Antenna

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Royal Entomological Society

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Author Guidelines

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Submissions are made by email to *antenna@royensoc.co.uk* and reviewed by *Antenna's* editorial team. There are no page charges for publication in *Antenna*, where we encourage use of full colour figures and photographs to accompany text. Standard articles are normally 1,000–3,000 words in length and submitted with four to eight images (file should be original size of image taken and not reduced in size nor cropped heavily).

Cover Picture: Male hover fly from the genus *Platycheirus*, photographed by Anthony Baggett at Burry Port, Wales. Submitted to the Society's Insect Identification Service, see article on page 51.

Editorial

Do you know who 'discovered' metamorphosis? Answer on page 19. I didn't until our treasurer, Gia, told me about a project her daughter Edda was doing at school. I was so pleased to hear of Edda's interest in a woman we should all know about, that I invited her to write a piece for *Antenna*. It's an absolute delight to read and good to know that the makings of future entomologists are present at primary school.

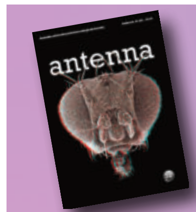
This issue is full of delights. Stuart Reynolds' Research Spotlight is as erudite and thought-provoking as ever, this time considering why so few insects live in the sea. At ENTO22 in Lincoln, many presentations grabbed my attention. These included Alex Dittrich talking about the rewilding of an urban golf course and the involvement of students in monitoring the outcome. Entomology is thus clearly alive and well at the University of Cumbria, but Amma Simon reports on an alarming dearth of courses in the UK which include even a modicum of entomological content and makes some suggestions as to why this might be and how to address it. One of the possible reasons is 'vertebratism'. Roger Morris explains why the criteria for 'red-listing', and methods for conserving, vertebrates can't readily be applied to most invertebrates.

The Orthoptera Special Interest Group (SIG) runs like clockwork on the first Wednesday of each November. The most recent meeting is reported. A brand-new SIG on Welfare and Ethics in entomology is soon to be launched, and its convenor, Eleanor Drinkwater, outlines the issues which it will address. We now have several International Representatives, who are promoting the Society in their country and promoting their country's entomology to the wider membership. Kimberly Gauci, Malta's representative, was first out of the blocks. The Society has also launched a programme of evening meetings, the first two of which are reported. Do sign up for future meetings.

This issue's Honorary Fellow interview features Jim Hardie, our Resident Entomologist. Jim's fascinating report on the many specimens sent in by the public for identification during 2022 follows. Our outreach activities may well account for some of Jim's work, and an incredible opportunity for spreading the word comes with the Society's garden at the Chelsea Flower Show in May. Garden designer, Tom Massey, is interviewed. It's all happening!

Many thanks to all contributors.

Richard Harrington



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Antenna

Bulletin of the Royal Entomological Society

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Letter from the President

Last summer I was fortunate to visit the village of Borth, in west Wales. The coastal village has an amazing view out across Cardigan Bay and the beach is evidence of the dynamism of our natural habitats. Dotted across the beach are ancient tree stumps, a reminder that 5,000 years ago there was woodland where there is now sand. This loss of prehistoric woodland is in contrast to recent initiatives to increase woodland cover in the UK. I recently visited Risley Moss, which is part of the Mersey Forest in NW England, where woodland is being recreated on post-industrial sites. Risley Moss was the site of a Second World War munitions factory. It will be interesting to see how woodland regeneration affects insect diversity, and the physical and mental health benefits for people from accessing these green spaces. Increases in UK woodland cover could help boost insects, and other species that depend on insects, and management will be important to ensure woodland is in good condition to help nature thrive.

I'm writing this as the COP15 meeting in Montreal comes to an end, and conservationists digest the outcomes and Government commitments to the Global Biodiversity Framework. One outcome is the commitment to protect 30% of the globe for nature by 2030 – the so-called '30 by 30' target to support biodiversity. This is being seen as a positive outcome of COP15 and good news for nature, but as with all things the devil will be in the detail, and the effectiveness of area-based conservation to deliver for biodiversity. The UK has a long history in establishing protected areas for nature – over 100 years ago Charles Rothschild and colleagues identified several hundred sites to protect for wildlife – the forerunner of the Wildlife Trusts and network of protected areas that we currently have in the UK. There is now a dizzying array of different categories of protected area in Britain (SSSI, AONB, SPA, SAC, NNR and many other acronyms), that together are not far off the 30% target if all are included, but probably less than 10% is managed effectively for nature. There are some new protected areas, such as Dearne Valley Wetlands in South Yorkshire, England, an ex-coal mining area that became a Site of Special Scientific Interest in 2021, but there is still a way to go to reach the UK's 30% target. Research is needed around the globe to understand how protected areas can best support insects, and of course promoting insect biodiversity outside these protected areas is important too, *e.g.*, in urban gardens, parks, and agricultural land.

Successful conservation must be informed by scientific evidence. The Royal Entomological Society is proud of its seven high-quality entomology journals as well as the other contributions it makes to disseminating insect science *e.g.*, the series of handbooks for insect identification. Publishing started soon after the Society was established. The *Transactions of the Entomological Society of London* started in 1836, with *Proceedings* starting in 1926, which morphed in 1976 into the journals we are familiar with today – *Ecological Entomology*, *Physiological Entomology*, and *Systematic Entomology*. MVE was launched in 1987, IMB in 1992, AFE in 1999 and ICD in 2008. Perhaps the time is right to launch another new journal to accompany them?

Journal editors Allan Watt, Manu Saunders and Raphael Didham have put together a virtual issue of published journal papers to coincide with COP 15 – check out the RES web page for details and links to papers (and other virtual issues). A large component of what the Society does is underpinned by income from journal publishing, and the Society is hugely grateful for all the support from editors and reviewers that make our journals, and Society, such a success. Do please continue to support the journals for publishing your exciting research – the journals cover a wide breadth of insect science, so there is something for everyone. The landscape for scientific publishing is changing very rapidly. We now have a Head of Publishing, Emilie Aimé, and we look forward to seeing our journals flourish and continue to publish exciting insect science.

Borth beach, Wales. Evidence of a 5,000 year old forest is revealed at low tide.

Jane Hill
President
Royal Entomological Society

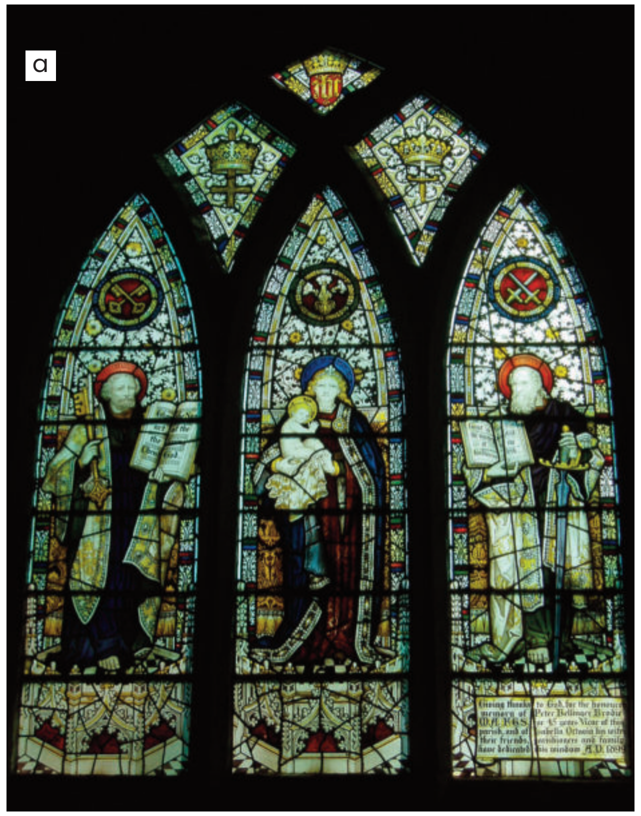
Correspondence

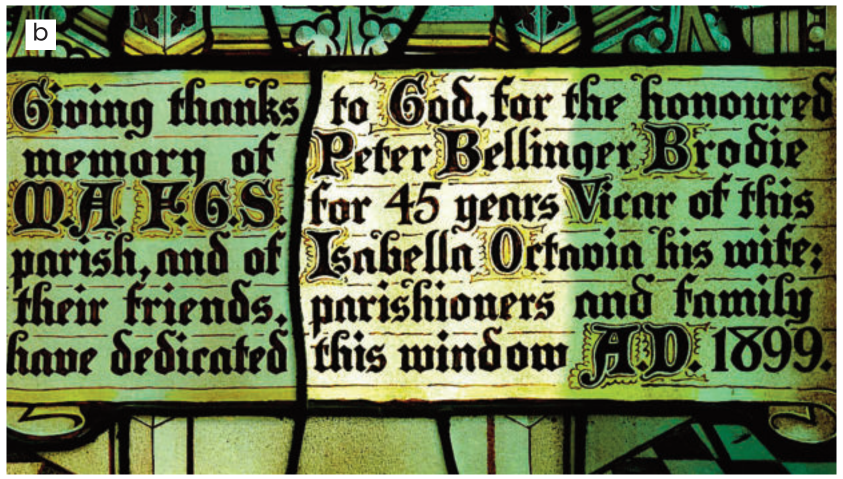
A window on ancient insects: the Revd P. B. Brodie

I was interested to read Hodkinson on Walton in the last issue as even palaeoentomologists were commemorated in stained-glass windows in late Victorian times (Figs 1, 2). By then, the popular revival of stained-glass manufacture included the use of tertiary colours with a focus on human interest. The Revd P. B. Brodie was the long-serving and dedicated vicar of St Laurence in Rowington, which alone would have justified such a window. He is also, however, in the Oxford Dictionary of National Biography for his pioneering work in earth science (Green, 2004), especially the study of Mesozoic fossil insects (Brodie, 1845).

Peter Bellinger Brodie (1815–1897) was the son of a lawyer and his first claim to fame was that, when elected in 1834, he was the youngest member proposed to the Geological Society of London, the world's oldest national geological society (Besterman, 1992). His thinking on fossil insects was revealed when he said in his unique 1845 book (p. viii): "...it would be most unphilosophical to overlook or disregard *even one* [his italics] of those creatures, however minute...". He was not going to be distracted by the competitive discovery of saurian bones, later better known as dinosaurs! From London, Brodie went on to Cambridge University where his mentor was The Revd Sedgwick (as in Sedgwick Museum), followed by vicarage appointments in the west country and then central England, commencing in the Vale of Wardour. This proved significant because Brodie worked in the right areas to find and build up a collection of Mesozoic fossil insects in his spare time, from what were then known as secondary rocks, today the Triassic, Jurassic and Cretaceous systems (Jarzembowski, 2021). Whilst concentrating on the geology, he sought entomological help from others, not least from this Society's John Westwood who was content to figure (illustrate) Peter's insects but, like many entomologists, hesitant to name imperfect fossils. Brodie duly supplied the necessary names but, not to be outdone taxonomically, Westwood (1854) named them himself in their next project! A notable feature of the book is that insects were already considered as potential palaeoenvironmental indicators, including climatic, although Westwood didn't appreciate sedimentary size sorting as a potential bias.

Brodie was a great believer in fieldwork, establishing the Warwickshire Naturalists' and Archaeologists' Field Club, amassing some 25,000 specimens in his lifetime. His key finds are in the Natural History Museum as well as some other historic British and foreign museums, including the Warwickshire Museum, although in Vienna his material appears to have disappeared. Working in a closet for a laboratory, Mesozoic insects were labelled with provenance data in an exemplary manner, characteristically penned on small pieces of rock. The only disadvantage of examining his insects is a patina of fine aerial pollution or efflorescence due to the passage of time.





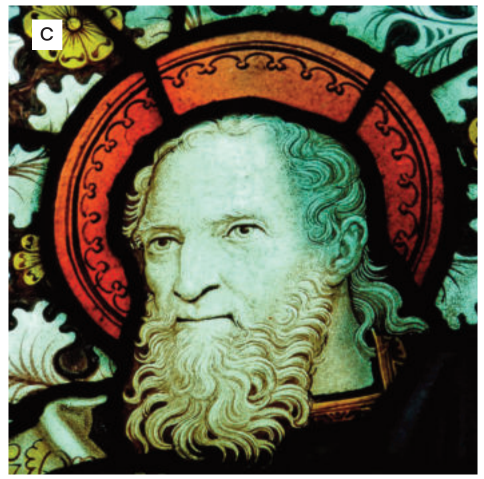


Figure 1a. the trade-marked Kemp window in St Laurence's Church, Rowington, Warwickshire; 1b. 1899 dedication to the Brodies; 1c. St Paul close-up.

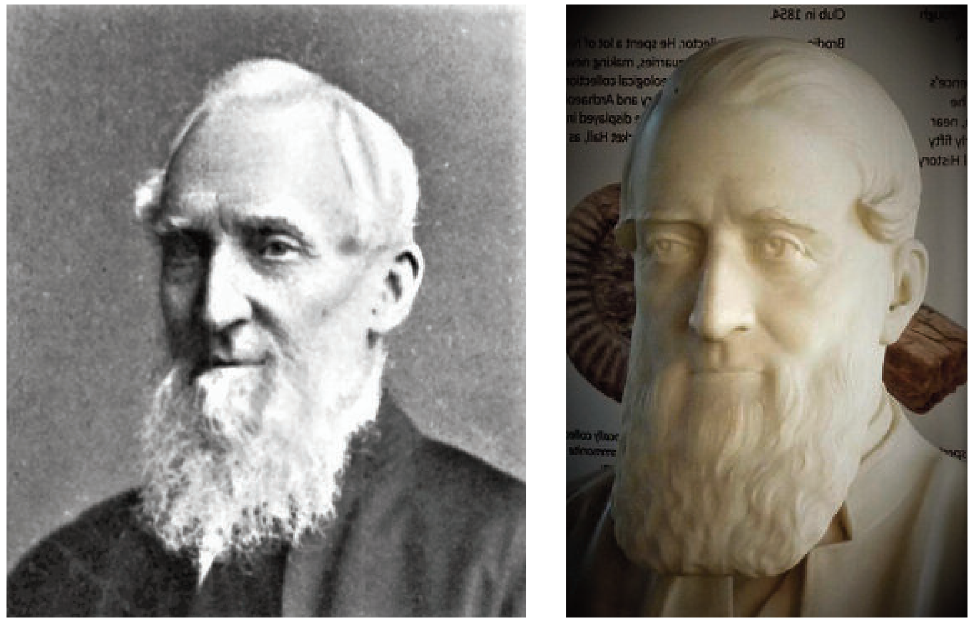


Figure 2. The Revd Brodie and bust in the Warwickshire Museum, Warwick.

Brodie went on to publish multiple papers. As a designer, he didn't embrace Charles Darwin (*pace* metahistorians!) and was apologetic for not visiting Londoners like Richard Owen at the Natural History Museum, blaming local commitments. He continued supplying European and American specialists with study material. As a student, I still used some of their work to help fill Brodie's hexapod gap in Mesozoic coverage – the Wealden of Southeast England. The centenary of Brodie's death was commemorated with papers in *Cretaceous Research* (Jarzembowski, 1999) and updates can be found online.

Acknowledgements
Thanks to Jon Radley and especially Stuart Burley for original images.

Ed. A. Jarzembowskii

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Insect Odyssey, a legacy

Reading Elisabeth Darby's article (*Antenna* **46** (3) 144–151), which outlines the history and content of *Insect Odyssey*, an exhibition with funding from the RES Goodman Award, was a timely reminder of the role that the arts can play in raising public awareness of important issues, and at this moment the world faces a multitude of challenges. One of these is biodiversity loss and, as we entomologists know, most animals are insects, and we are losing them at an alarming rate.

