats using nets, beating trays and pitfall traps. In September 2018, I conducted a survey of a local SSSI reserve, revealing 25 previously unrecorded species of Carabidae, aquatic Coleoptera and aquatic Hemiptera, the majority of which can only be identified by a specialist – or an amateur, like me, with a microscope and identification keys. It was during their identification that I realised how much I enjoy the flipside to entomology's accessibility – its obscurity, so I began to see entomology as a meeting place both for the things that I enjoy – enthusing others about wildlife, field and lab work, discovery – and for the things that are deeply important to me – evidence-based biodiversity conservation and its place within global food production.

By studying for a Master's in Entomology at Harper Adams, I've been given the chance to develop my lab skills, to expand my knowledge of ecological interactions, to explore conservation management solutions and to study the role of – and threats to – insect biodiversity in agricultural environments. Perhaps most importantly, I've been given the chance to undertake my own investigations in entomology as I work towards my dissertation. The receipt of this scholarship means a great deal to me. It has allowed me to undertake this course funded solely on the money I saved from waiting at tables. As such, I'll be able to graduate unencumbered with debt and have the financial freedom directly to pursue my goal – to become an entomologist working in the field of conservation.

Jennifer Jones



I have had a fascination for insects since I was young, from searching meadows for grasshoppers, or finding ladybirds harvesting aphids on our allotment bean plants, to watching bumblebees forage on our garden flowers. I am still adding insect specimens to the box I have from when I was younger, and I also look after eight New Guinea stick insects from the Natural History Museum. This fascination has now grown into a thirst for deeper knowledge and I am so grateful to the Royal Entomological Society for this scholarship, which has enabled me to focus completely on studying insects and their ecology.

Coming from an ecological background, insect conservation is incredibly important to me, especially as insects are affected by many anthropogenic threats and are often underrated in favour of charismatic megafauna. I am passionate to study entomology and help work against and maybe even reverse this decline.

In my spare time I transcribe data on Zooniverse and enjoy contributing to citizen science projects. At Aberystwyth University I attended the Penparcau Wildlife Group, alongside other frequent attendees including Buglife's Liam Olds and several other insect recorders. I picked up a wealth of knowledge through their surveys, talks and identification days. I have recently attended the AFON Now for Nature 2019 conference where I met fellow young conservationists and entomologists and developed my knowledge and my professional network. I have worked on improving my field skills through domestic and exotic field courses and biological recording in Shropshire, Sweden and Borneo, and from a recent ecological consultancy internship at a major engineering firm. I really enjoyed using different surveying techniques and being able to apply my knowledge in the field and I am looking forward to all the practical experiences I will gain from this MSc course. My experiences have reinforced my long-term goal of moving into a research-led career; choosing to study an MSc to undertake an independent research project was an important step towards this.

I was attracted to Harper Adams' MSc in Entomology because of the University's excellent reputation and industry connections, particularly to the Natural History Museum. The modules covered include a lot of my areas of interest; I am looking forward to deepening my knowledge of the ecosystem services which insects provide and developing habitat modelling skills. I am looking into taking an independent GIS course to help me begin a research-led career, and this scholarship will help me fund this. I am hoping to find an area within entomology to specialise in and look forward to developing ideas for my research project and possible further research.

I am incredibly thankful to the Royal Entomological Society for this scholarship. Through my undergraduate studies I was fortunate to be supported by my parents and Student Finance, however, I now need to be financially independent and this scholarship has allowed me to do this. The scholarship means I can attend conferences and improve my professional network and develop my knowledge of novel entomological techniques.

Charlie Rose

First and foremost, I wish to give my thanks to the Royal Entomological Society for awarding me one of the coveted bursaries available to MSc Entomology students at Harper Adams.

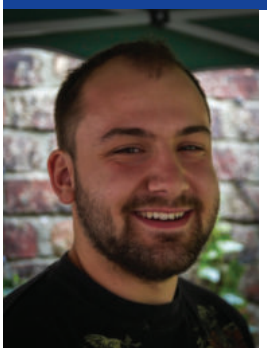
I've known that I wanted to study entomology since I completed my GCSEs, and before that I had always had a fascination with insects. Ever since I was able to crawl, I was known as "Bug Boy" by my family. The older I got the more I would wander off to hunt for insects, completely ignoring whatever family activity was going on around me. While volunteering at the Oxford University Museum of Natural History, I assisted Darren Mann with a project reviewing the conservation status of several British dung beetles. Under the mentorship of Darren, I cemented my plans to study entomology. Having worked with him at the museum and thoroughly enjoying the experience, I was reassured that it was indeed the right path for me.

There are several modules that are of particular interest to me, with 'Biology and Taxonomy of Insects' being uppermost, as I have done little insect dissection, and this is a skill I would like to develop. 'Ecological Entomology' is another module that I am looking forward to, with ecology being one of my main interests. I find the behaviours and interactions of insects fascinating, especially those of parasitic or socially parasitic species. Finally, the research project module is something I am greatly looking forward to, the dissertation module of my undergraduate course being the highlight of my last two years at Derby. I love coming up with research concepts and experiment design. Any chance I have of building on those skills would be amazing.

The Royal Entomological Society bursary is going to be hugely helpful in funding my living while studying at Harper Adams, as well as helping me to purchase resources and equipment that I want or need such as *The Ants of Central and Northern Europe* by Bernhard Seifert. Being severely dyslexic, owning my own copies of literature pertaining to the course and my own specific interests is of great benefit, allowing me to study them at my own leisure, without the constraints of library return dates and opening times. While I intend applying for a part-time job whilst studying, the bursary is going to enable me to concentrate on my academic progress rather than worrying where my next meal is coming from! As well as this, it enables me to attend more networking events and conferences such as the Verrall Lecture and Supper. Events like these are invaluable in gaining professional contacts in the entomological community.

I am ecstatic to be starting my entomological studies in earnest and can't wait to see what the year ahead has in store!

Louis Nicholls



My obsession with entomology stems from my childhood when I would always be catching and studying the insects from my surroundings wherever I went. Originally, I found insects interesting because of their intricate, beautiful design and immense diversity. After my A-levels and through my degree, my passion has led me to participate in a number of entomological projects. Firstly, I assisted Dave Goulson's PhD student Andreia Penado on a Solitary Bee project in Portugal. During the second year of my degree I improved my insect identification skills whilst identifying carabids for a Manchester Metropolitan University research project and subsequently taught a third-year project student carabid identification. I am also working for Dmitri Logunov, Curator of Arthropods at Manchester Museum, where I am re-curating and writing about the museum's Mantodea collection. Most recently, I completed my dissertation on the effects of savannah degradation on Kenyan mantid species and am excited to have begun the process of publishing it. To add to the excitement, there will be a new species and genus description coming from the collection that I made during the research.

The MSc in Entomology at Harper Adams is well-suited to my aspirations as a prospective entomologist for many reasons. I wish to understand fully the complex and skilful process of systematics, the hands-on approach with the 'Biology and Taxonomy of Insects' module will, I believe, guide me in understanding it with the necessary background and skill development to empower self-motivated study. The 'Insect Physiology and Behaviour' module explores an area which I haven't previously had the opportunity to study in detail due to its complex and specialist nature; the behaviour of insects as well as the complex functioning of their organ systems are so different, and arguably alien, from our own. I find this deeply fascinating and I'm excited to be delving into it at Harper Adams. The worldwide relevance and applications of the 'Biodiversity and Ecosystem Services' module is of great importance to me too. I look forward to being surrounded by like-minded enthusiasts in entomology and the expert teaching staff who, I anticipate, will maintain a steep and invigorating learning curve. I seek competence and confidence in my subject area and I believe that Entomology at Harper Adams will provide this through its thorough and committed approach to such a vast subject; I am deeply excited to learn entomology at the level of depth that will be provided by Harper Adams.