Raising public support for organisms that fall just below the threshold of human perception is problematic and whilst progress is being made it is slow and time is slipping by. In Simon Schama's recent TV documentary series *A History of Now* he examined how art had responded to major events in modern history and how it had galvanised social and political change. Could *Insect Odyssey* leave a legacy that could shift public perspectives in favour of insect conservation?

When the exhibition was dismantled, I was invited to attend the closing ceremony and thus met many of the artists involved. I was amazed by the energy and enthusiasm emanating from this small group; they were so keen to continue the project and work with entomologists to produce more insect-inspired works of art. *Insect Odyssey* had brought the beauty and complexity of insects to the attention of the general public in the Salisbury area, so could it be the first step on Simon Schama's road to changed perceptions?

In an attempt to channel the wild enthusiasm that I encountered, I am working with the RES Southeast England Regional Representative, Sarah Arnold, to hold a one-day meeting at the NHM London where artists can meet with entomologists and discuss possibilities. The day will comprise a series of short talks, a behind-the-scenes tour of the Coleoptera Department, generously offered by Max Barclay, and an open discussion of where we go next.

So, I am searching for entomologists who have an interest in the arts and would be happy to work with artists to discuss ideas and help to generate works of art. If you would like to be involved, drop me an email outlining your area of interest and any previous experience of Sci Art events that you have.

At the time of going to press we have no date but once this is fixed, I will circulate details to all interested parties.

Peter Smithers, peter@royensoc.co.uk

Evolution of polymorphism - Response to Jamie Weir

My *Research Spotlight* article on insect colour polymorphisms (Reynolds, 2022) prompted Jamie C. Weir to comment in a letter to *Antenna* (Weir, 2022) that I was wrong to consider as unpersuasive the notion that "*polymorphism in a population may be intrinsically advantageous*"; he asserts that it "*make(s) sense to think of polymorphism as an adaptation which can be beneficial in and of itself under certain circumstances.*"

I'm sorry to disappoint Jamie, but I continue to think that the evidence in favour of fitness benefits accruing from polymorphism *per se,* as once advocated by Dobzhansky (1951), is tenuous, even though Weir is by no means the only person recently to argue in favour of such population level selection (*e.g.,* Forsman, 2016; Takahashi *et al.,* 2018).

In my view, there are two big problems with the idea that polymorphism 'in and of itself' is subject to natural selection. First, there is little evidence in favour of the assertion, and second, there is as far as I can see no good explanation of how such selection can occur. A single argument which I suggest may be fatal to this approach to the evolutionary population genetics of genetic variation, is that polymorphism can only be the attribute of a population, not of an individual. Since it is the individual that reproduces and differential individual reproductive success that is susceptible to selection, how can polymorphism 'in and of itself' be a naturally selected trait?

In what follows, I elaborate on what I said in the last section of my *Research Spotlight* article. Here, I frame the argument in terms of insect colour polymorphisms (after all, that's what my article and Weir's letter were about). Consider a colour gene that has newly arisen in a single individual as the result of a mutation, and which has the potential to confer increased fitness but only at the level of the group to which the individual belongs. The potential benefits of such a gene can only be favoured by natural selection if the gene spreads through a significant fraction of the group. But spreading can only occur if the gene has already caused an increase in the population's fitness. This makes it clear that if selection is to favour a polymorphism *per se*, then it can only do so if it first favours the individual that bears the gene that causes the polymorphism (this assumes of course that a single gene can indeed cause polymorphism to occur). Since the polymorphism doesn't yet exist in the population, this suggests that either the gene cannot spread or that whatever it is that is selected isn't polymorphism *sensu stricto*. This doesn't absolutely prohibit the possibility that a gene of this kind might separately benefit both the individual and the population, but it would then be very hard to prove the existence of the separate population level effect.

So we must consider mechanisms of selection that can maintain the polymorphic state in the population by acting at the level of the individual. First, density-dependent balancing selection. As discussed in my article, and also by Weir, a range of natural selection mechanisms has been proposed to account for such balance, including fluctuating selection pressures that vary in space and time, antagonistic pleiotropy, heterozygote advantage, heterosis, the use of learned search images by predators (apostatic selection), and visual confusion by predators in complex visual environments. A particularly interesting case occurs when there is genetic linkage between genes specifying colour and antipredator defences (McKinnon *et al.,* 2010). All these mechanisms of balancing selection have been shown to act under certain circumstances. But in all these cases, natural selection is acting solely by favouring different genetic lineages which have different relative fitness values that vary according to the demographics of the population; it is not polymorphism *per se* that is being selected.

But is it possible that at least some of the selection pressure that maintains insect colour polymorphisms may not additionally be exerted by the action of natural selection on the trait of polymorphism *per se*, as opposed to just the relative fitness conferred by the colour traits themselves? Weir mentions, in particular, apostatic selection (Bond, 2007) and the 'protective polymorphism hypothesis' (Karpestam *et al.,* 2016), both of which rely on the idea that polymorphism among their prey distracts predators from identifying suitable victims effectively. Both these putative mechanisms are in my view just elaborations of the concept of frequency-dependent selection on the colour traits themselves. Moreover, they can only lead to the sustained greater overall survival of members of a population as long as the predator exerts no influence on its polymorphic balance within the targeted species as the result of its predatory activity; if a greater proportion of one morph than the other is taken by the predator, then the supposed cause of confusion among the latter must inevitably disappear. Given that the whole hypothetical scheme is predicated on the predator being selective according to colour, this appears to me to pose a serious problem for any model of natural selection that is supposed to favour polymorphism *per se*. Moreover, as noted above, these two mechanisms can only work at all in the context of a balanced polymorphism that already exists; they cannot account for the initial selection and spread of a new colour polymorphism at a time when almost all individuals would be the same colour.

In what I see as a more plausible approach to this question, Weir also identifies risk-spreading or diversified bet-hedging (DBH) as a way in which polymorphism *per se* could be favoured by natural selection. He supposes that polymorphism may confer long-term reproductive success on a population of insects by increasing the within-population variability of its heritable colour traits, thus allowing faster and more effective population-level evolutionary colour responses to changing ecological conditions; another way of putting this is that a polymorphic population is *buffered* against future changes in its environment (Weir, 2022). Such resilience in the face of a changing environment is thus supposed to be effectively the same thing as a gain in fitness over what might have happened had the population not been polymorphic.

I have no doubt that real organisms sometimes engage in risk-spreading. The strategy has been intensively examined by those interested in life history evolution. In mathematical terms, DBH is said to occur when an unpredictably variable environment causes selection to favour genotypes with lower variance in fitness over space and time at the cost of lower mean fitness. There is empirical evidence that evolutionary bet-hedging occurs in a variety of organisms, but it is unclear how common the strategy is (Hopper, 1999; Simons, 2011). On the other hand it may be that the statistical criteria for accepting DBH as a proper description of actual behaviour are too strict, and Yasui (2022) has argued that relaxing these criteria only slightly would cause bet-hedging to appear universal. Where it has been shown to occur, DBH appears mostly to be a mechanism for diversifying developmentally-programmed life-history strategies, especially involving initiation of development, hatching, growth trajectory and periods of developmental arrest (Ratcliff *et al.*, 2014). For example, Scholl *et al.* (2020) discuss the idea that plants hedge their reproductive bets by producing a range of seed sizes, which germinate over a prolonged period; this gives an average fitness less than the maximum that could be achieved under the best germination conditions, but superior to that which would be achieved under the worst conditions by the best-performing seeds. In animals, Pinceel *et al.* (2021) have recently shown that the balance of slow versus quick hatching strategies of fairy shrimps is consistent with diversified bet-hedging, even under the strict definition.

But it is uncertain that such ideas about DBH can be applied to insect colour polymorphisms. Philippi *et al.* (1989) assert that a genetic polymorphism is *not* equivalent to DBH, and specifically claim that the risk-spreading life-history strategies seen within eukaryotic populations are due to phenotypic plasticity (*i.e.*, environmentally regulated developmental switching) rather than selection on genetic differences between differentially developing lineages. If this were true it would pose a big problem for the idea that insect colour polymorphisms are naturally selected, since the genetic basis of most such polymorphisms is known. But since the ability to respond to changing ecological circumstances by changing the rate or even the end point of a developmental programme is highly likely to influence fitness and might well be under the control of a single genetic regulatory network (GRN), selection on variation in the sensitivity of the network might easily occur at the level of the individual. As I commented in my original article, involvement of epigenetic control mechanisms is also possible, and variation in the sensitivity of these controls to environmental conditions might be selected even if the phenotype was not permanently altered.

As Weir notes, the idea that ecological risk-spreading may account for the evolution of colour polymorphisms in insects is a long-standing one; it was proposed more than 120 years ago to explain colour variation in lepidopteran larvae by a former president of the Royal Entomological Society, Edward Poulton (1890), and was much later elaborated by Dempster (1955). But as far as I am aware there is little or no evidence to support the role of this kind of selection in balancing insect colour polymorphisms. It was experimentally investigated in the case of polymorphic grasshoppers by Caesar *et al.* (2010), with only mixed results (see the further commentaries on this and other studies of animal colour polymorphisms by Forsman *et al.* (2008) and by Bolton *et al.* (2015; 2016). The review by Forsman (2016) was written largely to defend the concept of possible intrinsic benefits of polymorphism, but even this paper does not seem to me to come up with much empirical evidence that group fitness benefits occur as a result of colour polymorphism within the population.

To sum up, I am grateful to Jamie Weir for raising the question of the possible intrinsic benefits of polymorphism. In doing so he identifies what has been described as "a central problem in evolutionary genetics", to explain the maintenance of genetic variability within populations (Tellier *et al.*, 2007). Even if I am not yet persuaded that there is good evidence to support Jamie's proposal that natural selection can favour polymorphism as in itself intrinsically advantageous, this doesn't mean that the question of critically identifying the level at which natural selection determines polymorphisms is not worth pursuing further.

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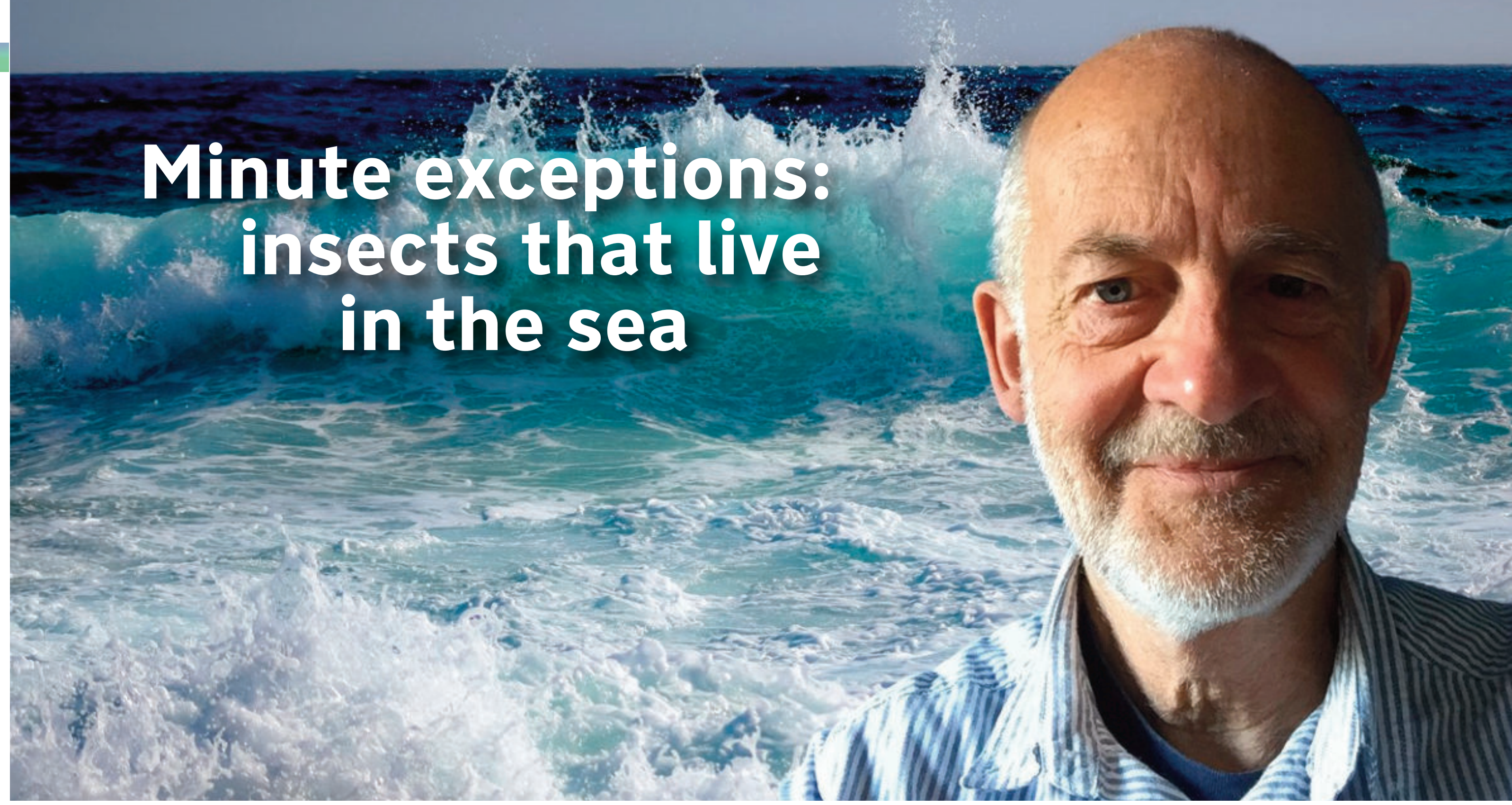

Minute exceptions: insects that live in the sea

RESEARCH SPOTLIGHT

"It has frequently been said that no true insect is marine; and though this is not literally true, the minuteness of the exception makes the rule even more striking than it would have been if absolutely universal"

Philip Henry Gosse (1855)

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(s.e.reynolds@bath.ac.uk)

It is well known that few insects live in the sea. Why is this so? Life originated in oceans, and arthropods were among the first animals to make the transition from marine to terrestrial life (van Straalen, 2021; Buatois *et al.*, 2022). As entomologists, we never tire of hearing that insects and their wingless relatives (*i.e.*, hexapods) are the most successful of those animal groups, and this is reflected today in their fabulous land-based diversity. Insects are everywhere – but only on land. They are less diverse in freshwater (Vermeij, 2020), but as we shall see, very few insects live on the seashore, and only a handful of species can realistically be said to live their entire lives at sea. Even then, they actually live on top of the sea, rather than in it. In failing to colonise the oceans, it seems that despite their prodigious capacity for diversification, insects have not adapted well to marine environments. This is the consequence of a general pattern seen throughout the Arthropoda, in which there is a strong tendency towards diversification but relatively few transitions between sea and land (Vermeij, 2020). This is in marked contrast to the phylum Nematoda, the other major hyperdiverse metazoan group (Blaxter, 2016), in which there is evidence that numerous transitions have taken place in both directions between marine and terrestrial ecosystems, but only a moderate

Fig. 1. Curtis's illustration of *Aepus marinus.* The accompanying plant is *Lobelia dortmanna*, incorrectly associated with the insect. From Curtis (1828).

degree of diversification (Holterman *et al.*, 2019).

Why have so few hexapods made the return journey to the sea? Such questions are hard to answer, but the first step is to know which kinds of insects actually occupy marine niches. This will then enable us to look for macroevolutionary patterns.

Insects that live in the sea

According to Miall (1895), early entomologists thought that there were no insects at all in the sea. The falsity of this prejudice was uncovered in the late 18th century, when the small carabid beetle *Aepus marinus* was discovered living on the seashore by the Norwegian naturalist Hans Strøm who described it in 1783 (see Plateau, 1890). It was immediately evident that this insect, widely distributed on European rocky shores, survived regular inundation by the tide. The discovery attracted much attention from entomologists, including the incomparable John Curtis (1828), who illustrated it in his beautiful book 'Insects of Britain and Ireland' (Fig. 1). But Curtis evidently couldn't believe that this was really a marine insect, and he incorrectly coupled it with a drawing of a freshwater plant, *Lobelia dortmanna*, instead of the intertidal seaweeds on which it is actually found.

Subsequently, it turned out that although they are generally not plentiful, plenty of other insect species can be found living closely associated with the sea. The question 'how many marine insects are there?' was addressed by the Belgian, Félix Plateau (1890), who included *A. marinus* in the first comprehensive catalogue of marine insects. There were remarkably few of them, the list including only 53 species from 24 genera. Most were predatory beetles. A further six species were wingless Collembola, then considered to be proper insects (although they aren't now); the most well-known being the tiny but beautiful deep-blue springtail *Anurida maritima* (Fig. 2), widespread on rocky shores around Europe and often seen floating on the surface of rock pools.

But there were unaccountable blanks in Plateau's list, including the notable omission of the whole of the order Diptera; Plateau asserted that he didn't believe that there were any flies that could survive immersion in the adult state (as if their corresponding larvae didn't matter!). Plateau specifically mentioned the acalyptrate fly *Helcomyza ustulata* and also referred to the work of Packard (1869) on the chironomid midge *Halocladius variabilis*. Larvae of both of these insects were even then known to live totally immersed in sea water. Astonishingly, Plateau nevertheless concluded "it is obvious that [these species] do not fall into the category of animals which I am trying to catalogue"!

Nowadays, we recognise that the order Diptera is the most strongly represented among marine insects, with many examples within six nematoceran and 4 brachyceran families. In almost all these cases, it is the larvae that actually live totally or partially in sea water, and the adults emerge from the sea in order to reproduce. Among the most familiar insects on the seashore, members of two dipteran genera, *Coelopa* (Coelopidae) and *Fucellia* (Anthomyiidae) are found in huge numbers inhabiting the linear piles of wrack seaweed so commonly found along the high tide mark (Fig. 3).

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Fig. 2. *Anurida maritima*. Photo by Gustav Paulay, eol.org, CC-BY-NC 4.0 https://eol.org/media/3313448.

Fig. 3. *Coelopa frigida*. Photo by Janet Graham CC-BY-2.0 https://en.wikipedia.org/wiki/Coelopa_frigida#/media/File:Coelopa_frigida_(by_Janet_Graham).jpg

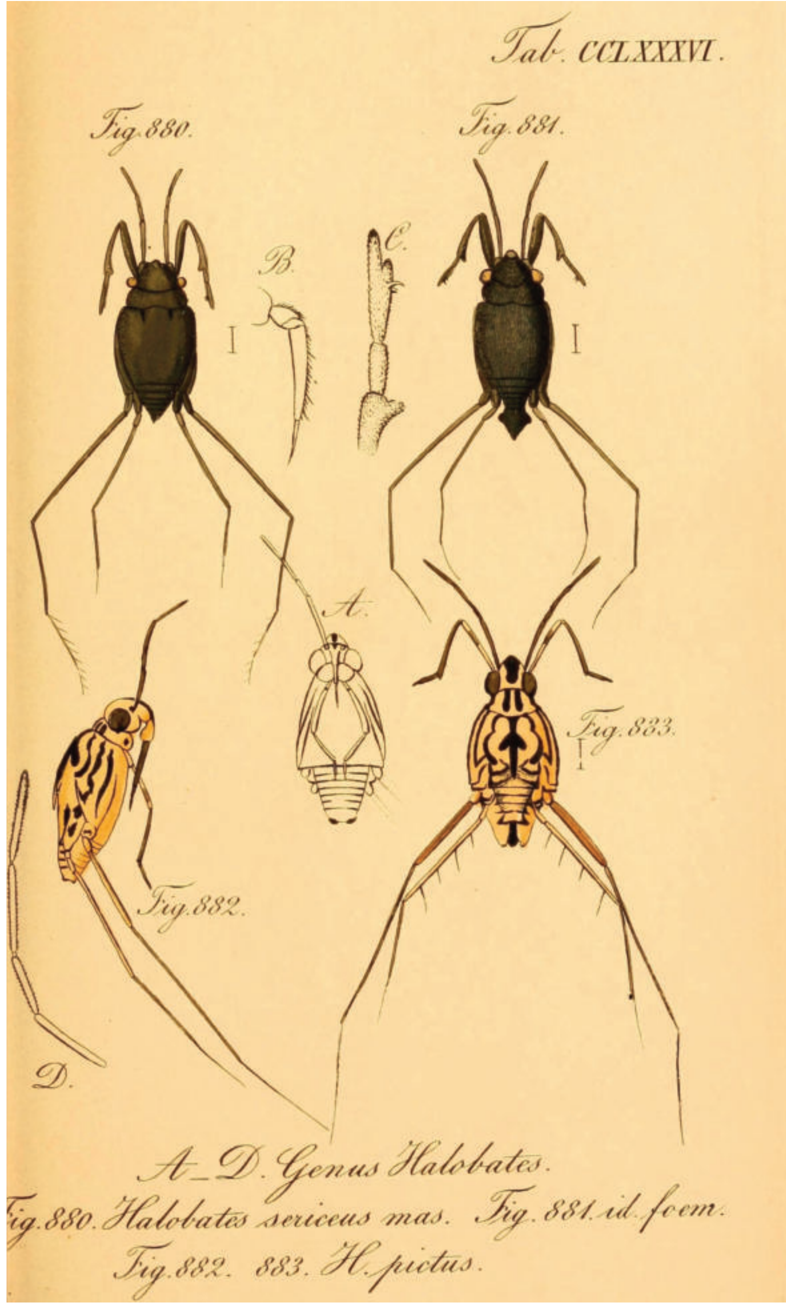

Fig. 4. *Halobates micans* Eschscholz. Male, body length 4.4 mm. From White, 1883 https://upload.wikimedia.org/wikipedia/commons/8/8a/Die_wanzenartigen_Insecten_%28Tab._CCLXXXVI%29_%287746553968%29.jpg

Fig. 5. *Bledius spectabilis.* Photo from ukbeetles.co.uk, image unattributed, CC-BY 4.0. https://eol.org/pages/1038239

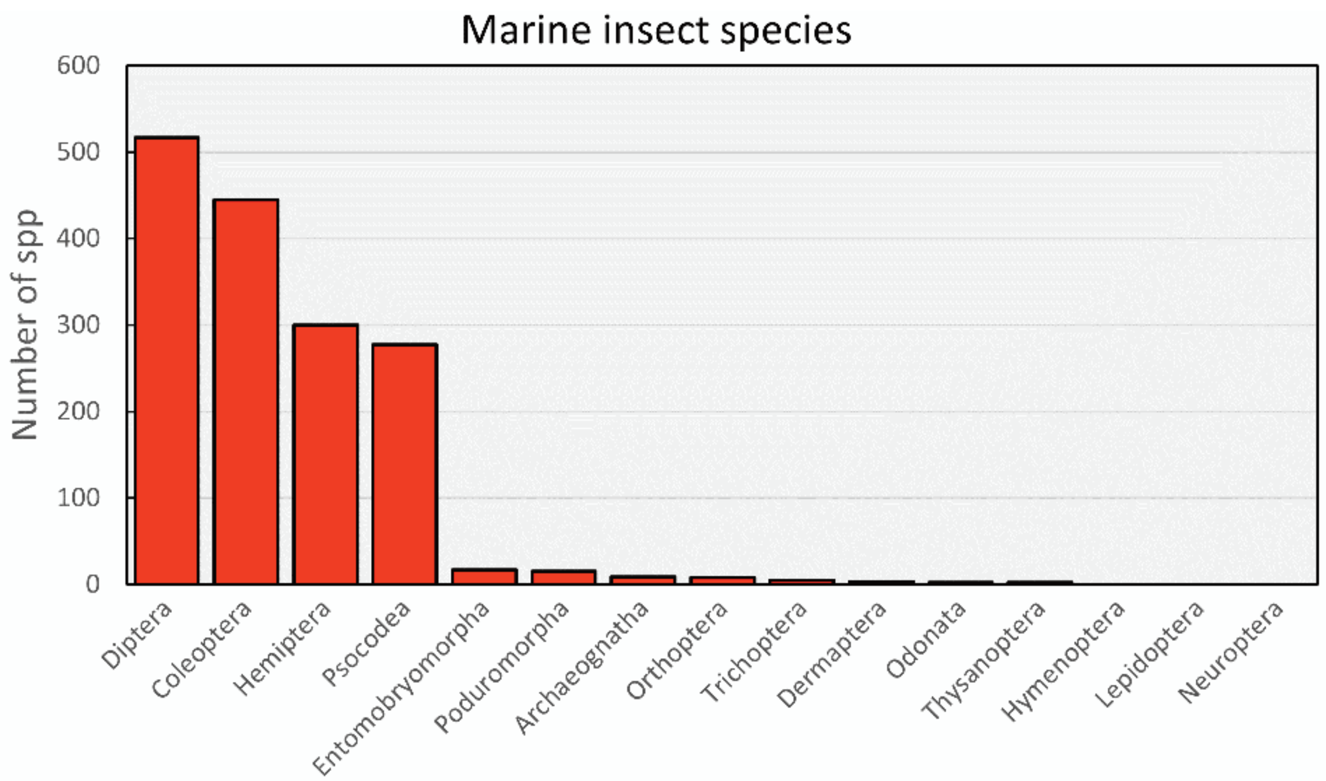

Fig. 6. Numbers of marine hexapod species according to order. Data taken from the WoRMS database. Original figure.

Another important limitation of Plateau's list is that it mentions only a single hemipteran species, *Aepophilus bonnairei*, a predatory bug of the family Aepophiliidae characteristically found skulking among rocks in the low intertidal zone. Many more marine Hemiptera are known today, and in particular Plateau was apparently completely unaware of the several species of ocean-going water striders (Family Gerridae) belonging to the genus *Halobates* (Fig. 4), which are almost certainly the only marine insects to live their entire lives on the open sea. *Halobates* is so extensively adapted to a life on the ocean wave that I'll return to it later in this article.

Plateau's attention was directed to the seashore, but this is not the only habitat that can justifiably be called 'marine'. Many saltmarsh insects live in burrows in the muddy substrate and are frequently inundated by seawater at high tide, so justifying the appellation 'marine'. Some well-known insect species found only on salt marshes are listed by Foster *et al.* (1976) including the staphylinid beetle *Bledius spectabilis* (Fig. 5) which lives in burrows that are regularly submerged by sea water.

Plateau's list updated: which kinds of insect are most common in the sea?

More than 130 years have elapsed since Plateau compiled his list. Although many additional species are now known from all around the world, there are still remarkably few of them. A remarkable database, the World Register of Marine Species (WoRMS), attempts to list all marine organisms, including information on synonymy (WoRMS Editorial Board, 2021). Appeltans *et al.* (2012) used WoRMS to count 2,037 species of insect and their six-legged relatives living in or close to the sea. This represents only about 0.2% of an estimated 1,013,825 described hexapod species (Stork, 2017). On both land and in freshwater, insects are notably adaptable, but considering that 71% of the Earth's surface area is covered by the oceans, surely there should be more marine species than this?

My own list of marine insects from WoRMS of 1,600 seagoing hexapod species is 21.5% smaller than that of Appeltans *et al.*, probably because I excluded records where the database entry gave no positive assurance of marine-associated status. I'm sure that this list is not complete; I identified a number of omissions of known species, and anyway, how could it be complete when so many insect species are as yet undescribed? But this is probably as good as we are going to get at the moment.

Most of the confirmed marine species (79% of the total) are members of just three insect orders, Diptera, Coleoptera and Hemiptera (Fig. 6). We'd expect these groups to be strongly represented simply because they are all extremely diverse; beetles, flies and bugs together represent more than 60% of insect species as a whole (Stork, 2017). A surprise for me was the realisation that the order Psocodea (bark and book lice as well as parasitic lice) is also extremely well represented among marine insects, accounting for 17% of all marine hexapods. On the other hand, the remaining hexapod orders are mostly either represented in single figures or are completely absent.

There's little doubt that hexapods evolved on land, perhaps having passed through an association with fresh water (van Straalen, 2021). The adoption of a sea-going lifestyle by a formerly terrestrial insect implies a process like a biological invasion of the ocean, the colonisation of a new niche presumably involving an initially opportunistic exploitation of abundant food sources of marine origin, possibly combined with relief from the attentions of land-based natural enemies, followed by a period of genetic adaptation (Sherpa *et al.*, 2021). The greater the contrast between the original land-based niche and the new marine one, the less the likelihood of a successful transition.

Marine-associated species are widely distributed within the

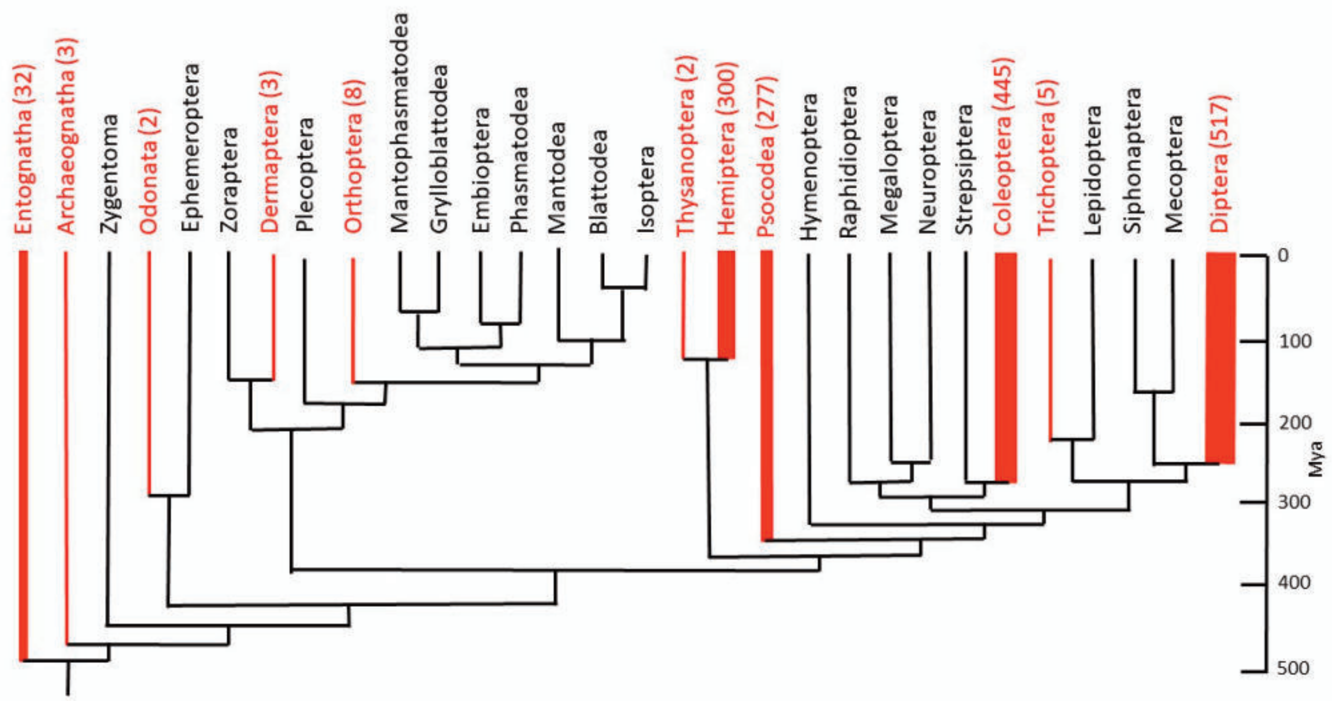

Fig. 7. Hexapod phylogenetic tree (data from Misof *et al.*, 2014). Those orders in which marine species occur are shown in red, the number of marine species being shown in parenthesis. Original figure.

hexapod phylogenetic tree (Fig. 7) indicating that invasions of marine habitats have occurred on multiple occasions and within well-separated clades. This implies that the challenge of recolonising the sea does not require the reinvention of an improbable trait. Consistent with this, Pak *et al.* (2021) concluded from a similar but deeper analysis restricted to marine-dwelling Diptera, that colonisation of the sea by insects of this order is likely to have arisen on at least 20 occasions.