I am honoured to be awarded the RES scholarship; this will allow me to spend less time in employment to support myself and more time on my MSc, allowing me to be more consistently immersed in my studies and to dedicate more of my time to entomology, gleaning the full potential out of my Master's. It will also free up my finances enough to be able to dedicate more funding to the project module, hopefully allowing me to publish the findings. I see the MSc as the pivotal time in my life where I can put essential, concentrated effort into realising my dream of becoming an ecological entomologist and eventually making a significant contribution to the field.

Graham Smith

Following a two-week field course on centipedes as part of my undergraduate degree, I began to develop my fascination with insects and other invertebrates. They are always hidden in plain sight, participating in a world of complex interactions that I wanted to take part in understanding. I have completed research on glow-worm distributions, practiced invertebrate identification with the Field Studies Council (FSC), and shadowed invertebrate surveyors; however, I wanted to achieve a more comprehensive understanding of insects. Choosing the entomology Master's at Harper Adams was ideal for nurturing this understanding and will enable me to work towards a future in entomological research. The course also provides a platform to make valuable connections with others who have similar interests, and is a course with a clear focus on engagement. This was important for me as I find it incredibly valuable to share my enthusiasm for what I have learnt with others, and I wanted to have the opportunity to communicate science both in and beyond the academic circle.

Two modules I am most interested to take part in are 'Insect Behaviour and Physiology', and 'Ecological Entomology'. I am particularly keen to learn more about how insects interact with their environment, and how their form and function enable this. There is an increasing need to understand the role of individual species and their groups within ecosystems, and I find that learning about each piece of the puzzle is ever more rewarding. When conducting my research on glow-worms, there was so much mystery and reliance on anecdotes, and this left so much open to query, even for a single species, and filled me with a great sense of wonder. As such I am also looking forward to the research project. The opportunity to be a part of answering relevant questions and to produce publishable science will be difficult but rewarding, and I am eager for the challenge. The project will also give me relevant experience as I aim to move forward into research.

It is an honour to receive the RES Scholarship, which will allow me to purchase key equipment to develop my learning beyond lectures. I currently have a basic field microscope, which has not been sufficient for a lot of species-level identification, and having the funds to purchase my own stereomicroscope will be incredibly valuable. Furthermore, the scholarship will enable me to purchase keys for groups such as the ichneumonid wasps and textbooks for further reading. This, in conjunction with a microscope, will allow me to improve my identification skills for the groups I aim to study. The scholarship will also make it possible to attend further courses with the FSC, particularly courses on botany which, while I am learning in my spare time, will benefit me from formal training. Overall the scholarship will give me a greater ability to explore my interest in and beyond my course, allowing me to obtain the tools and skills I need for a future in entomological research.

Competitions

RES Garden Redesign

Luke Tilley
Chief Executive

RES Council would like to thank all the entrants of last year's RES Garden Design Competition. Each entry provided excellent and innovative ideas for the future of the gardens and the trustees are proud to publish an abstracted summary of the winning entry. It was agreed that the winning entry offered exciting concepts that were sensitive to the existing site and landscape. Particular attention was also given to the need to fulfil the Society's charitable aims for public benefit.

Council will now work with the winners in consultation with professional gardeners to develop the garden for the benefit of insects and the Society's activities. The full submission with references can be viewed at www.royensoc.co.uk/garden.

Winners: Peter Harper and Stuart Reynolds

Rationale

Our basic idea is that the RES's new garden in St Albans, the former Royal National Rose Society's formal rose garden, should be redesigned as an entomological teaching and research facility, with the majority of the existing planted areas converted into a demonstration garden in which contrasting management schemes to encourage insect biodiversity can be tested.

To this end, we divide the RES garden into three basic divisions, as well as a large pond, each with a distinct management regime and concomitant ecological differences, as shown in the zoning map (Figure 1). Insect populations can be compared between these basic divisions, which will provide an opportunity for the systematic investigation of factors that have been hypothesised to improve insect populations in gardens. This broad division scheme will probably be best for highly mobile insects such as butterflies, but we also propose to establish temporary "patches" within some of these basic divisions in order to test more local management effects. This will be more suitable for looking at less-mobile insects such as leaf and flower beetles, aphids, plant-hoppers, soil insects, etc.

We envisage that the new RES insect-garden will not be open to the general public but will be extensively used by school groups on day-long field trips; we also suggest that the garden will be used by visiting groups of professional and serious non-professional gardeners.

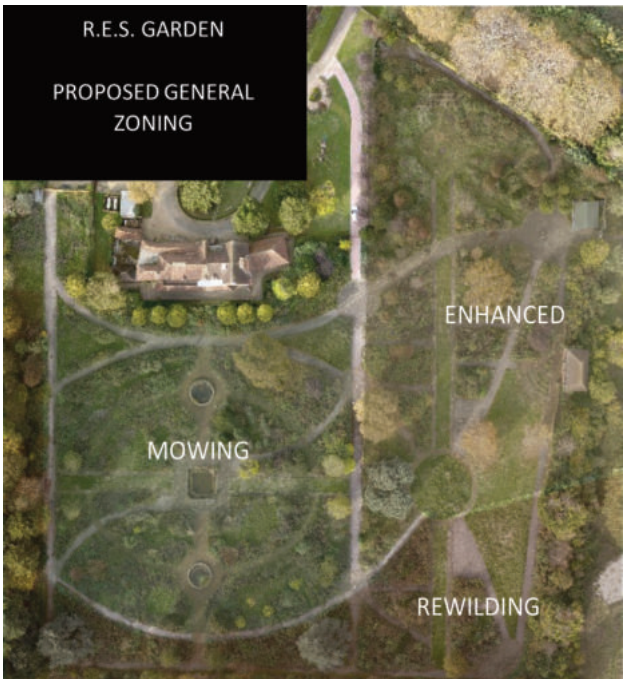


Figure 1.

The plan

THE EXISTING SITE

There are some fine trees that ought to be preserved in any reorganisation, notably

- A large lime near the Mansion House building
- A weeping birch with circular seat
- A grove of cypresses casting dense shade
- Silver firs
- Copper beech.

There are also 'sentinel pairs' of mulberry and fastigiate copper beech marking the ends of the cardinal avenues, and many tall trees along the boundaries. On the northeast, beyond the boundary fence, there is dense stand of large sycamores (Figure 2).

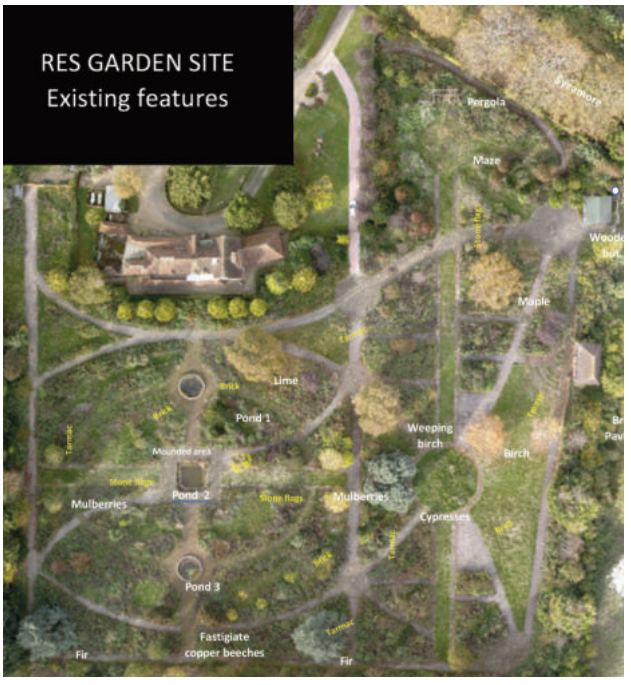


Figure 2.

The site is almost completely flat, aside from a small mound east of the northernmost pond. The ponds themselves are differentiated, with some unusual plants.

THE GENERAL APPROACH

Our aims in redesigning the garden were as follows:

- Maximising habitat diversity
- Creating resources for both teaching and research
- Minimising both establishment and maintenance costs
- Maintaining a light-touch 'managed garden' feel.

SIX KEY RECOMMENDATIONS

- Keep most of the paths and large trees
- Some "rewilding"
- Create large areas of mown grass, subject to different mowing regimes
- Establish a single area of visually attractive ornamental planting of perennial plants in the "Oudolf style", using species known to be attractive to insects
- Establish a zone of "enhanced insect habitat"
- Remove existing ponds, replacing these with a single larger new pond

ZONES AND HABITAT DIFFERENTIATION

We feel the garden offers great opportunities for both teaching and research. Essentially, it can be divided into zones with different maintenance regimes, which could offer habitat differences helping to answer some of the questions about insect populations and biodiversity (Figure 1). We are particularly aware of the work of Jane Memmott HonFRES and others showing substantial differences between land-uses at scales in the range of 0.1 to 10 hectares (Figure 3 for garden dimensions). The RES garden site could be used to test these highly suggestive results (Baldock et al., 2019).

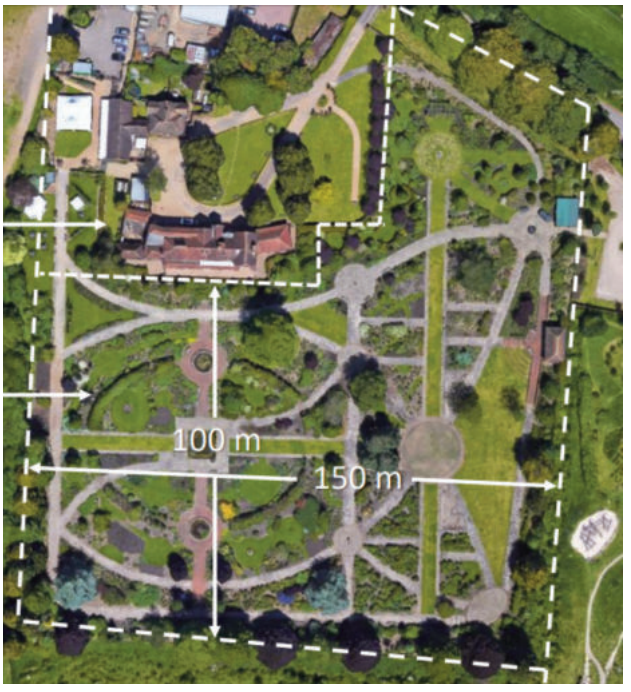


Figure 3.

From the perspective of zoning, the existing layout of paths seems entirely suitable to neatly separate one zone from another, while providing access and occasionally a 'distant vista'.

We are aware that there are limited funds for both reconstruction and maintenance. Consideration of both cost and habitat creation suggest three broad zones:

1. 'Rewilding', essentially managed neglect, applied to a broad swath around the boundary. This is the lowest-cost option both for establishment and maintenance.
2. An area of mown grass could be created in the flat western half of the site, replacing the formal rose garden. This is more expensive to create and maintain than rewilding, but still relatively cheap. It offers possibilities for variation in terms of formal research.
3. A third zone might be labelled 'enhanced insect habitat', where efforts are made deliberately to create a variety of attractive habitats and food sources. This will be the most expensive to set up and maintain, but perhaps the most valuable. We suggest a location in the northeast area of the site.

The approximate locations of these zones are shown in Figure 1. It should be noted that the area occupied by each zone can be adjusted to suit the budgets.

REWILDING

This area (marked K in Figure 4) would embrace all the boundary trees and larger areas between main paths and the boundary. Much of the area can already be considered semi-natural woodland, although with a large proportion of 'edge'. Paths can be maintained to provide access for observation and sampling.

Maintenance measures would consist essentially of keeping access routes open, perhaps occasionally felling trees that might be dangerous to visitors, but of course any felled timber can be left *in situ*.

Figure 4: Proposed transfer of soil is shown by dashed arrows.

Some of the proposed rewilding area is currently mown grass, and this could either be allowed to proceed with a natural succession or be deliberately replanted with trees. Simple neglect will generate the 'revert to scrub' pattern over the first ten years or so, with coarse grasses and saplings, and this is perhaps an evolving habitat in its own right, worth monitoring.

An alternative possibility is that the currently-grassed area could be replanted with traditional coppice trees, and coppiced from time to time. This is an additional maintenance task but not difficult and suitable for (say) visiting school groups. Coppice is famously biodiverse and could make a useful addition to the habitat portfolio of the site (H in Figure 4).

We are keenly aware of the great value of decaying timber and smaller items of wood for many species of insect, especially Coleoptera, which are associated with the saprophytic fungi that exploit this resource (see for example Orledge and Reynolds, 2005), some species of which are nationally or absolutely rare and of high conservation value. We would recommend consultation with an expert in this field before finalising plans for this zone. In general however, the key to management of this area will be "not too tidy".

MOWN GRASS

Fine mown lawns tend to be depauperate in biodiversity terms, yet can be made much more interesting through selective mowing. Open grass is an agreeable sight, and useful for school groups to run about, let off steam, and picnic (A in Figure 4). Seed mixes can contain low-growing nectar-rich species such as clovers and medicks that will flower between mowings. Some areas can be infrequently mown, generating much longer grasses that provide habitat and egg-laying sites, especially for Orthoptera and Lepidoptera. The grasses can be allowed to flower, and of course 'wildflowers' will turn up on their own. If these areas have crisp mown edges and 'rides' through them they appear attractive and deliberate.

Well-maintained grass areas create a managed look, but we wondered whether there should be additional areas with standard garden-style planting. Traditional herbaceous borders are too labour-intensive, but possibly the dense tall-plants style (many of them grasses) associated with the Dutch designer Piet Oudolf might be considered. This is relatively easy to maintain, and provides a flourish in the latter half of the year. Early interest can be added with spring bulbs. Such an area, or areas, would add a touch of glamour.

As practiced by Oudolf, the selected plants are to be planted in drifts. A modification from Oudolf's normal practice could be to use the paths to separate the plants, so as to be quite clear about which plants are associated with which insects. The kinds of plants we have in mind here will be (early summer) geraniums, irises, campanulas, salvias; (high summer) *Kniphofia*, yarrows, agastaches, *Rudbeckia*; and (late summer) sedums, Michaelmas daisies, Japanese anemones etc.

Forb-rich areas can also be maintained by mowing, providing less controlled but rich sources of pollen and nectar.

An obvious area for re-grassing is that on the western side in front of the house. It is flat, with few trees, one small raised area and three ponds. The ponds are problematic because in the long run they will probably leak and require expensive maintenance. Our suggestion is that at least two of the ponds be removed, perhaps all of them, and the areas cleared and re-sown to grass. Rubble, foundations and broken masonry can be transferred to the 'mound' (see below). Ashlared stone can be re-used to create vaults within the mound, stacked for use elsewhere, or sold to defray costs.

Most of the paths in this area can be retained, with minor repairs, creating grassy 'parterres'. The small raised area near the northernmost pond is a candidate for the Oudolf-style planting, creating a conspicuous feature with plants taller than an onlooker. The area can of course be extended, but establishment is inevitably expensive.