It is immediately obvious that these insect invasions of the sea have occurred very unevenly; the third and fourth largest insect orders, Lepidoptera and Hymenoptera, are completely missing from the WoRMS list of marine insect species. To some extent, the absence of eusocial Hymenoptera is understandable: their societies depend heavily on chemical communication through surface deposits, and this would be hard to maintain underwater. Moreover, species that make a living as pollinators of flowering plants are unlikely to prosper in marine environments, and while some species of ant have been recorded to forage on the shore, they don't do so to the exclusion of other environments away from the sea. But a sizeable fraction of this order is made up of parasitoid wasps, some of which parasitise shore-dwelling insect hosts. For example, Hodge *et al.* (2016) found 19 species from six hymenopteran families parasitising various seaweed flies (Coelopidae) on beaches in New Zealand, while Yamazaki (2012) reported nine parasitoid species from two families parasitising the very numerous seaweed flies *Coelopa frigida* and *Fucellia* spp. on beaches in central Japan. The rate of parasitism in the Japanese study approached 15% of the fly larvae examined from one locality. The platygastroid wasp *Echthrodesis lamorali* is found in the intertidal zone of the Cape Pensinsula, South Africa, where it parasitises spider eggs (van Noort *et al.*, 2014). Extrapolating these findings to the rest of the world suggests that there must be a considerable number of marine parasitoids, and yet not a single species has been registered on the WoRMS database. Since wrack seaweed is thrown up in huge quantities on beaches all over the world (Hyndes *et al.*, 2022) and is associated with diverse and numerous dipteran and coleopteran populations, it is clear that parasitic Hymenoptera have probably been underestimated as components of marine insect communities. Although a review of the existing literature on host relations of hymenopteran parasitoids would yield additional candidates for the marine list, what is really needed is a dedicated empirical study of the parasitoids of marine insects.

By contrast, the complete absence of butterflies and moths from the list of marine insects is probably a real phenomenon. The total number of species may not be zero; the lepidopteran family Crambidae includes many species that have freshwater aquatic larvae, and at least one, the antipodean *Hygraula nitens*, has been found in the brackish waters of estuaries, where it eats eelgrass (*Zostera* spp.) (Habeck *et al.*, 2005). But many adult butterflies and moths are only passing visitors to the seaside; a few lepidopteran species are associated with salt marsh plants (Foster *et al.*, 1976) but these species may also occur in fully terrestrial habitats and so cannot be regarded as marine specialists. One possible explanation for the absence of dedicated marine Lepidoptera is that these insects do not thrive in contact with water due to the delicacy of their scaly adult cuticle. Although the larvae of a few members of at least some lepidopteran families do live under the surface of still, fresh waters (Pabis, 2018), they are not numerous, and it may be that they cannot cope with the mechanically rough conditions that typically occur in the sea. But it is likely that a more important factor is that lepidopteran larvae are virtually all specialist herbivores, the order owing its evolutionary success almost entirely to the adaptative abilities of individual species to overcome the chemical antiherbivore defences of living angiosperm land plants (Janz, 2011). Moreover, many adult Lepidoptera are nectivores that possess specially modified mouthparts for the purpose, and it would not be easy for insects with this dual feeding strategy to make a living in a marine environment. Although some angiosperms are plentiful in the sea (Heck *et al.*, 2006), their secondary chemistry is entirely different from that of terrestrial angiosperms (Zidorn, 2016), their flowers do not secrete nectar, and there are no known specialist pollinators in the sea.

Marine lice and other parasites

One group of insects that has been conspicuously successful in colonising the sea is the parasitic lice (Phthiraptera) found within the order Psocodea. The WoRMS database lists no fewer than 277 marine species of lice. Although Phthiraptera are indeed diverse, whether on land or at sea, the order Psocodea represents less than 1% of all described insects (Stork, 2017), so that lice appear to be overrepresented among marine hexapods by almost twenty-fold. There are three major superfamilies of parasitic lice: Ichnocera, made up mostly of specialist parasites of birds; another, Anoplura, found only on mammals, while a third group, Amblycera, comprises parasites of both birds and mammals (Johnson *et al.*, 2018). In general, bird lice eat feathers, but mammalian lice drink their hosts' blood. Parasitic lice in general have narrow host ranges, and those parasitising sea-going birds and mammals are not found on non-marine hosts (Murray, 1976). Although lice have diversified at a greater rate than other animals, including the vertebrate hosts they parasitise (Johnson, 2022), the large number of marine psocodean species is due to the fact that there are so many different kinds of sea-going birds and mammals. There are more than 550 species of seabirds in 30 families (Hackett *et al.*, 2008) all of which come on shore to breed (many in large, closely packed colonies), where they are particularly subject to parasitism by insects, especially lice. There are fewer marine mammals but there are nevertheless 134 species in 21 families (Society for Marine Mammalogy, 2022); while most of these are whales, dolphins *etc.* (cetaceans) living entirely in the sea and therefore free of psocodean ectoparasites, there are still 35 species of pinniped in three families (seals, sea lions and walruses), all of which haul out of the sea to breed, when they acquire and exchange specialised siphonapteran ectoparasites.

Interestingly, like their hosts, marine lice do not reproduce in the sea, but synchronise their reproduction with that of their hosts, so that their eggs and immature stages are not exposed to immersion in sea water at all during the period while their hosts are out of the water. Phylogenetic analysis shows that repeated host switching has occurred frequently during the evolution of bird lice, but there is less evidence for this in lice parasitising mammalian hosts. Interestingly, lice that infest pinnipeds (seals) appear to have co-evolved with their hosts (Leonardi *et al.*, 2019), presumably because they are mostly vertically transmitted from the mother, with only very limited opportunities for the parasite to come into contact with other potential host species (Leonardi *et al.*, 2013).

Sea-going lice have special adaptations to enable their parasitic lifestyle. Obviously, they must be able to cling onto the feathers or fur of their hosts under mechanically challenging circumstances, and like all other lice they have developed specially modified appendages for this purpose. Like other insects, lice need to moult their exoskeleton as they grow and develop (and I for one would like to know how they manage this). But a greater challenge must be to survive immersion in seawater. The deepest pinniped dives are those of Southern Elephant Seals (*Mirounga leonina*), which dive to 2,000 m (20.31 MPa) and may remain underwater for up to two hours (McIntyre *et al.*, 2010). Clearly, their specialised lice, *Lepidophthirus macrorhini* (Fig. 8), must also be able to tolerate such pressures and Leonardi *et al.* (2020; 2022) have shown experimentally that this is the case.

Lice are not the only hexapods associated with the sea through parasitism, or some other kind of phoretic relationship with larger vertebrate seagoing animals. Aboard HMS Beagle, on February 16th 1832, Charles Darwin put ashore on the remote St Paul's Rocks, a tiny Atlantic archipelago (0° 58' N, 29° 15' W) 870 km from the coast of S. America and 560 km from the nearest island. There he found a "vast multitude" of nesting seabirds. He noted (Darwin, 1845, p10): "*Not a single plant, not even a lichen, grows on this islet; yet it is inhabited by several insects and spiders*". Among the several kinds of insect he found in and around the nests of Brown Boobies (*Sula leucogaster*) was an ectoparasitic hippoboscid (often called a 'louse fly'); probably it was *Olfersia aenescens* (see Smith, 1987). This biting insect occurs widely at low latitudes and is frequently associated with seabirds. Although it has functional wings, it rarely flies or indeed leaves its host at all. Darwin also found a tick at the same site, also associated with seabird nests. Unfortunately, the tick specimen that Darwin collected has not survived; it might have been the hard tick *Ixodes uriae*, but a more likely candidate is the soft tick *Carios capensis*, which has since been recorded from the location. Both of these ticks specialise in parasitising seabirds and use the Brown Booby as a host (Dietrich *et al.*, 2011).

Okamura *et al.* (2022) have observed that evolutionary transitions between freshwater and marine environments are particularly common among endoparasites. The data from marine lice, however, imply that such transitions between the realms of life may also occur frequently in ectoparasites. If this is so, then is it of ecological significance? Although marine lice and other arthropod ectoparasites come in many different kinds, I suggest that they probably contribute little to marine ecosystems, either in terms of their absolute numbers and biomass, or the flow of materials and energy through them. On the other hand, it is possible that that lice and other arthropod ectoparasites may exert significant indirect effects on seabird and sea mammal populations by acting as disease vectors (Hirzmann *et al.*, 2021; Ebmer *et al.*, 2022).

Halobates: ocean going water striders

If there is a convincing exception to Gosse's 'rule' that insects don't live in the sea, then surely it is the genus *Halobates*. There are numerous estuarine representatives of this genus, all of which live on the surface of the water during all of their lives. But five species have colonised the open sea and never return to the land at all, even to reproduce (Andersen *et al.*, 1999; Cheng *et al.*, 2022). Although discovered and described in the first quarter of the 19th century (Eschscholz, 1822), the first report of a *Halobates* species (now designated *H. micans*) in an English journal was that of Templeton (1835). But no proper account of the biology of *Halobates* as a permanent resident of the ocean surface was given until more than 50 years after its discovery, when White (1883) described the entomological findings of the 1872 global scientific expedition of HMS *Challenger* (Fig. 4).

This raises the question of why Charles Darwin, who spent 5 years at sea (1831–1836), and was a keen entomologist, failed to notice *Halobates*. Had he seen this charismatic insect, he would certainly have mentioned it in *The Voyage of the Beagle* (Darwin, 1845). Cheng *et al.* (2011) have pointed out that Darwin did not systematically sample the ocean surface with a net. As for spotting it visually on the surface, why would he have looked for it there if he did not already know about it? And anyway, *Halobates* is tiny, inconspicuous and patchily distributed, fast-moving and readily submerging when alarmed. Had Darwin been aware of Templeton's paper (published during the Beagle's voyage), he would doubtless have looked for *Halobates*. It must originally have been hard for entomologists of the time to overcome the prejudice that insects do not belong on the surface of the ocean. Even Templeton himself believed that *Halobates* was not really an open-sea insect, suggesting that the insects that he had captured in mid-Atlantic may have been driven away from the shore of Africa by a south-easterly gale.

We now know that ocean-going species of *Halobates* have a worldwide distribution across all tropical oceans. Their populations are not numerous compared with the most successful terrestrial insects; according to Nakajo *et al.* (2013), *Halobates* spp. may reach densities of 86,000 adults km^{-2}, which sounds like a lot, but this actually represents less than one insect in a sea area of 100 m^2. Nevertheless, with such a large area of habitat to exploit (total tropical ocean area is in the order of 170 x 10^6 km^2), there are probably billions of individual *Halobates*.

Fig. 8. The Elephant Seal Louse, *Lepidophthirus macrorhini*. Photo from Frost Entomological Museum, CC-BY-2.0
https://commons.wikimedia.org/wiki/File:Lepidophthirus_macrorhini.jpg

The unexceptional: why are most insects excluded from the oceans?

Ever since the existence of insects living in or close to the sea was first discovered, their scanty diversity has been a popular topic for speculation by both entomologists and marine biologists. Are these insects really 'exceptional' as Gosse (1855) suggested? The issue came into sharp focus in 1976 with the publication of what remains the only monograph on the subject, *Marine Insects*, edited by Lanna Cheng of the Scripps Institution of Oceanography in La Jolla, California. The question of why most insects (presumably the 'unexceptional' ones) fail to prosper in the sea recurs repeatedly in the book's 19 chapters. Its title begs the question, are there any truly marine insects at all? Even Cheng, still the doyenne of those who study marine insects, admitted in her Introduction that "*as far as we know, no marine insects remain submerged throughout their lives*" (Cheng, 1976). Even the five *Halobates* spp. that manage to live full time in the open ocean avoid becoming immersed and can only lay their eggs on floating materials (Andersen *et al.*, 1976). It was once claimed that the four species of the marine chironomid genus *Pontomyia* lived and reproduced entirely under the surface of the sea (Edwards, 1926), but it is now known that the flies leave the water to mate and lay their eggs (Huang *et al.*, 2011). Thus, not a single one of those usually described as a 'marine insect' occupies a niche that is fully immersed. Marine insects may survive occasional or even regular prolonged submersion in seawater, but sooner or later it seems that almost all of them must leave it, either to complete their development or to reproduce. In this sense, insects appear to have failed where other essentially terrestrial animal classes such reptiles (sea-snakes) and mammals (dolphins and whales) have succeeded in returning at least some representatives full-time to the ocean.

Many commentators have attempted to 'explain' the comparative lack of success of insects in exploiting the oceans in adaptive terms; in other words, they consider the problem in terms of the physiological, ecological or developmental problems faced by hexapods attempting to live in the sea. The continuing interest in this topic is quite natural if we are interested in insect evolution. If we can identify the adaptations that have enabled just a few exceptional insects to colonise the sea, then we will have made significant progress towards understanding why the vast majority of hexapods have failed to do so.

I won't look here in any detail at particular hypothetical adaptive traits, but I will list a few of them. Evans *et al.* (1971) showed experimentally that when saltmarsh beetles are submerged by the tide and thus deprived of oxygen, they react by ceasing to move, but nevertheless incur an oxygen debt; but some marine insects overcome this limitation in the same way as scuba divers, and as early as 1835 the pioneering entomologist William Spence drew attention to the fact that some marine beetles carry down air bubbles when they are submerged, commenting that they "*alternately decompose and renew the small bubble of air*". Carpenter (1928, p282) commented on the small size and winglessness of many marine insects; Mahadik *et al*. (2020) drew attention to the extreme hydrophobicity of some marine insect cuticles, as well as the presence of comb-like assemblages of long cuticular hairs to support the insect on the surface; Hinton (1966) documented the use by many marine insects of arrays of short cuticular hairs that allow plastron respiration; while Bradley *et al.* (2009) noted salt transport across the wall of the hindgut. As well as adaptation to physical aspects of the environment, biotic interactions may also be important. Buxton (1926) and Van der Hage (1996) proposed that a lack of angiosperm plants in the sea was a limitation, although this idea was criticised by Ollerton *et al.* (1998) on the ground that angiosperms are evolutionary newcomers compared to the Hexapoda. Nevertheless, I suggest that this factor may have been particularly important in preventing the adaptation of Lepidoptera to enter the sea. One of the strongest cases for a single limiting factor was made by Maddrell (1998), who argued that the air-filled tracheal system of insects imposes a serious limitation on their ability to dive and thus avoid predators; although the physiological problems of a tracheal system are undoubtedly present, Ruxton *et al.* (2007) subsequently pointed out that there are many alternative antipredator strategies available to aspiring colonists of marine habitats.

I concur with Ruxton *et al.* (2007) in their conclusion that no single adaptive explanation is completely satisfactory, and the existence of obvious exceptions implies that each of the suggested, supposedly insuperable, difficulties can in fact be overcome.

Irreversible evolution? Marine insects as exceptions to the rule?

If we can agree that for a present-day insect or apterygote to recolonise the sea must require it to recover at least some of the adaptive traits that allowed its remote ancestors to live in the ocean, then we face a problem. Can evolution ever be 'reversed' in order to adapt to a habitat previously abandoned?