ENRICHED HABITAT

There is great scope for imaginative contributions here, because there are many potential garden features that provide food, shelter or habitat for one species or another, and of course there are very many species.

We supposed that the best place for this zone would be in the northeast section, which would also contain the entrance, study and lunching facilities, and an all-weather workspace. It is where most insects would exist and where they are the most observable to visiting groups.

The central feature must inevitably be a largish pond (F in Figure 4), specially designed for habitat enrichment and replacing (or at least complementing) the existing formal ponds. It would be designed with suitable features such as deep and shallow areas, open and shaded areas, muddy banks, a large 'wetland' area, islands, rafts etc. It would be provided with suitable 'starter' plants but others would inevitably arrive. Monitoring of the 'succession' and colonisation would be an attractive project in its own right.

The pond should also be designed with observers in mind. One obvious feature is to provide jetties projecting from the sides just above the surface level. A wide jetty can create a darkish space underneath, that can be observed via suitable holes in the jetty surface, but of course the edges provide plenty of scope for on-the-belly observation. Well-placed mirrors can provide sideways views. In the wetland areas, a simple boardwalk will be enough, a good place for close-focus binoculars.

There are Health & Safety implications here (as elsewhere). Works on the site will have to conform to the most recent edition of the Construction (Design and Management) Regulations, but there is some room for compromise provided that risk assessments are properly made. An alternative to jetties is the creation of a spur or dike between two pond areas, or even two separate ponds.

Creating a pond can be expensive, and its size might be determined by the available budget. There would be a considerable volume of spoil, but this might be turned to advantage as part of an artificial hillock or mound. This creates habitat diversity by presenting a lighter, drier side and a darker, damper side, and these features can be exaggerated by various kinds of profiling and planting. Indeed a mound can incorporate burrows or caverns which remain cool, dark and moist all year round, favouring many insect species. The mound can receive contributions from surplus material arising from construction or demolition work in any part of the garden, avoiding trucking and waste-handling charges.

The habitat enrichment area can contain all manner of specific facilities for different species, such as 'insect hotels', hollow stems of various kinds, dry stone or brick walls, piles of logs, decaying tree stumps, leaf litter, compost and other decaying organic matter. These can be inexpensively created on site using second-hand industrial softwood pallets.

Honey bees can be encouraged with regular hives designed for honey collection, but possibly a natural comb in a small dedicated, darkened shed is more interesting to observe. It might also be possible to channel bees returning to the hive through a transparent tube to observe the various colours of the pollen being collected. To achieve this, it will be essential to establish links with one or more local beekeepers' associations. Our experience is that beekeepers are only too keen to help. There are some liability insurance implications of keeping beehives on site, which the Society would need to investigate.

Many insects feed on nectar and pollen, and a regular supply must be provided throughout the year and, equally important, throughout the day. This requires a considerable area of flowers carefully chosen for the timing of their flowering periods and accessibility to different kinds of insects. Traditionally this is done on a fairly hit-and-miss basis through the 'wild-flower meadow' whose main role is to provide humans with an agreeable spectacle. There is nothing wrong with this, but it will be more of a challenge to design a suite of species aimed at insects rather than people.

There is probably a need for more careful choice of plants that are traditionally considered to enrich habitats for insect pollinators. The emphasis here would be on compiling a list of plants that would provide resources for pollinators all year round, and also around the clock. This part of the garden is not envisaged to be subdivided into patches for statistical comparison, as most of the attracted pollinators will be highly mobile flying insects. The RHS publishes long lists of suitable plants and the final list of those to be planted here could be taken from these. The final selection of plants would be made on the basis of soil testing and trial plantings.

Nectar- and pollen-bearing plants need soil nutrients to flourish, yet if these are provided too abundantly many valuable plants are outcompeted by wind-pollinated forms such as docks, nettle and grasses. For this reason, it is desirable to reduce nutrient levels commonly found in topsoil, usually by removing the top 10–20 cm and sowing flower-seeds on the underlying subsoil. Another approach has been to introduce semi-parasitic species such as the yellow rattle (*Rhinanthus minor*) to weaken the grasses, but this parasitic plant too has its own preferred conditions (it is shade intolerant, for example, and doesn't cope well in long grass) so that it isn't a failsafe option to use it to facilitate the establishment of a flower-rich sward. Indeed, to investigate the impact of yellow rattle on insect diversity itself offers another research opportunity.

The construction process might be able to deliver some of this reduction in fertility without greatly altering the levels. Topsoil can be removed both from the pond area and from the wildflower area and used to make up levels in the area of the demolished ponds, or contributed to the multi-functional mound. Further excavation of the pond will generate subsoil that can be spread on the wildflower area. This will require careful planning and phasing.

The garden and the Society's aim

We suggest that research into the effectiveness of insect-garden design and the associated outreach activities, as well as the use of the garden to enhance entomological awareness among school children and university students, is eminently suited to the RES's charitable aim (the stated aim of RES outreach is to promote and increase public understanding of entomology as well as to improve the diffusion of entomological science and contribute to science education as a whole).

Peter Harper is a member of the Royal Entomological Society. He is a graduate in Zoology of the University of Exeter, and undertook postgraduate research in the molecular basis of learning at the University of Sussex before leaving to establish (with others) the Centre for Alternative Technology at Machynlleth, Wales (www.cat.org.uk). He worked at the Centre for many years, took special interest and responsibility in the Centre's gardens and grounds, and is the author of *The Natural Garden Book* (1994). He is also a tireless campaigner for Environmental Action, and is co-author of *Zero-Carbon Britain*. He is currently a Visiting Lecturer at the University of Bath.

Stuart Reynolds is a Fellow and former President of the Royal Entomological Society. His first and second degrees (Natural Sciences and Zoology) are from the University of Cambridge. He did postdoctoral work at the University of Bristol, and was a Harkness Fellow at the University of Washington in Seattle, USA, before returning to a lectureship at the University of Bath. He is currently Emeritus Professor of Biology at Bath.

References

Baldock et al. (2019) A systems approach reveals urban pollinator hotspots and conservation opportunities. *Nature Ecology and Evolution* https://doi.org/10.1038/s41559-018-0769-y

Orledge, G.M. and Reynolds, S.E. (2005) Fungivore host-use groups from cluster analysis: Patterns of utilisation of fungal fruiting bodies by ciid beetles. *Ecological Entomology* **30**, 620-641.

Profile

Manuela Carnaghi

– Postgraduate Rep Profile –

I have to confess, my experience with insects is not very broad! I graduated from the University of Milan (Italy) in Biology (with Hons) and then I continued my studies with an MSc in Biodiversity and Evolution. I never paid too much attention to insects, partially due to the fact that neither of my two degrees offered any courses that focused on entomology. Sure, I was convinced that insects played an important role in our ecosystems, and every now and then I discovered some interesting facts about them, but that was about it!

I started to become more interested in insects when I discovered my fascination for parasites, especially for tropical diseases, which in many cases are transmitted by arthropod vectors. After my studies, I undertook several courses on tropical diseases and I worked in Mozambique as an Assistant Project Manager on a food security project, focusing on reducing malnutrition in pre-school children. In September 2018 I began my doctoral studies at the Natural Resources Institute (NRI), University of Greenwich, focusing on the sensory synergies displayed by malaria mosquitoes during host-seeking behaviour.

Since I started my PhD, I felt that I needed to broaden my knowledge on insects, and with a colleague, we started a weekly meeting where we cover different groups of insects and talk about their peculiarities. So now it's safe to say, I have become completely engrossed by insects! I am excited to be one of the RES PG reps and I'm looking forward to the upcoming postgraduate forum in February 2020!

SCHEDULE OF NEW FELLOWS AND MEMBERS

as at 4th December 2019

New Honorary Fellows
None

New Fellows (1st Announcement)
Dr Simon Tristram Segar
Dr Alasdair Justice Nisbet
Dr Mathyam Prabhakar

Upgrade to Fellowship (1st Announcement)
None

New Fellows (2nd Announcement and Election)
Dr Federico Lessio (as at 2.10.19)

Upgrade to Fellowship (2nd Announcement and Election)
None

New Members Admitted
Dr Christos Georgiadis (as at 2.10.19)
Miss Beatriz Monteagudo-Santesteban
Professor Stephen Holding
Mr Ray Gabriel
Dr Trisna Tungadi
Miss Christina Mitchell

New Student Members Admitted
Mrs Sherry Morgan Janse Van Rensburg
Ms Claire Hewitt
Mr James Emrys Illingsworth
Mr Louis Gabriel Aaron Nicholls
Mr Guthrie Allen
Mr Mark Wrathall
Mr Graham Smith
Miss Jennifer Jones

Re-Instatements to Fellowship
None

Re-Instatements to Membership
None

Re-Instatements to Student Membership
None

Deaths
Mr C.L. Nissen, UK, 1956 (as at 2.10.19)

We are sad to report the death of Dr Peter Bateman, pest control legend and former Head of PR with Rentokil. An account of his life in pest control can be found at https://bpca.org.uk/News-and-Blog/remembering-peter-bateman/242978, courtesy of The British Pest Control Association, of which he was a former President.

Reviews

Embiopteran Tools revisited

Craig Macadam

Conservation Director, Buglife

Back in January 2002 I started writing regular articles for *Antenna* called *Embiopteran Tools*. The purpose of these was to provide readers with reviews of technology and websites of use to entomologists. In the intervening 17 years much has changed. For a start, I'm writing this article on my smartphone, which has eight times as much storage space as my PC back in 2002! When Richard Harrington asked me to resurrect *Embiopteran Tools* I was reluctant as there are so many websites, apps and technologies now that selecting a small number seemed rather futile. As a compromise I thought that I'd look at the phone apps that I use regularly. These can be split in to three categories: weather apps; mapping apps and recording apps.

Whither the weather?

Much of my entomological research focuses on aquatic insects and the impact of climate warming in the uplands. My 'go to' weather app is *XC Weather*. I've been using this for years, and before that I'd rely on their website (www.xcweather.co.uk). I've always found their forecasts very accurate and the app interface is clear and easy to use. I also use *RainToday* (www.raintoday.co.uk) if I quickly want to see if there is any rain on the way in the next hour or two. If I'm looking at potential rain or snow arriving over a longer period, I find *SailDrone* (www.saildrone.com) indispensable. This app delivers forecasts of wind, precipitation, temperature and cloud cover for anything from 3 hours to 72 hours in the future. Importantly, the animations also show where the weather is coming from – essential if you're heading into the hills.

If, like me, you are interested in all things aquatic then you need to know whether rivers are likely to be safe to sample in. Fortunately, data from the UK river gauging network are available through the *RiverApp* (www.riverapp.net). This provides near real-time information on river heights for the whole of the UK. Of particular use is the ability to look back at data from the last two days, which allow you to see whether the river is rising or falling. For £7.99 you can unlock options to look at flows for longer time periods; however, flow data for three months are available free at www.gaugemap.co.uk, which also provides images from the growing number of river webcams.

Location, location, location

Okay, now that we've got the weather sorted, we need to look at where we're going.

Years ago, I purchased the *ViewRanger* app (www.viewranger.com) and *Landranger* map coverage for the whole of the UK. At the time, this package cost over £100 but now for less than £25 per year you can have access to the full Ordnance Survey (OS) leisure map series. The OS produces some of the best maps in the world so it makes sense to take these maps with you on your tour phone or tablet. The *OS Maps* app (www.ordnancesurvey.co.uk/shop/os-maps-online.html) provides a paid-for service that also gives access to the full range of *Landranger* (1:50,000) and *Explorer* (1:25,000) maps. If you've recently bought a paper copy of an OS map, look out for the QR code on the inside cover which will give you free access to the digital version of the map through the app. Another excellent app from the OS is *OSLocate* (www.ordnancesurvey.co.uk/shop/os-locate). This turns your phone into a simple GPS with a compass dial, grid reference and altitude reading. A really neat feature is that you can use an overlay of the compass on the built-in phone camera app to allow you to take a bearing from a paper map.

Two other apps that I use when planning my fieldwork are both from the British Geological Survey. The first, *iGeology* (www.bgs.ac.uk/igeology), provides geological information for the whole of the UK. You can select to look at either superficial or bedrock geology, or a combined view. By selecting a point on the map, you are provided with a brief description of the geology at that point. Similarly, the *mySoil* app (www.bgs.ac.uk/mysoil) provides information about the soils beneath your feet. By selecting a point, you are presented with information on the soil pH, annual and monthly soil temperatures, soil depth, soil texture and soil parent material. Finally, a very basic indication of land use at the point is given.

Put it on the record!

When it comes to wildlife recording there's only one app that I use. The *iRecord* app (www.brc.ac.uk/iRecord) is simple to use and makes sure that my records are sent to verifiers and to the NBN Atlas (www.nbnatlas.org). I've used the *iRecord* app in all sorts of habitats – in the middle of a river, at the top of a mountain and even in caves. The beauty of the app is that you don't need a mobile signal to use it – any records you make while in a signal blackspot are uploaded to *iRecord* the next time you have a mobile signal.

If you need to collect more detailed information than is possible in the *iRecord* app, then you could try *EpiCollect* (https://five.epicollect.net). This allows you to create bespoke forms for collecting information. The form builder takes a bit of getting used to but once you master it

you can add fields to collect date/time information, photos, location details, scan barcodes and enter text. Once you've completed your form you can publish it or receive a link to send to those you want to use it.

And finally….

If you're like me, you have probably amassed a large collection of books. Fear not, the *LibraryThing* app (www.librarything.com) will help you keep a record of the books in your library. Simply scan the barcode on the book or enter the ISBN number and the app will populate the record with the details of the book, including an image of the cover. Scanning a full bookcase doesn't take too long and, if you have some obscure publication which the app can't find, you can enter the details manually. Once completed, you can go online to analyse your catalogue or export it to different formats.

Editor's note

This all looks fantastically useful to me. I have not asked Craig to resurrect his column in perpetuity, but I hope very much to hear from *you* about apps you use in your entomological pursuits. Contributions will be published alongside book reviews, space permitting. RH.

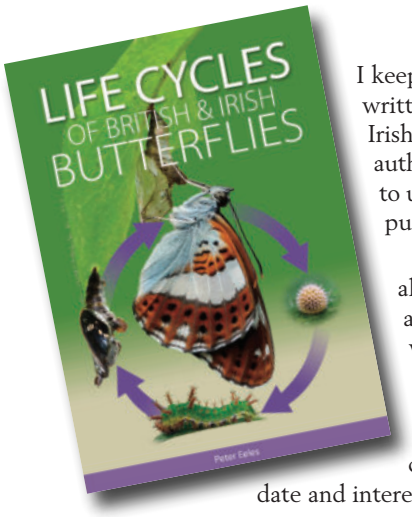
Life Cycles of British & Irish Butterflies

Peter Eeles

Pisces Publications, Newbury, 400pp

ISBN 978-1-874357-88-9

£35.00



I keep thinking that every book that could be written about British and Irish butterflies has been written. Wrong. I also keep thinking that I know most of what there is to know about British and Irish butterflies. Wrong again. This book is in a league of its own and the result of the quest of the author to photograph every life-stage of our 59 species, including each larval instar, and his passion to understand their biology and ecology. I was particularly awe-struck by some of the pictures of pupae just prior to adult emergence, with the wing colours shining teasingly through.