In 1893, the Belgian biologist Louis Dollo (1893) proposed that "*an organism cannot return, even partially, to an anterior state already realised in the series of its ancestors*" (my translation). It is now generally agreed that to be seriously considered, Dollo's Law must be modified to refer only to 'sufficiently complex traits' (Gould, 1970; Goldberg *et al.*, 2008). The real issue is one of homology (Collin *et al.*, 2008). If an ancestor and a descendent both possess the ability to live in the sea, but are separated in the phylogenetic tree that connects them by at least one organism that did not possess that adaptive trait, then is it the case that evolution has recreated the original (*i.e.*, homologous) trait in the way that Dollo's Law prohibits? Or is the resumption of the ancestral marine condition merely the result of convergent evolution? The assumption behind the modern version of Dollo's Law is that a newly emergent 'sufficiently complex trait' could not be identical to the original on statistical grounds.

Collin *et al.* (2008), however, suggest that identity does not need to extend to every last codon of the relevant genes, and that re-evolved adaptive traits may be said to be homologous if their expression is governed by the same regulatory gene network (RGN) as the ancestral character. RGNs preserve their function despite differing in detail between species (Davidson *et al.*, 2005). It is not unlikely that modern hexapods might well retain RGNs with the same function as were originally present in their crustacean ancestors to preside over the suite of adaptive responses to, *e.g.*, salinity; these would have been preserved because the network's genes were always required, *e.g.*, when living in periodically dry environments, as experienced by a large fraction of terrestrial species. In that case, it would indeed be true that in regaining the ability to live in the sea, a formerly terrestrial insect might be 'reversing evolution' and would thus be an exception to Dollo's Conjecture, which could no longer claim the status of a 'law'.

Nevertheless, we might still consider that it is at least less likely that the RGN governing a highly-derived trait that is adaptive in one realm of the biosphere could be successfully transformed so that it is adaptive in another realm of the biosphere. This would mean that evolutionary transitions from one realm to another occur less frequently. This general approach to investigating the evolution of marine insects seems to me to be interesting but challenging, as we don't yet have much information about the RGNs that govern the relevant traits.

Ecological explanations

The difficulty or cost of adapting to physical conditions may in any case not be relevant to the question of how a few 'exceptional' insects have recolonised the sea. In two closely argued but perhaps rather speculative essays on the subject, Vermeij *et al.* (2000) and Vermeij (2020) shrug off most previous speculation about such traits to put forward two mainly ecological explanations for the paucity of the marine insect fauna. First, they reiterate what they call the 'incumbency hypothesis', which suggests that it is difficult for colonists in a new habitat to

displace those species that are already well adapted to it. This is in effect the other side of the coin of the 'empty niche' hypothesis of biological invasions. Second, they compare the diversity of marine and freshwater insects, pointing out that the latter are at least ten times more speciose than those in the sea. They attribute this largely to the greater possibility of escaping predation in small bodies of fresh water, speculating that the greater diversity of ecological conditions in freshwater may be responsible for this disparity. To some extent this may be the result of the 'island' nature of small lakes and streams, which may not be large enough to support resident populations of predators, and it is true that aquatic insects do much less well in large lakes than in small ones.

Vermeij (2020) goes on to propose that the functional roles played by insects and other small terrestrial arthropods in terrestrial ecosystems may place them in a disadvantageous starting position from which to invade marine habitats; these roles "*emphasise high locomotor performance and long-distance communication, traits that work less well in the denser, more viscous medium of water*". One can hardly challenge the first part of this statement as a concise and percipient summary of why insects have been successful on land, but is it really true that these traits are less useful in marine habitats? Perhaps.

Competitiveness thus emerges as a central issue in understanding the apparent exclusion of insects from the oceans. Vermeij (2020) observes that "*Unlike the spread of species into physically similar but previously unoccupied geographical regions, transitions among realms generally involve species that were not powerful competitors in their ancestral realm… High competitive status in any one realm, therefore, evolves in that realm and is not the direct consequence of colonization.*"

But how could this essentially qualitative argument be turned into a testable hypothesis? There is little consensus on how to measure competitiveness between species in natural environments (Hart *et al.*, 2018). An indirect approach would be to compare speciation rates in marine, freshwater and terrestrial hexapods, as did Davis *et al.* (2022) for Crustacea, finding that speciation rate in terrestrial lineages is significantly greater than in freshwater or marine habitats. I hope that someone will attempt a similar project for hexapods. But even this approach would still have to infer competitiveness from a different parameter.

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The challenges of rewilding for insects in urban and suburban Britain: a case study in Carlisle

Figure 1. Established wildflower meadow with woodland area.

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The term 'rewilding' has been defined in a number of ways, but most commonly refers to a *'process of rebuilding a natural ecosystem by restoring natural processes and the complete or near complete food web at all trophic levels… rewilded ecosystems should require no or minimal management whilst recognising also that ecosystems are dynamic'* (Carver *et al.*, 2021). There is a rapidly increasing number of rewilding projects globally, including many in the UK (Jepson, 2016), and a corresponding recognition that longer-term project monitoring and evaluation are required (AECOM, 2022).

The origins of rewilding are rooted in a (largely) North American view of landscape-scale conservation, which does not necessarily translate readily to the UK, where smaller-scale peri-urban/urban landscapes can also provide a range of conservation benefits, not least in terms of enhanced connectivity. Rewilding projects also tend to focus on large, charismatic and highly interactive species such as wolves and beavers, with the role of functionally-important groups such as invertebrates frequently overlooked; the so-called 'unseen majority' (Contos *et al.*, 2021). This article focusses on this very problem, and one such case study in Carlisle, a city in northwest England.

There is compelling evidence (globally and in the UK) that insect populations are in decline. One recent estimate in the UK suggested a 58% loss in abundance between 2004 and 2021, using data based on insects "splatted" on car number plates (Ball *et al.*, 2022). These declines are caused by several interacting factors such as habitat loss (and associated urbanisation), intensive land use, agro-chemicals, urban heat island effect and invasive plant species (Fenoglio *et al.*, 2021). This is potentially a global catastrophe. There is, however, a silver lining to this cloud. It is often difficult (and potentially dangerous) to involve the public in rewilding projects involving large animals; insect-based rewilding projects, on the other hand, offer an excellent opportunity for accessible, local, public education and engagement.

Urban centres, with their greater population density and accessibility, can make ideal locations for conservation efforts involving the public. Spending time in nature provides mental and physical health benefits, but urban communities, particularly in lower income areas, usually have to travel far to access green spaces (Lachowycz and Jones, 2013; Dadvand and Nieuwenhuijsen, 2019; Mears and Brindley, 2019). Thus, urban rewilding is a win–win scenario, benefitting both insects and people.

Carlisle is a relatively green city (in a 2022 study by Exubia, it was ranked the 7th 'greenest city' in the UK) and, with areas of high deprivation, there is good potential for community-based nature engagement. In 2020, Carlisle City Council and Cumbria Wildlife Trust acquired a 17-hectare former golf course site in the city centre (close to the River Eden) with a view to restoring the site as the 'Swifts Nature Reserve'. Golf courses are not renowned for high biodiversity value; they tend to be privately owned with restricted public access and are often heavily planted with non-native species that do not benefit native insect fauna. However, as with many conservation issues, this is very much context-specific, and in urban areas they can provide a level of biodiversity benefit (Colding and Folke, 2009).

Insect conservation projects integrating the human community require significant engagement in order to gain acceptance, ownership and participation. In urban and suburban settings, green roofs and green walls are becoming increasingly common (Bates *et al.*, 2013); restorative changes to habitats, however, are somewhat rarer but gaining momentum for insect conservation (Lehmann, 2021). They also present a unique set of challenges, not least that the public may perceive restoration processes as 'messy' or 'lazy management'. Getting the public on side with the 'messy phases' of ecological restoration, identified here as the transitional stage between the initial intervention and the desired community ecotype, requires significant work (Filibeck *et al.*, 2016).

Throughout 2021–2022, Carlisle City Council and Cumbria Wildlife Trust were involved in several restoration interventions at the Swifts site, which are ongoing and still transitional. These include reduced mowing, wildflower planting and seed sowing (including red clover and yellow rattle to improve the meadow for pollinators), planting native trees and removing non-native species. The site was developed into both wet meadows with scrapes to hold water over winter, and traditional wildflower meadow with small patches of woodland (Figs 1–2).

In order to address negative community perceptions of the land-use change and 'messy' phase of regeneration, Cumbria City Council, the University of Cumbria and Cumbria Wildlife Trust (via their Get Cumbria Buzzing project, www.wildlifetrusts.org/get-cumbria-buzzing) developed a series of community events and interactions. A pollinator festival was launched over summer 2021, which hosted several events on the site in order to communicate the aims of the project and engage the community in the work being undertaken. Information boards were erected on the Swifts site, and management was orientated towards community use (*e.g.*, mowing paths and improving drainage). Site management was also integrated into the zoology curriculum at the University of Cumbria, and several students developed Swifts-focused dissertation projects over the summers of 2021 and 2022. The aim of this was to give the students experience of real-world conservation near to their place of study (the site is less than 15 minutes' walk from campus) and to provide the project with more visibility, with local students and staff working on the site year-round, talking to the public, highlighting the insect benefits of site restoration and, in the process, helping to mitigate public concerns around the 'messy phase' of restoration (Fig. 3).

Insects proved to be useful as both indicator species and tools for teaching identification skills, and site-specific learning was integrated into other zoology modules, including activities such as designing and conducting surveys and order-level insect identification. The students picked up some valuable species-level identification skills working on the site, monitoring specific taxa such as ground beetles, butterflies, leafhoppers and planthoppers.

In 2021, ongoing monitoring proved successful, with ten species of butterfly regularly recorded throughout the summer, 21 species of ground beetle recorded summer to autumn, and 15 species of leafhopper, planthopper and froghopper recorded throughout spring and summer. Generally, these were common species, so

Figure 2. Patches of Red Clover planted on the site.

their presence was not unexpected, but these data provide a valuable baseline for the site.

Another important take-home message is that as the students got to know the site and the local community, they became ambassadors for positive change. They also developed good entomology skills and the ability to identify a range of insects. The lessons from this project are scalable and transferable; students can play an important role in site restoration and there is potential for student groups across the UK to get involved in similar projects on their doorstep. It is hoped that further student field visits and dissertation projects will help supplement the monitoring of the site as it matures, producing some good-quality, long-term data that can feed into the management of the site. Therefore, students can provide a tremendous opportunity and are a relatively untapped resource that can be used more widely to assist in evidence gathering for these community conservation projects.

Figure 3. Alex Dittrich sorting insects in the field.

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ARTICLE

Edda with Maria's book in the RES Library.

Maria Merian – extraordinary entomologist

I was inspired to find out more about Maria Merian at school when we did a lesson on her in science, and I came home and told my parents. From that day on I was very interested in her life. I may not have been interested in insects for a long time, but insects (and arachnids) are very intriguing, and I will always want to know more about insects. My favourite life stage of insects is caterpillars because of their fascinating colours and how they move; it's just amazing.

See below if you want to know more about Anna Maria Sibylla Merian. I am intrigued by her, and you should be too.

Maria Merian was born on the 2nd of April 1647 in Frankfurt, Germany. Maria's father died when she was three years old in June 1650. Later, her mother married a man called Jacob Marrel, known for his detailed artwork. Her full name is Anna Maria Sibylla Merian and her mother, who was called Johanna Catherine Sibylla, was an important part of Maria's life. Maria was interested in insects from a young age; she would capture silkworms to spy and witness their movements. She had a silkworm farm.

Maria was a young artist and loved to paint with watercolours; at that time women were not allowed to use oil paints. She would illustrate her sightings and would stare at insects all day long! Since her stepfather was an artist, he encouraged Maria to be an artist and illustrator. Maria sometimes captured insects (mostly caterpillars so she could see them metamorphose into butterflies) because she enjoyed seeing bugs in their natural habitat. She also had a special bug-catching net. As a result of her work, she was exceptionally smart with many ideas: discovering metamorphosis, publishing her discoveries and more!

After a while, Maria discovered metamorphosis, *meta* meaning change, *morph* meaning shape, and *osis* meaning state. Maria was interested in many aspects of entomology. She was a bright young woman with many ideas. She published her first book in 1679 and it was a two-volume book.

Maria married one of her stepfather's students, although their marriage didn't last long. Maria didn't want to hear the click of the clock, she wanted to hear the buzz of the bees and the flutter of the butterflies. She was a beautiful beetle strutting the world of entomology; she recorded and illustrated 186 species of insects and described the life cycle of over two hundred species of insects and amphibians. She went on a voyage to Suriname with her daughter, but later in her travels she got malaria and had to travel back to Germany for proper care. She was an ambitious lady. Maria died after suffering a stroke on the 13th of January 1717.

David Attenborough said about Maria "She was an amazing contributor to the field of entomology." Her legacy is unforgettable. She was very young when she discovered metamorphosis. People have known her for a long time; after all she died 300 years ago.

She was a miraculous person with many ideas: disproving a Greek myth (people used to think that insects came from the mud!), discovering metamorphosis and more. She was the only known female to make a scientific illustration workshop in her time!

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Paragraph from Edda's teacher

We were working on a science unit called Living Things and Animals in Year 5. Alongside that, we were learning how to structure and write biographies in English. As a class we had looked at the life of David Attenborough and the children loved this. However, for their independent piece of writing the children had a choice of which naturalist they could research and later write about. The majority of the class chose Steve Backshall, Greta Thunberg or Hamza Yassin. Edda decided to link her knowledge from her science lessons to her English and opted to further research Maria Merian, which was a fabulous choice. Once the children had written their biographies, they then performed them to the class, which was a delightful way to finish the unit and showed their writing off beautifully.

Mrs Mercer

Entomology in Higher Education: United Kingdom perspective

Insects play central roles in our natural world, agro-ecosystems (Gallai *et al.*, 2009), and the justice system through forensic entomology (Catts and Goff, 1992; Lutz *et al.*, 2021). Insects have also made immense contributions to fine art, textiles (Lee, 1948; Campana *et al.*, 2015) and music such as Nikolai Rimsky-Korsakov's *Flight of the Bumblebee*. Modern forms of media have also taken inspiration from insects. From the insect ecology-inspired video game Pokémon (Acorn, 2009), to insect anatomy inspiring the spaceships in *Star Wars* films (Entomology Today, 2018).

In 2016, 41.6% of United Kingdom (UK) Science, Technology, Engineering and Mathematics (STEM) graduates were in a STEM-related occupation or further education six months after graduation (National Audit Office, 2018). This, in conjunction with insects' impact on society both within and outside of science, highlights the importance of insect-related teaching in higher education.

Despite the importance of entomology, Leather (2007) highlighted the lack of Entomology university departments and degree courses in the UK. Entomology is typically characterised as part of Zoology in Higher Education Institutes (HEIs). Over-representation of zoologists specialising in vertebrate organisms (Leather and Quicke, 2009) and resistance to establishing invertebrate groups (Shardlow, 2012) can lead to decreased insect teaching at HEIs (Cuisance and Rioux, 2004; Leather, 2007).

The over-representation of vertebrate zoology (Leather and Quicke, 2009) indicates a poor state of insect-related teaching at HEIs. Here, an investigation into the prevalence of 'insect modules' and 'invertebrate modules' within 282 undergraduate and 91 postgraduate UK courses for the 2023/24 academic year is reported. A module was designated an 'insect module' if the module title and/or description entailed entomology or mentioned a specific insect (Latin and/or common name). Some modules had little or no description, making it difficult to ascertain whether insects were studied. To account partially for this, the presence of 'invertebrate modules' was also investigated. A module was designated as an 'invertebrate module' if the module title and/or description mentioned the word 'invertebrate'. Insects may be studied within invertebrate modules, but it is not guaranteed.