After a short foreword by the ubiquitous Chris Packham, a preface, introduction and alphabetical list of the vernacular names of larval food plants with their Latin binomial alongside, the book covers the species family by family. Each family has a two-page overview where common characteristics are highlighted. Particularly useful are the tables of subfamilies and the lists of species therein. The first page for each species has a photographic diagram of the life-cycle together with a typical habitat shot and a time-line for the four life-stages. This is followed by detailed accounts of the distribution, habitat, conservation status and life-cycle, the latter being the unique selling point, although the others contain a wealth of up-to-date and interesting information.

I am going to risk embarrassing myself by pointing out just ten of the many fascinating facts of which I was unaware.

1) Swallowtail pupae are able to survive submersion in water for long periods.
2) Adult skippers have 'eyelashes'.
3) Dingy Skipper larvae can fire their frass more than a foot.
4) The upward pointing abdomen of female pierids is usually a signal of rejection of a male rather than an offer of copulation.
5) Five of our fritillaries are heliconians ('long-wings').
6) Female Speckled Woods play dead when rejecting the advances of males.
7) Small Heaths sometimes open their wings briefly when at rest to assess temperature. I have never witnessed this, let alone got a photo.
8) The *valesina* form of Silver-washed Fritillary is dominant and the form is rare partly because it is less recognised by males.
9) The Purple Emperor requires neither woodland nor oaks.
10) This is perhaps my most uncomfortable admission. I didn't realise that the Riodinidae (represented only by the Duke of Burgundy in this Country) is closely related to the Lycaenidae and not, as I had always presumed, to the Nymphalidae.

So, thank you, Peter, for putting me right on these and other points.

This is the most extraordinary labour of love and a gift to all lepidopterists which should be snaffled up with great gratitude. I do hope that the author is extremely proud of his astonishing achievement and can now reduce his butterfly miles and have the occasional lie-in.

Richard Harrington

Protecting Pollinators: How to Save the Creatures that Feed Our World

Jodi Helmer

Island Press

ISBN 978-1-610919-36-4

£20.99

It is certainly no small feat that the author, Jodi Helmer, has set out to achieve. To condense the debate on pollinator decline into a sleek 176-page volume is an ambitious undertaking. *Protecting Pollinators* focuses predominantly on issues faced in the USA, drawing first-hand accounts from researchers, conservationists and concerned citizens alike. Helmer engages the reader by recalling nostalgic imagery of flagship species, such as the regal Monarch caterpillar plumping-up on native milkweeds or the vibrant broad-tailed humming bird busily foraging in the floral-rich gardens of yesteryear.

The book begins by transporting the reader to the author's homestead, where she tends colonies of honeybees, introducing the author herself, explaining how her interest in pollinators was piqued and how the idea for the book was born. The subsequent chapters explore all manner of anthropogenic pressures impacting pollinators, from landscape heterogeneity, lethal and sublethal effects of chemical pesticides, to the complex ecological shifts being driven by a changing climate. The book also includes supplementary text boxes with informative titbits and engaging anecdotes, which perhaps wouldn't have found a home elsewhere in the text, but nevertheless have a deserved place in the book.

Helmer doesn't just focus on the causation of these issues, but there is emphasis on the effort invested in ameliorating the observed declines. The book is full of first-hand accounts of those who manage pollinator gardens, have helped to lobby for pollinator corridors, or have ditched their dependency on commercial hives in favour of conserving and harnessing natural pollination services. She ventures into the complexities of uniting research with strategy and delves into the difficulties involved when livelihoods are on the line and big business has a vested interest. Furthermore, Helmer navigates the maze of pitfalls which can capture those who are often the most willing to help. She forewarns the overeager of falling victim of "loving pollinators to death", by the provision of resource out of season which can lead to abandonment of migratory behaviour, the release of captive reared pollinators such as Monarchs, or the increase of apiculture and number of honeybee hives. Helmer instead encourages education and a sound understanding of pollinators' life histories, advocates connecting with organisations which hold annual plant sales focused on the requirements of local pollinators for effective habitat creation and raises a strong case to engage with citizen science initiatives.

Perhaps in part due to the slimline nature of this book, or to appeal to a wider audience, the translation of research findings is offered as condensed snippets, often isolated from their wider context. I frequently found myself with appetite whetted, eager to dive into the original research article, but only to be left high and dry. With no citations in the text and instead having to rifle through a long bibliography, finding the original research is more challenging than it ought to be. No doubt the book would benefit from the use of a numeric citation system, allowing the reader to easily immerse themselves within the subject and to freely explore the research in its original context.

Nonetheless, as an introduction to this expansive topic, the book certainly gives a good overview of some of the most pivotal points. Perhaps more critically, the reader is left with a sense of empowerment to help mitigate the issues contributing to pollinator declines. The take home message is simple: global pollinators are suffering under increased anthropogenic pressure and we all have a part to play in their salvation. As consumers, gardeners, or parents and educators of the next generation, it is vital that action is taken to help protect these species to which we are indebted for our survival. With a growing number of initiatives, it is becoming easier to make informed decisions, engage with citizen science and not to forget to do our bit to support the long-nosed bats and raise a glass or two of TIPs-certified bat-friendly tequila.

Alice Mockford

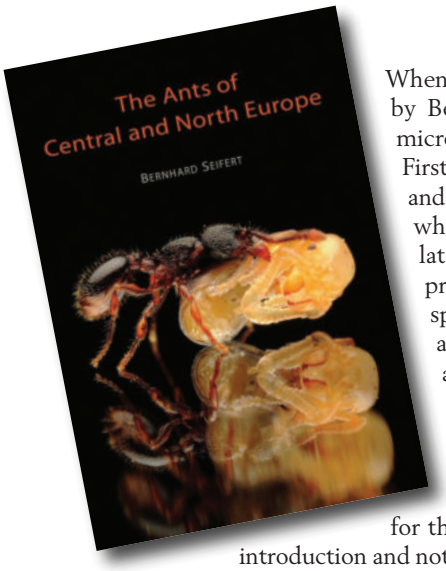
The Ants of Central and North Europe (English ed.)

Bernhard Seifert

Lutra

ISBN 978-3-936412-07-9

£64.99



When I was a PhD student I remember attending a seminar, I think in Granada Spain, delivered by Bernhard Seifert in which he discussed the various pros and cons of different types of microscopes for fine-scale measurement of ants. I was struck by two things during that session. First, here was a man who very clearly knew his ants! Second, it was very obvious that precision and accuracy were hugely important. With those thoughts in mind I knew exactly what to expect when his book *The Ants of Central and North Europe* came through my letterbox some 20 years later. I was expecting a book that would be as complete as it would be possible for it to be, precise in its approach and accurate in the information it provides. I have to say that, having spent some time going through the book, I was not disappointed. To that list, though, I can add that the book is highly usable, very pleasingly laid out, beautifully illustrated and absolutely loaded with interesting information.

The first 60 pages or so provide a wonderful introduction to ants, from their morphology through to their ecology. The broad range of ecological interactions is skilfully explored, providing an excellent level of detail but avoiding becoming bogged down in any particular area. Congratulations should go to Elva Robinson, who provided the English translation for this section. I defy anyone, no matter how much they know about ants, to read through the introduction and not learn something new. Some beautiful photographs, many of which were taken by the author, accompany this section to great effect.