All course curricula investigated were from the following scientific disciplines: Agriculture, Biochemistry, Biodiversity and Conservation, Biology, Ecology, Forestry, Horticulture, Natural Sciences, Plant Sciences and Zoology. Due to low numbers of postgraduate Plant Sciences, Biochemistry and Advanced Biology/Biological Sciences courses investigated, these subjects were combined into 'Biological Sciences'. For the same reason, Forestry and Horticulture courses were also combined under 'Forestry & Horticulture'.

Most of the 282 undergraduate course curricula investigated offered no insect modules (70.6%) and no invertebrate modules (65.2%) (Fig. 1a, b). The prevalence of insect and invertebrate modules varied between scientific disciplines. Forestry & Horticulture and Biochemistry courses had the lowest representation of insect modules (Fig. 2a). Forestry & Horticulture, and Agriculture courses had the lowest representation of invertebrate modules (Fig. 2b). Plant Sciences and Zoology courses had the highest representation of insect and invertebrate modules (Fig. 2a, b).

The vast majority of the 91 postgraduate course curricula investigated had no insect modules (83.5%) and no invertebrate modules (91.2%) (Fig. 1c, d). Forestry & Horticulture, Biodiversity & Conservation and Zoology courses had the lowest representation of insect modules, whereas Agriculture and Ecology had the highest representation of insect modules (Fig. 2c). Forestry & Horticulture, and Agriculture courses had no invertebrate modules. Ecology and Zoology had the highest representation of invertebrate modules (Fig. 2d).

As this investigation was based on module titles and descriptions provided by HEIs, the self-reporting nature of this may mask the true presence of insect teaching at HEIs. However, it gives an indication that explicitly insect and invertebrate modules are lacking at UK HEIs.

Undergraduate Biodiversity & Conservation and Biochemistry courses had the lowest representation of insect modules despite many of these HEIs offering insect and/or invertebrate modules in Biology, Ecology and/or Zoology courses. Widening the availability of mandatory insect and invertebrate modules from Agriculture, Ecology, Biology, and/or Zoology courses to Plant Sciences resulted in all investigated Plant Sciences courses offering at least one insect or invertebrate module. Whilst timetabling may present some challenges, this would be an effective and low-cost way to increase the presence of insect and invertebrate modules in disciplines where they are currently lacking.

Forestry & Horticulture had no insect or invertebrate modules and were more prevalent at specialised HEIs. These HEIs may not have in-house expertise to deliver insect/invertebrate modules, so guest lecturers from other HEIs could provide insect-related teaching (Lucky *et al.*, 2019). Making initial connections may take considerable time and effort from course managers but could be beneficial for both students and HEIs by creating inter-HEI connections.

Postgraduate courses had lower representation of insect and invertebrate modules than undergraduate courses. Entomology is an inter-disciplinary subject, so even within the more specialised postgraduate courses, insect modules would still be relevant. Guest lectures and wide availability of insect modules could increase insect and invertebrate module presence in the short-term. A more sustainable and long-term implementation would be for HEIs to invest in teaching and research expertise to deliver such modules.

Vertebratism (preference for vertebrate funding and research) (Clark and May, 2002; Leather, 2008, 2009, 2013) may partially explain the low representation of insect modules in Biodiversity & Conservation courses particularly at postgraduate level. There is a need for more taxonomists but particularly invertebrate taxonomists. In 2021, 39% fewer Red List invertebrate and Arthropoda population trends were assessed than Chordata populations (IUCN, 2021). The shortage of people with insect taxonomic and conservation skills affects our ability to conserve insects (Clausnitzer *et al.*, 2009; Leather, 2013). In-depth insect conservation teaching would require many laboratory and field practicals, which some HEIs may not be able to provide. This gap could be filled by a UK Entomology summer school similar to that of

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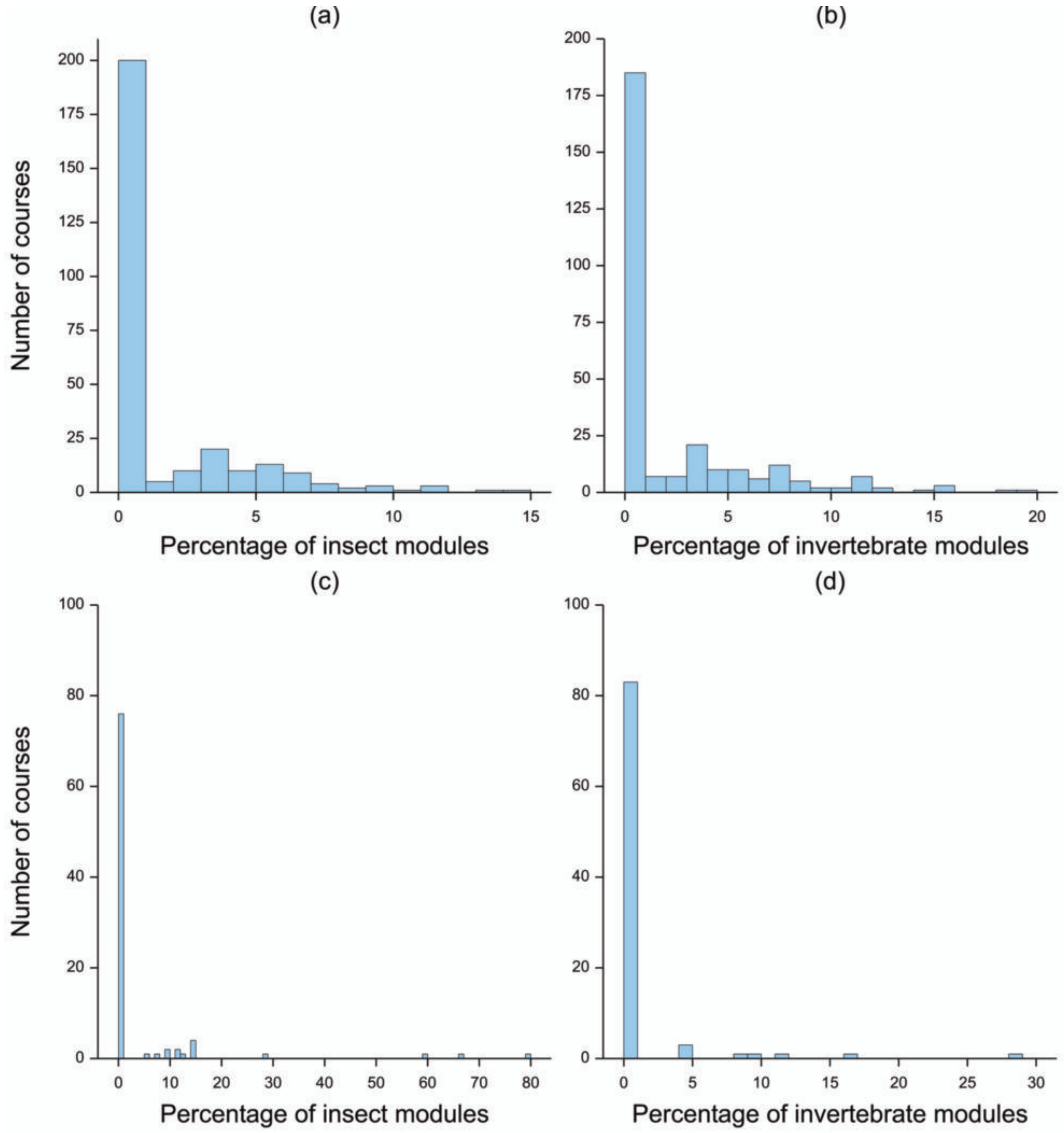

Figure 1. Percentage of modules that were assigned as **a)** insect modules **b)** invertebrate modules across 282 undergraduate courses and **c)** insect modules **d)** invertebrate modules across 91 postgraduate courses at Higher Education Institutes in the United Kingdom.

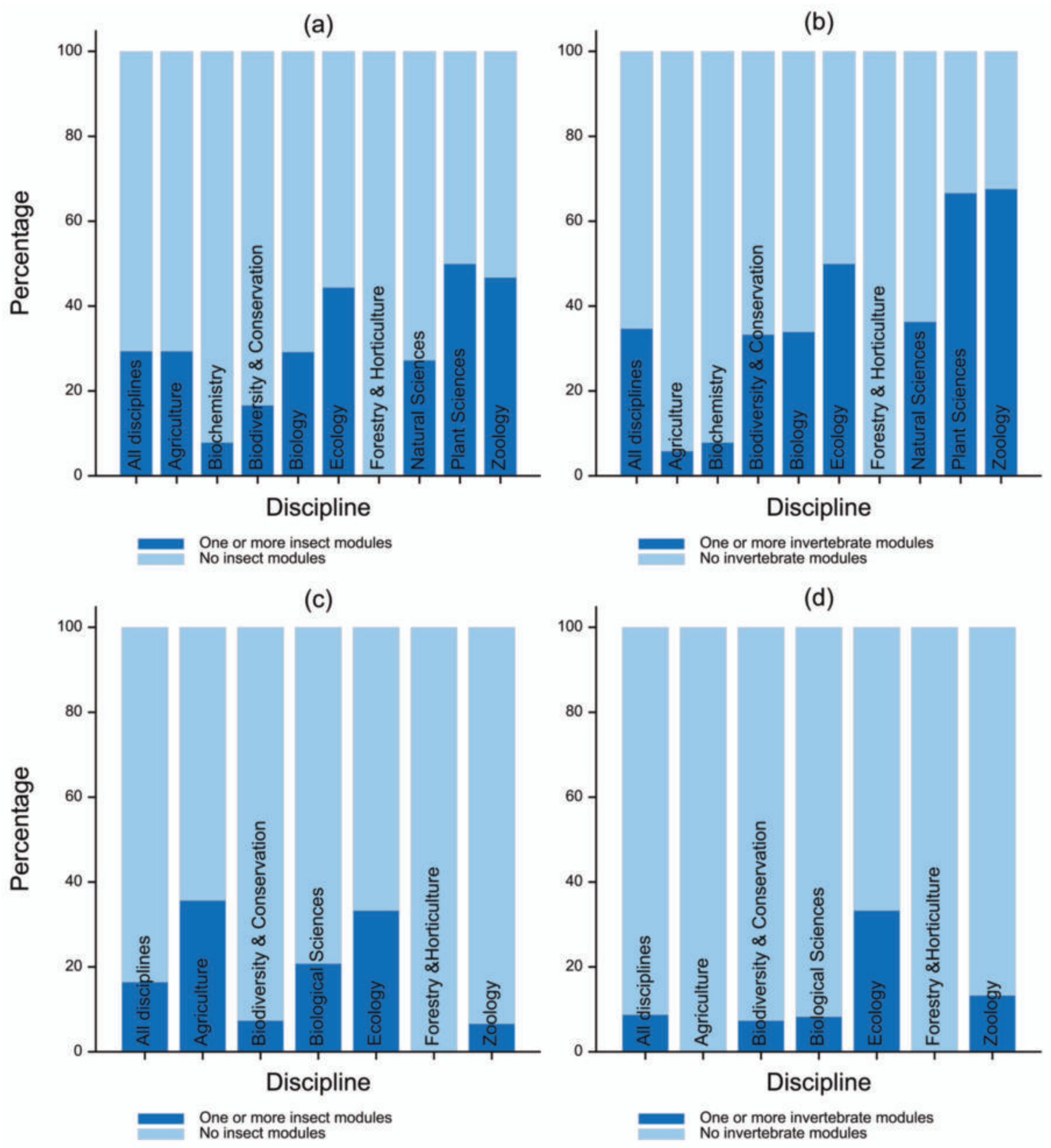

Figure 2. Percentage of courses within a scientific discipline that contain any **a)** insect modules **b)** invertebrate modules across 282 undergraduate course curricula **c)** insect modules **d)** invertebrate modules across 91 postgraduate course curricula at Higher Education Institutes in the United Kingdom.

The Gatsby Plant Science Summer School which is a week-long intensive program for undergraduate students (https://www.gatsby.org.uk/plant-science/programmes/gatsby-plant-science-summer-school).

This work has shown that most UK undergraduate and postgraduate courses are not offering explicitly insect or invertebrate modules. Increasing the prevalence of entomology teaching at HEIs would require significant changes to ensure students finish higher education with insect knowledge that can contribute to the next generation of insect-inspired science, conservation, and art.

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OPINION PIECES

Institutional vertebratism is alive (and kicking invertebrates)

Sciapus platypterus (Fabricius) Dolichopodidae is one of the few 'long-legged flies' that might be recognised from a photograph. It is widespread and sometimes common but only about 6 mm long. Photograph Brian Valentine.

Introduction

Over a decade after the late Simon Leather coined the phrase 'Institutional Vertebratism' (Leather, 2009), what has changed in Great Britain? Simon Leather's contention was that funding and protection measures for animal conservation were grossly biased towards vertebrates, and that invertebrates (with a few charismatic exceptions) were almost invisible; a systemic inequality that had been widely recognised previously (*e.g.*, Gaston and May, 1992; Bonnet *et al.*, 2002; Clark and May, 2002).

Simon Leather argued that this lack of invertebrate representation was mainly due to their low visibility within professional and public arenas. There are a few exceptions; butterflies, for example, have been described as 'complementary' to birds and bats (Defra, 2021), but why should this be so, apart from the degree to which they attract public interest and detailed monitoring? These 'accessible' insects can hardly be said to represent overall insect biodiversity in Britain. Butterflies (59 species) represent 1 in every 700 invertebrate species whereas one in six species is a fly (7,100+ species).

Whilst adult butterflies are easily identified, their larvae have very similar life-strategies, as they are almost entirely plant eaters. How do they represent consumers of waste material, filter-feeders or predators and parasites? There are two obvious reasons for elevating butterflies to honorary membership of the vertebrate world: they are amongst the few insect taxa for which there are sufficient data to undertake detailed long-term analyses; furthermore, they have a high public profile because many can be identified with ease in the field or from good photographs.

Whilst it might be inferred that poorly-known British insects are irrelevant, many are superb indicators of environmental health, *e.g.*, the abundance of craneflies on upland blanket bog. There is good evidence (Carroll *et al.*, 2011; 2015) that where such bogs are re-wetted, cranefly abundance increases, as does breeding success of European Golden Plover (*Pluvialis apricaria* (Linnaeus)) and Dunlin (*Calidris alpina* (Linnaeus)). Insects provide a far more complex web of life-histories but they have few champions in the world of professional nature conservation and so are largely ignored.

Ignorance translated into action

The process of defining Red Lists for Britain's wildlife has evolved. Methods developed for plants, for which good distributional data existed from early recording for the monumental atlas of Britain's plants (Perring and Walters, 1962), were applied to invertebrates. Five classes of threat were used: Red Data Book 1–3 and Nationally Scarce A & B. The first two invertebrate Red Data Books (Shirt, 1987; Bratton, 1991) were followed by a set of species status reviews published in the early 1990s.

IUCN threat criteria based on population statistics – an estimate of population size and an analysis of rates of decline – have subsequently been adopted for all taxa in Britain. Mammals and birds attract a lot of research funding and abundant observations from a network of volunteer recorders and eco-tourists. This is not the case for all invertebrates.

Using these criteria to assess populations of insects may make

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Stag Beetle *Lucanus cervus* (Linnaeus) is potentially threatened by over-collecting and may warrant legal protection. Photograph Roger Morris.

sense for butterflies and dragonflies, for which comprehensive data exist. However, the rationale for applying them to animals studied by a small minority of people makes much less sense. Why is it assumed that the twenty or thirty people who study and record relatively obscure families of insects such as fungus gnats, the long-legged, metallic green dolichopodid flies or snail-killing flies can generate data sufficient to match those obtained for butterflies or birds? The data are not in any meaningful way comparable: butterfly recording generates hundreds of thousands of records per year, whereas for many insect families 5,000–10,000 records would be a good year. Bearing in mind that these families often comprise several hundred species, the comparison becomes even more ludicrous.