The main body of the book starts with some detailed and technical information on collecting ants, storing and mounting specimens and microscopy. There is a table of the species covered and a fabulously detailed and useful table showing the environmental factors (temperature, soil humidity, plant density and so on) associated with each species. Following a useful discussion of species definitions, the book moves into more traditional territory with close to 70 pages of well laid out and nicely illustrated keys. Of course, assessing keys is a job best done with a specimen or two in front of you but where many keys use vague and sometimes confusing terms such as "short" or "long", Seifert provides actual measurements (including statistical error and sample size associated with those measurements). I can well imagine this key becoming indispensable for anyone studying ants within the geographical range of the book.

For me, as good as these early sections are, it is the 200-odd pages devoted to life histories and profiles of the 180 ant species within the range of the book that really puts Seifert's work into a class of its own. Each species has a profile, often extending to a full page or more that includes photographs and detailed notes covering taxonomy, habitat, abundance, nest construction, colony demography, population structure, sexual forms, mating, colony foundation, nutrition, behaviour and morphometry. Where knowledge is lacking on any topic, the topic remains but is filled by "Not Studied". Once you get your eye in for the headings and the structure of these sections it becomes very quick and easy to scan through and find the information you require. To say that this section of the book is loaded with detail is an understatement. For some species described, full morphometric data are provided, a one-stop shop that will be invaluable to many, although to those less familiar with the range of measurements used to define the morphology of ants, a regular trip to the acronym section at the back will be required.

There are many little points that make this book much more approachable and useable than it could have been given the scope and scale of the task Seifert undertakes. The book is a good size – a "handbook" format – and the text is set in a pleasing font. The headings in the species profile section are highlighted in red text in a way that makes them very easy to find on the page. Likewise, the glossary and the explanation of acronyms are easy to navigate and contain entries that are concise, precise and helpful. As one might expect, there is an extensive reference list of more than 1000 sources. If you are serious about ants then this is one for the bookshelf. Even if you aren't I still recommend it simply for the pleasure of soaking up some of the information and looking at the photographs.

Prof. Adam Hart

Obituary

Professor Tecwyn Jones

CMG, OBE, FRES, CBiol, FRSB

Dai Jones

Professor Tecwyn Jones, Honorary Fellow and former Vice President of the Royal Entomological Society, died suddenly on 12th November 2019 at the age of 90.

Tecwyn Jones, affectionately known as "Tec", was a proud Welshman, born in the small coal-mining town of Caerau, near Maesteg on 7th February 1929. He moved when he was seven, first to London, and then to Cardiganshire, as an evacuee during World War 2. There he attended Aberaeron County School. His interest that led to his career began when he declared in Junior School that he wanted to be a scientist and liked insects. Later, when asked why entomology he replied "there is no single group of organisms in existence of such fundamental importance to the survival of the world than insects". On returning to London in 1945 he attended a technical college in Essex. He went from there to Imperial College to read Zoology and Applied Entomology.

Tec began his career in November 1952 at the Forest Production Research Laboratory, Princes Risborough, in Buckinghamshire. During this period, he accepted a research job in the Gold Coast (now Ghana). On the way to Ghana, his ship stopped in Freetown, Sierra Leone: his introduction to West Africa and to the continent to which he was to dedicate 25 years of his working life.

Sierra Leone introduced him to levels of poverty, hardship and human suffering he had not seen before. He witnessed suffering associated with elephantiasis and river blindness, diseases transmitted by insects. His initial apprehension about making a new life in Africa was overcome on recognition of the contributions he could make to change people's lives. Contemporaneously, entomologists were recognising the importance of controlling insects that spread diseases of humans, crops and animals. Tec's first project in Ghana was on the biology and control of Ambrosia beetles (Platypodidae and Scolytidae). They were devastating certain species of hardwood trees, including mahogany, in Gambia, Sierra Leone and especially in Ghana and Nigeria. This was having a significant impact on the local economies. His work expanded to investigations into other insect species and their roles in disease and destruction.

In 1959 Tec began a long-standing association with the East Africa Agriculture and Forestry Research Organisation (EAAFRO) in Nairobi, Kenya. Here he served first as Head of Entomology, Biological Sciences and Forestry Research and then as Deputy Director. He became involved in a whole range of agricultural science rather than just entomology: soil chemistry and physics, plant breeding, crop protection, animal husbandry and agricultural engineering. This diversification was to prove critical during the management of the integrated science needed to deal with the Desert Locust and East African Armyworm plagues in the 1960s. Reflecting the importance of the research done under Tec's leadership, the *East African Agricultural and Forestry Journal*, which he edited, was transformed from a farming journal to a respected international scientific journal.

In April 1974 Tec took up the post of Deputy Director of the Centre for Overseas Pest Research (COPR). With the integration of COPR into the Tropical Development and Research Institute (TDRI) and subsequently into the Overseas Development Natural Resources Institute (ODNRI), he retained his role as Deputy Director and became more involved in the direction of scientific programmes concerned with crop protection. At this time, he was awarded an OBE in recognition of his services to agriculture in Africa.

On his retirement, in 1989, he became a consultant at the UN Food and Agricultural Organisation (FAO) on plant protection, pest management, quarantine services and training in Africa and Asia.

In 1992 Tec was appointed Director of the International Institute of Entomology (IIE) of the Centre for Agriculture and Biosciences International (CABI). It was there that he had the idea of establishing a global network of self-help regional organisations dedicated to enabling developing countries to identify, research, elucidate and understand the relationships between the plant and insect species which constituted. their natural biodiversity. By February 1997, BIONET INTERNATIONAL was established, with regional networks in 120 countries of which 80 were developing nations. He became Director of BIONET INTERNATIONAL until his retirement in 2001.

Concurrent with his work between 1987 and 2002, Tec was appointed Honorary Professor of Applied Biology at Cardiff University. In May 2001 he was awarded an Honorary Fellowship of the Royal Entomological Society for his long-standing service to Entomology. In 2002 he was awarded the Companion of the Most Distinguished Order of Saint Michael and Saint George (CMG) for his services to biodiversity and conservation in developing countries.

In February 2017 Tec lost his beloved wife Joy who walked beside him in a life of great adventure and success.

Tec's warm personality and wonderful sense of humour made him welcome everywhere. He was an excellent communicator and raconteur whose stories, with their origins from across the world, were legendary. He was humble in respect to his professional achievements and in later years found genuine pleasure in his much-loved town of Aberaeron, where he volunteered for roles in numerous charities.

Tec Jones was a courageous man who was always concerned for others and had a real sense of fair play. He was a visionary, a consummate professional, a true gentleman and a great ambassador for Africa and for his country, Wales. As an entomologist, he will long be remembered for his visionary and pragmatic contribution of fundamental importance in safeguarding the world's rich resources and variety of life in developed and developing countries to ensure sustainable development for the benefit of humanity.

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 so that refreshments can be organised. Day meetings typically begin with registration and refreshments at 10 am for a 10.30 am start and finish by 5 pm. Every meeting can differ though, so please refer to the details below and also check the website, which is updated regularly.