How can the IUCN approach be applied to insects that have been recorded on a handful of occasions over a period of several decades? Rare or under-recorded species often have lifestyles that make them extremely difficult to locate, let alone count. For example, there are insect guilds living in grass tussocks that can only be sampled using a suction sampler. The people who have the technical skills and interest to investigate this fauna are probably better described as 'critically endangered' than the insects they study!

Table 1. Main provisions of Schedule 5 of the Wildlife and Countryside Act, 1981.

Animals which are protected from killing and taking	Schedule 5 – Section 9.1
Animals which are protected from possession	Schedule 5 – Section 9.2
Animals which are protected from intentional damage or destruction to any structure or place used for shelter or protection	Schedule 5 – Section 9.4
Animals which are protected from sale	Schedule 5 – Section 9.5

Assumptions based upon vertebrate ecology now extend further into wildlife law. For example, this year's stakeholder consultation for the 7th quinquennial review of the Wildlife & Countryside Act (1981) (WCA) includes a long list of insects and other invertebrates proposed for protection under Schedule 5 of the Act. All species listed for consideration have 'Critically Endangered' status in recent species status reviews. In other words, it is assumed that the data generated by a few dozen specialists are directly comparable to the data generated by many thousands of observers.

Is species protection an appropriate tool for all insects?

Species protection measures may be realistic for large and obvious animals, some of which are persecuted *e.g.*, raptors and cormorants. In such cases there are obvious reasons for enacting protective legislation that is readily enforceable.

Placing Critically Endangered species on Schedule 5 of the WCA, the highest level of protection afforded by the Act, makes sense from a vertebrate perspective. This Schedule prohibits collection or disturbance, loss of their habitat and the sale of specimens. From an invertebrate perspective it makes less sense because most insects are tiny, often extremely difficult to find, and only identifiable under high magnification using lethal methods.

Schedule 5 recognises, however, that there may be differing reasons for providing some degree of protection as can be seen in Table 1.

It is possible to protect species using just one part of Section 9 of Schedule 5. Twenty butterflies, two moths and one beetle are protected solely under Section 9.5. Just one, the Mire Pill Beetle (*Curimopsis nigrita* (Palm)), is protected under Section 9.4. The remaining 24 species have full protection. Unlike preceding iterations, in the 7th quinquennial review it is proposed that all Critically Endangered species be given full protection regardless of the actual threats.

While there is a clear case for high levels of protection for birds, mammals, amphibians and reptiles, can an analogous case be made for invertebrates? Unquestionably, some butterflies and moths have received too much attention from collectors and dealers. Many larger butterflies and moths, together with dragonflies, might almost be considered 'honorary vertebrates' because of their size, their relative ease of identification and in their appeal to the public. Stag Beetle (*Lucanus cervus* (Linnaeus)), Ladybird Spider (*Eresus sandaliatus* (Martini & Goeze)) and Fen Raft Spider (*Dolomedes plantarius* (Clerck)) arguably also fit a 'vertebrate model' for their protection.

Similarities between insects and vertebrates disappear as insect size decreases and they become difficult to locate, and their identification requires dissection. For example, Figure 1 shows the dissected male genitalia of two almost identical species of scuttle fly (Phoridae), both <2 mm long, and only reliably separable using features of the external genitalia of males. One species is common, the other is scarce; their females cannot be identified to species.

Once species are protected from 'intentional damage or destruction to any structure or place used for shelter or protection' [Sch. 5 (9.4)] the question arises: who will ensure that they continue to exist? In principle, unless you can be sure that no protected species occur on a particular site, all the standard sampling techniques are, in effect, proscribed or have to be licensed.

These proposals may please some NGOs, but will they deliver real conservation gains? After all, almost all data used in conservation management come from volunteer entomologists who rely to some extent on lethal methods. An as yet undefined proportion of insects can be identified using non-invasive techniques such as photography, but many of the scarcest cannot.

How many British insects are less than 3 mm long? For example, the Chloropidae (grass flies or frit flies) currently comprise 178 species, almost all of which are less than 5 mm long and most less than 3 mm long. Other species-rich fly families dominated by small/tiny species in Britain include the Ephydridae (151 species), the Sphaeroceridae (144 species) and the Phoridae (356 species). There are over 100 families of British flies, many of which include large numbers of species under 5 mm long. Comparable figures can be quoted for parasitic wasps, rove beetles and many others.

Some examples

Fifteen fly species were recently proposed for Schedule 5 status by Defra: six long-legged flies (Dolichopodidae), two robber flies (Asilidae), four hoverflies (Syrphidae), a soldierfly (Stratiomyidae), a flat-footed fly (Platypezidae) and a beefly (Bombyliidae). None of the fifteen species was considered by the specialists consulted to be suitable for Schedule 5 status because:

- Proper consideration has not been given to the difficulty of identification without capturing and, potentially, killing specimens for determination, *i.e.*, there is a basic incompatibility with Schedule 5 protection; and
- The implications for surveillance and monitoring of these species, and any others at the same site are considerable.

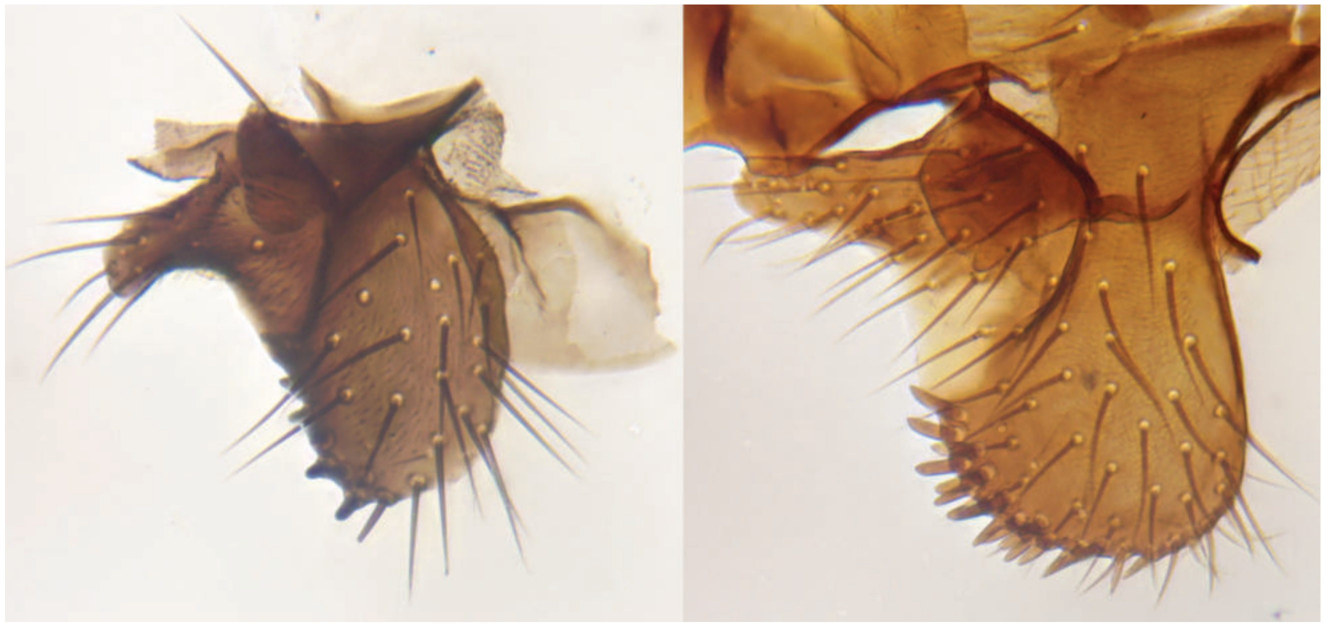

Figure 1. Male genitalia (right claspers) of two phorids from Norfolk: left *Conicera schnittmanni* Schmitz (scarce), right *Conicera floricola* Schmitz (common). Magnification x400. Photos Mark Welch.

Volucella zonaria Poda is Britain's biggest hoverfly (Syrphidae). Once a greatly prized rarity, it is now widespread and relatively common as a result of climate warming. Photograph Roger Morris.

The six Dolichopodidae proposed are under 5 mm long and one, *Ortochile nigrocoerulea* Latreille, has not been recorded for sixty years. One tiny species *Cyturella albosetosa* Strobl (a mere 1 mm long) was rediscovered in 2007 from a small area of base-rich flushes in a Norfolk field, many years after it had been presumed lost from Chippenham Fen when the site warden built a hut on the area where it (and several other rare species) had previously been found (Drake, 2007). Why place such a species under such onerous 'protection' against 'collectors' when its fate was inadvertently decided by the warden's need for a shed and the main threat to its known site is interruption of groundwater supplies (Drake, 2018)? This is just one example of a wide-ranging set of proposals that have assumed that a species listed as 'Critically Endangered' is most at threat from collectors and not from nature reserve managers!

Beware unintended consequences

It is easy to assume that there is a substantial pool of 'experts' available to identify insects. In fact, there are very few such people; in the case of Diptera, fewer than 100 people across the country could realistically identify the species now proposed for Schedule 5. Most 'experts' specialise, meaning that fewer than 30 would be capable of identifying with confidence any of the Dolichopodidae recommended by Defra for Schedule 5 status. Of those thirty, a small number would be capable of *finding* the species in question.

Recent species status reviews were compiled by specialists very familiar with the organisms in question, their biology and the limitations and scope of available data. Will a future specialist provide the same expert input when it could lead to a clamp-down on their specialism? In addition, they could make recording scheme organisers extremely wary of making specialist data publicly available.

Adding species to Schedule 5 with any meaningful intention to enforce the legislation and to monitor its positive impact requires effective funding. Does such funding exist and has any thought been given to the additional staff complement required to prepare consents, commission surveys, collate and act upon the results of commissioned surveillance? If not, what is the point of designation when the obvious result will be to cut off the already limited flow of data on these species?

There is plenty of anecdotal evidence that the capacity of expertise to maintain existing levels of surveillance is declining. Numerous natural history societies report a looming demographic crisis as younger people choose alternative interests or opt for non-lethal methods. It is also noteworthy that the Darwin Tree of Life (DToL) project involves lethal sampling of invertebrates and calls upon those same unpaid specialists to contribute to the process. DNA analysis is argued by some as the way forward for insect identification, but the task is enormous, being both technically demanding and logistically complex. Neither the manpower nor the funding are available to complete this task within the foreseeable future. DNA is not the solution for a very long time to come. Until then, a small army of taxonomists will be needed to deliver its objectives.

What needs to happen?

Habitat representation at an invertebrate scale and not at the scale needed for vertebrate conservation is the key. Unfortunately, very little is known about the biology of so many insects, including most of those currently proposed for listing on Schedule 5. Far more effort is needed to understand why scarce and threatened species are so rare. Doubtless many have very precise requirements, but others may prove to be a lot more widespread as populations have yet to be detected.

Crucially, we still don't know what occurs where. There are very few detailed inventories of species for National Nature Reserves (NNR), let alone Sites of Special Scientific Interest (SSSI). Therefore, an assessment of all invertebrate data is needed, to determine representation on protected sites. In addition, an assessment of the intensity of recording effort is needed so that a more targeted approach to surveillance can be developed.

Following a comprehensive assessment of the occurrence of scarce and threatened invertebrates on protected sites, site protection needs to be extended to those species that are currently unrepresented on protected sites schedules. Seeking unenforceable protection for a 1 mm long fly is an easy win, but unless sites are protected and owners or site managers know where threatened species reside, it is always possible that a new shed will be placed directly on its habitat!

A radical re-appraisal of conservation policy and planning is needed to ensure that specialist invertebrates are taken into consideration. Such an approach means that landscape-scale planning must think in terms of key issues such as lithology, hydrology, aspect and vegetation structure rather than in vague 'habitat' descriptions that relate to vertebrates and the National Vegetation Classification. As has been seen for *Cyturella albosetosa*, precise groundwater conditions can be crucial. Moreover, re-wildling projects need to happen where there are genuine gains for invertebrates. Again, the choice of locations may be determined by the same principles outlined for landscape planning.

Re-assessment of the viability of IUCN guidelines for selecting invertebrate species for inclusion on Red Lists would be another positive change. These criteria are aimed at taxa that can be counted or their populations reliably estimated, and for which robust data exist. Applying them to insect species that are elusive or have been found on a handful of occasions is unworkable for several reasons, not least being that no assessment can be made of population numbers, ecology and distribution without a far bigger workforce of taxonomically-competent specialists and funding to support their studies. In the absence of such a revision, meaningful invertebrate conservation will continue to be dominated and handicapped by vertebrate priorities.

Given the shortfall in expertise and detailed knowledge of species' ecology and distribution, the relationship between conservation policy/practice and the providers of surveillance and monitoring data must be re-appraised. The reality is that the bedrock of invertebrate conservation in Britain is a tiny community of specialists who record and report the species that others cannot identify. An audit of that capacity, focussing on technical competence, taxa coverage and 'workforce' demographics is also needed for future planning.

Finally, we suggest that more training is needed for existing and emerging conservation and environmental professionals. Far more attention needs to be paid to invertebrates, but in a way that makes sure that conceptual thinking concentrates on micro-habitats. It is all too common to find that the warm sunlit corners of woodland edges have been straightened by tree planting, or that natural footpaths with bare ground have been metalled to provide a better visitor experience. Such simple, seemingly innocuous, actions eliminate important invertebrate habitat and contribute to the overall decline of Britain's magnificent invertebrate heritage.

Acknowledgements

We thank Dr Martin Drake and Dr Rob Wolton for their challenging critiques of earlier versions of this article.

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Royal Entomological Society

Society News

Troops on the move. Credit Milton Barbosa

News from Council

Meetings of Council

Council met on 23rd November 2022. There were discussions relating to the current year business plan and the draft plan for 2023–2024. There were continued discussions surrounding Mansion House and the Vice Patrons and Ambassadors of the Society. Decisions were taken on business development, membership structures and pricing for the upcoming year and around new terms of reference for the updated committee structure that will allow the Society to have maximum impact and the best chance of success with the 2022–2025 strategy. Several committees fed back to Council on any key discussions and decisions taken at recent meetings.

Business Development

Historically, Society income has mainly come from publications and, in particular, the portfolio of RES journals. With the significant changes to this portfolio, including the move to Open Access publishing, there are discussions about how to diversify income and ensure that there is the ability to invest more funds into insect science and membership benefits. Several policies and documents were shared to agree the direction of travel. This included processes around due diligence of any potential partner and collaborator. The policies were agreed, and the development of income diversification will continue through the next period, working with the RES legal partners.

Membership Structure

The membership structure and pricing were discussed and agreed. The membership structure will introduce a new tier of Associate Member which will have fewer benefits but be more affordable. Trustees welcomed that there has been significant growth in membership with approximately 350 students taking advantage of the free trial. The Society is hopeful that many will remain members after their first year, with plans in place to ensure they can be supported at the start of their career.

Patrons, Vice Patrons and Ambassadors

Currently, the Patron and Vice Patron roles are not filled. The Royal Patron will be announced in due course. Council discussed the role of Vice Patron and has taken the decision to rename this role as Ambassador. The Ambassadors will take on a time-limited role to support the Society and promote its work in other sectors. This will help raise profile and funding, and present other opportunities. As such, Ambassadors are unlikely to be entomologists. It was also noted that the Society has a significant number of Honorary Fellows whom we wish to engage and work with more to promote insect science in a variety of ways.

Business Planning

The progress of the current year business plan was discussed. Overall, it was noted that the plan showed significant progress with a few items that had been delayed for a variety of reasons. The draft plan for 2023–2024 was noted and this will be developed further in the coming weeks.