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

Forest Insects Special Interest Group
Thursday, 2 April, 2020
The Mansion House, Chiswell Green Lane, St Albans, Herts, AL2 3NS

Food & Feed Special Interest Group
Tuesday, 21 April – Wednesday, 22 April, 2020
Natural History Museum, London, SW7 5BD

EntoSci20
Thursday, 30 April, 2020
Harper Adams University

Annual General Meeting
Wednesday, 3 June, 2020
The Mansion House, Chiswell Green Lane, St Albans, AL2 3NS

National Insect Week
Monday, 22 June – Sunday, 28 June, 2020

Ento '20
Tuesday, 25 August – Thursday, 27 August, 2020
University of Exeter, Penryn Campus, Penryn, Cornwall, TR10 9FE

Symbionts Special Interest Group and Infection & Immunity Special Interest Group
Thursday, 24 September – Friday, 25 September, 2020
Emmanuel College, Cambridge

Data, Ecology and Electronics & Computing Special Interest Groups meeting on E-ecology
Monday, 19 October, 2020
World Museum Liverpool, Liverpool

Scottish Regional Meeting
Wednesday, 7 November, 2020
SASA Edinburgh

Pollinators in Agriculture meeting in collaboration with the BEC and AAB
Wednesday, 11 November – Friday, 13 November, 2020
Copthorne Hotel , Slough

NON-SOCIETY MEETINGS

XXVI International Congress of Entomology, Helsinki, Finland, 19-24 July, 2020
'Entomology for our planet'

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

author guidelines

We are always looking for new material for *Antenna* – please see below if you think you have anything for publication

AIMS AND SCOPE

As the Bulletin of the Royal Entomological Society (RES), *Antenna* publishes a broad range of articles. Articles submitted to *Antenna* may be of specific or general interest in any field related to entomology. Submissions are not limited to entomological research and may, for example, include work on the history of entomology, biographies of entomologists, reviews of entomological institutions/methodologies, and the relationship between entomology and other disciplines (e.g. art and/or design).

Antenna also publishes Letters to the Editor, Meeting Reports, Book/App/Website Reviews, Society News, Obituaries and other items (e.g. selected Press Releases). *Antenna* further includes details of upcoming entomological meetings in its Diary Section and features information and reports on RES activities including National Insect Week, Insect Festival and National, Regional and Special Interest Group meetings. Details of RES Awards and recipients are also covered, as is notification of new Members (MemRES), Fellows (FRES) and Honorary Fellows (HonFRES).

READERSHIP

Antenna is distributed quarterly to all Members and Fellows of the RES, as well as other independent subscribers.

INSTRUCTIONS FOR AUTHORS

Standard articles are normally 2,000-6,000 words in length, though shorter/longer submissions may be considered with prior approval from the Editorial Team. The length of other submitted copy (e.g. Letters to the Editor and meeting reports) may be shorter, but should not normally exceed 2,000 words. The use of full colour, high quality images is encouraged with all submissions. As a guide, 4-8 images (including figures) are typically included with a standard article. Image resolution should be at least 300 dpi. It is the responsibility of authors to ensure that any necessary image permissions are obtained. Additional supplementary material may also be submitted for consideration for publication on the members' area of the RES website.

Authors are not required to conform to any set style when submitting to *Antenna*. Our only requirement is that submissions are consistent within themselves in terms of format and style, including that used in any reference list.

PAGE CHARGES

There is no charge for publication in *Antenna*. All articles, including images, are published free-of-charge in full colour, with publication costs being met by the RES for the benefit of its membership.

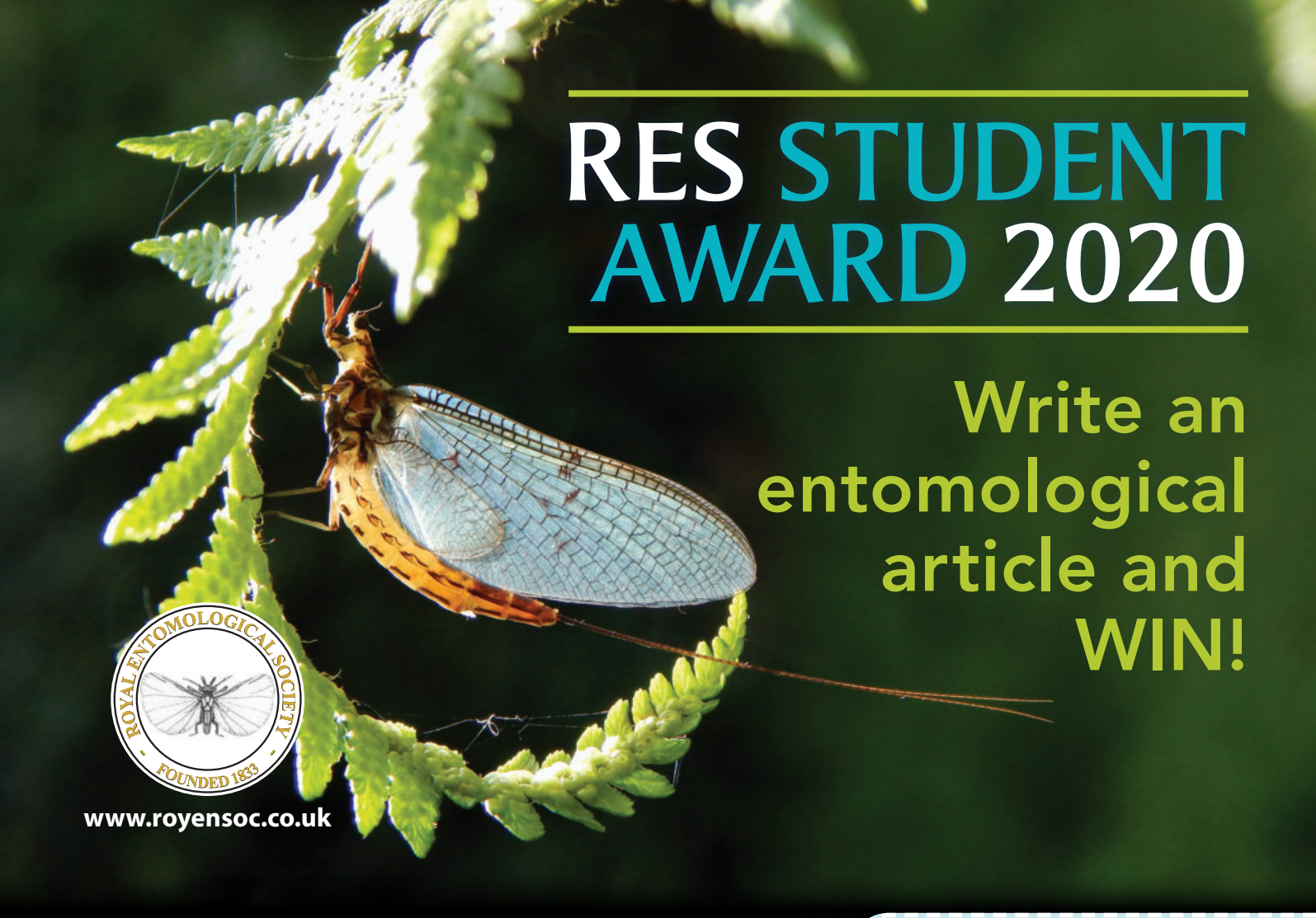
REVIEW AND PUBLICATION PROCESS

All submissions are reviewed and, where necessary, edited 'in-house' by the *Antenna* Editorial Board, though specialist external review may be sought in some cases (e.g. for submissions that fall outside the Editorial Board's expertise). Receipt of submissions will be provided by email, with submitting authors of accepted articles being offered the opportunity to approve final pdf proofs prior to publication. Where appropriate, authors will be requested to revise manuscripts to meet publication standards.

SUBMISSION PROCESS

All submissions should be sent electronically to 'antenna@royensoc.co.uk', preferably in MS Word format with images sent as separate files (see above). Image captions and figure headings should be included either with the text, or as a separate file.

EDITORIAL BOARD



RES STUDENT AWARD 2020

Write an entomological article and WIN!

www.royensoc.co.uk

REQUIREMENT

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

WHO CAN ENTER?

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

PRIZES

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

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

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

ENTRIES

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

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

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

For further information telephone **01727 899387**

Please include:

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

THE JUDGES

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

CLOSING DATE

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

PLEASE CUT AND RETURN THIS PORTION WITH YOUR ENTRY

Article title: _____

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Student name: _____

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Address: _____

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Telephone: _____

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Name of academic institution:

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