Simon Ward
Chief Executive Officer

Student Representatives

Ayman Asiri
Cardiff University
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I grew up fascinated by entomology, progressing from keeping woodlice farms, to tarantulas and praying mantises. I did my undergraduate in Biological Sciences at the University of Plymouth, graduating in 2020. While I was studying, I undertook a placement year working as a curatorial assistant in an entomology laboratory. It was there that I realised I could pursue entomology as a career, and after graduating I went on to complete an MSc by Research in Entomology at the University of Reading.

During my degrees I had the opportunity to work on a range of entomology-based research projects including isopod immunity, ladybird disease and colour forms, and spider biodiversity. I am now in the second year of my PhD at Cardiff University, researching how honeybees use smell to detect and respond to infectious disease within the hive.

Vera Kaunath
University of Potsdam
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My interest in exploring biodiversity began in my school days, but my passion for insects – especially bumblebees and beetles – was only utterly ignited by a 3-month stay in a nature reserve in Havelland. After that, I took as many courses on insects as possible in my undergraduate years at Freie University of Berlin and spent many weekends outdoors with a sweep net, and many hours more identifying the insects afterwards. During my Master's in Biology and Ecology at the University of Greifswald, I had the opportunity to investigate different study fields such as the impact of pesticide exposure on reproduction in wild bees and the impact of artificial light on activity of carabid beetles.

I am particularly interested in the interface between applied ecology and nature conservation, and how different environmental schemes affect the conservation of insect diversity. Therefore, I am now investigating ground beetle diversity in flower strips in my PhD at the University of Potsdam.

Ava Searles
University of Lincoln
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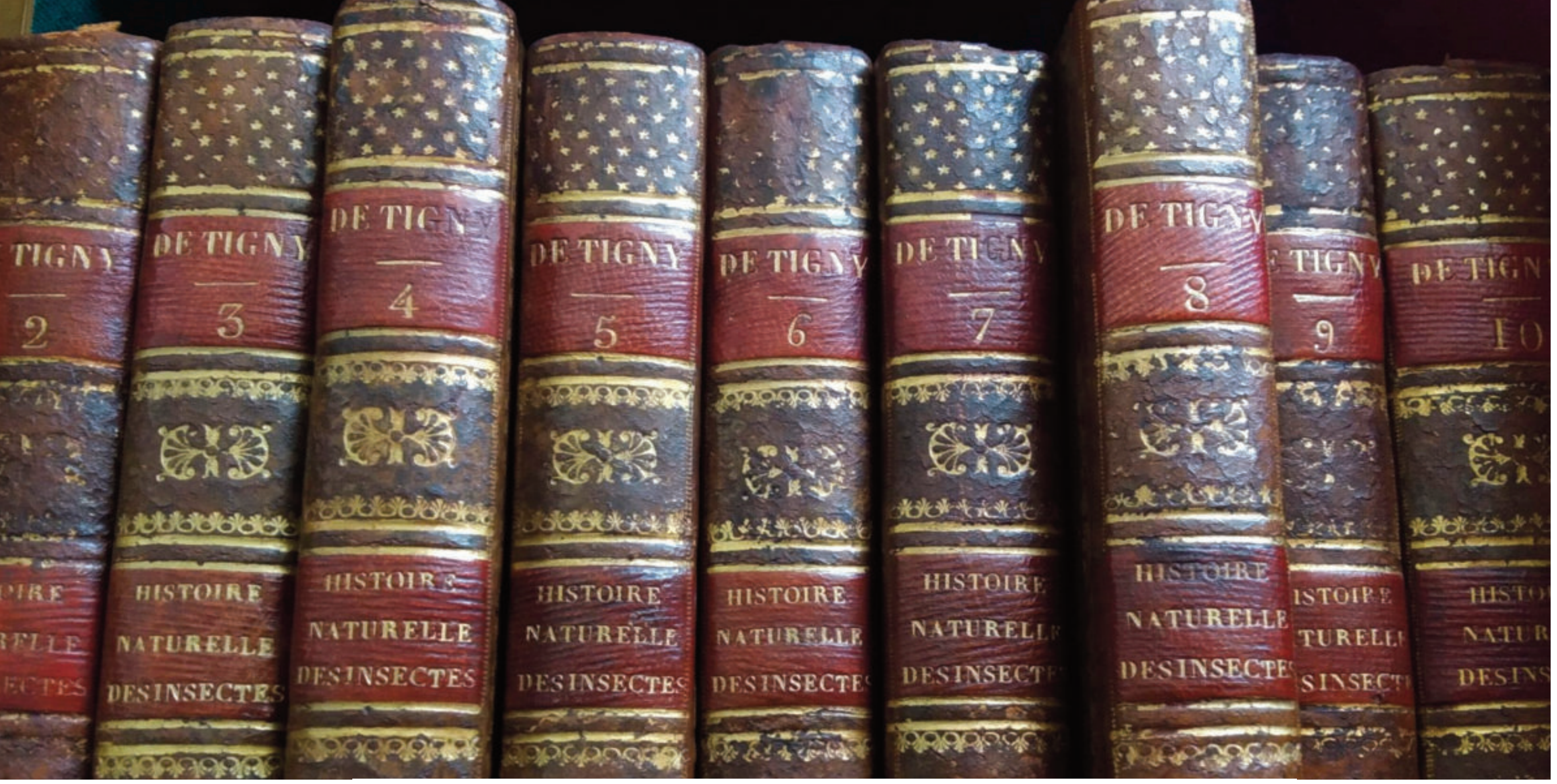
I am quite new to entomology but have always been interested in the animal world. I completed my undergraduate degree in Zoology at the University of Lincoln where I became fascinated by the diversity and value of insects. From there I stayed on at the University of Lincoln and am currently studying for an MSc by Research in Evolution and Ecology. For this I have been surveying a new rewilding site (Wilder Doddington, Lincolnshire) for Silphidae and looking at the ecosystem services that *Nicrophorus vespilloides* provides.



Journals and Library

Research to inform policy

From January this year all RES members and Fellows are entitled to free online access to our journals. Please visit our website to find out how to take advantage of this member benefit. We know that many of our members can access our journal content via their institution, but for our many members who do not have another way to access this content we are excited to be able to offer this option.

Basic research is key to informing policy, and it's often the case that those working in policy and practice settings don't have access to this primary research. We're especially pleased to be able to offer free access to members working in these sectors.

The end of 2022 saw two key COP meetings – COP 27 and the UN Biodiversity Conference. It's vital that these meetings and those like them are informed by rigorous research so that policy is evidence-based. To support this endeavour RES journal editors have put together two Virtual Issues.

The UN Biodiversity Conference Virtual Issue, edited by Allan Watt, Manu Saunders and Raphael Didham, presents a selection of research from across the Royal Entomological Society journals, addressing the many challenges surrounding insect biodiversity and its loss. One fundamental challenge is describing the exceptional diversity of insects, an essential first step for implementing conservation. Reversing the decline in biodiversity requires, amongst much else, novel approaches to monitoring insect abundance and diversity, including cryptic species, and acknowledging the valuable role of citizen science. It also requires greater understanding of how drivers of biodiversity loss impact insects, which requires research on molecular, physiological and ecological processes. Furthermore, improved knowledge of the role of insects in delivering ecosystem services is essential in developing more sustainable practices in agriculture, forestry, animal husbandry and human health. Finally, these articles, and many more, describe much-needed research on developing and evaluating the policies and practices being put in place to combat biodiversity loss (IPBES 2019).

The COP27 Virtual Issue, edited by Tilly Collins, Allan Watt, Raphael Didham and Emma Weeks, highlights recent articles from a range of entomological disciplines and demonstrates a range of study approaches. These articles, and many more, provide vital underpinning research to help understand critical problems and thus contribute to solutions. Modern molecular and modelling techniques generate new insights and add to the foundation of field studies and microcosm experiments. From the details of genetic adaptation to the real-world expression of these patterns in nature, and how they influence human perception and behaviour, insect science is vital in understanding, mitigating and adapting to climate change.

To read more detailed introductions to both Virtual Issues, as well as all the articles for free, visit our website.

Meetings

Insect Welfare and Ethics Special Interest Group

Eleanor Drinkwater
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Ethics as a field is constantly evolving. One area which appears to be gathering momentum is the ethics surrounding the use of invertebrates. Some of these developments are happening at a governmental level, with the recent inclusion of all decapod crustaceans under the Animal Welfare (Sentience) Act 2022. Other developments are happening within academia with a flurry of key papers on invertebrate ethics, from those on the possibility of pain perception in invertebrates (Gibbons *et al.*, 2022), to ethical practices in invertebrate farming (IPIFF, 2019; Delvendahl *et al.*, 2022).

These developments are not confined to one branch of invertebrate science, but represent a shifting ethical landscape, which is being felt across fields from fisheries science to entomology. Within entomology, conversations and debates are happening across disciplines; from researchers discussing how to reduce bycatch (Fischer and Larson, 2019), to biologists concerned about issues like parachute science (George and Bockarie, 2022), to industry concerns about the best practice for the production of invertebrate protein products (IPIFF, 2019). It is an exciting time for those interested in the ethics surrounding the use of invertebrates, as the discussions which are taking place across disciplines have implications for invertebrate production, engagement with the general public, and interdisciplinary research.

These discussions on ethics are crucial for the invertebrate-production industry. Certain bodies within the industry have already been taking the lead in this area. For example, Naturland has started providing guidelines for husbandry standards for organic certification (Naturland, 2022), while the International Platform of Insects for Food and Feed has been encouraging the adoption of Brambell's Five Freedoms for invertebrate welfare within the sector (IPIFF, 2019). However, these standards are not universally accepted, and there is uncertainty and debate about whether welfare standards, which are usually rooted in vertebrate research, are appropriate for invertebrate welfare industry practices, and recognition of a need for species-specific research and discussion (Delvendahl *et al.*, 2022).

Ethical discussions about the use of invertebrates are also important for engaging with the general public. Brunt *et al.* (2022) demonstrated from a survey in Canada (n=959) that there was a gap between expectations of the public in terms of oversight of invertebrate studies, and current practices. These concerns of a mismatch in expectations highlight the importance of transparency and clear messaging and discussion about practices within a field. These open discussions may not just be important in terms of public education about science, but also for maintaining public support.

Finally, open dialogue about the ethics around the use of invertebrates is important for entomologists. There is a variety of views about welfare and ethics in entomology, in part reflecting the huge diversity of this field. However,

Eleanor helping with the release of some Large Marsh Grasshoppers, *Stethophyma grossum* (Photo credit Stuart Green) differences in ethical expectations of practices could lead to a risk of moral injury, particularly to newcomers to the field or individuals who move between fields. One solution to this could be to encourage discussion about moral risk associated with entomology (Fischer and Larson, 2019).

How these discussions take place is also important. Work conducted by entomologists provides cutting-edge support to developments in food security, medical research and conservation, for example. Therefore, ethical developments must happen in ways that support, not hinder, cutting-edge research. It is thus vital that entomologists take the lead in discussions, allowing any changes to develop organically from within the field.

Any changes also need to come from a multidisciplinary space. Currently, many discussions seem to be occurring in isolation, with separate approaches, frameworks and guidelines being discussed in industry and academia. However, the diversity of ideas from interdisciplinary work is needed to navigate the complicated and shifting field of ethics surrounding the use of invertebrates.

What we need is a space and a forum for collaborative and nonjudgmental debate; a space where individuals from across different disciplines of entomology can come together and discuss different areas of welfare and ethics with their peers, and gain insights from colleagues and friends about developments in different fields. Hopefully the Insect Welfare and Ethics Special Interest Group (SIG) can provide this.

Aims of the Welfare and Ethics SIG

The aim of this SIG is to help build a community of entomologists interested in developing their understanding of the welfare of invertebrates. We aim to meet annually to share research on different topics of invertebrate welfare, discuss new developments and trends across different fields of entomology, participate in friendly debates, and build cross-disciplinary collaborations with others.

How could you get involved?

If you are interested in getting involved, please get in touch to join the SIG's mailing list and receive updates about the first meeting, which we will be holding this summer as a hybrid (online and in-person) event at Writtle University College. If you would like to get involved with running the meeting or have any particular area you would like to see discussed at the first meeting, please let me know.

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43rd Orthoptera Special Interest Group

Natural History Museum Hybrid Meeting, 2nd November 2022

Convenors: Darron Cullen, Judith Marshall and Ed Baker

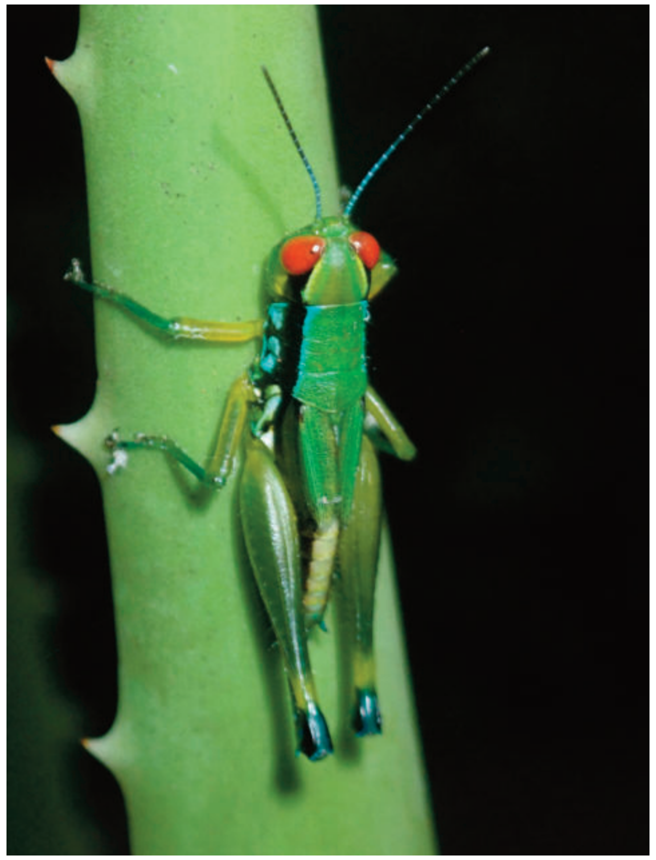
Report by Richard Harrington

The Natural History Museum (NHM) played host to this hybrid meeting, with 40 orthopterists getting together in-person and a similar number joining online and hence missing what I gather was an excellent supper. The meeting spanned an impressive range of science from the molecular to the population level and I'll begin by thanking the organisers, speakers and their co-authors, questioners, exhibitors and the RES team for keeping up the Orthoptera SIG's reputation for scientific, social and gastronomic excellence. Thanks also to Dan Hall (NHM), who helped with meeting set-up, and Clive Huggins (NHM Volunteer), who helped ferry people to supper and out of the building.

I'm getting on a bit and, especially in a crowded, noisy room (yes, okay, a pub!), I find it increasingly difficult to follow conversations. I thus listened intently to Tom Austin's (University of Leicester) talk on using Desert Locusts to understand age-related hearing loss. Popular theory has it that reduced metabolism is the root cause. Locusts make good subjects for testing this as they age rapidly and it's possible to use large numbers for invasive experiments. By playing a tone to locusts and eavesdropping on the auditory information heading for the central nervous system, Tom showed that locusts indeed have age-related hearing loss, which correlated with their measured metabolic rate decreasing with age. The causative link remains elusive, however – altering the locusts' metabolic rate via cooling or starvation had no obvious effect on hearing. Tom's next step will be to look at the effect of up-regulating metabolism using caffeine.

Is resilin all it's cracked up to be? This was the question posed by Steve Rogers (University of Lincoln). It is widely assumed that the rubbery protein, resilin, puts the spring in the grasshopper's jump but, using RNA interference to produce Desert Locusts with greatly reduced amounts of resilin, Steve found only a 15% reduction in jumping prowess, largely due to a reduction in tendon size. It seems that a more important role of resilin

A wild-type mature male *Schistocerca gregaria* mounting a fellow male in which the bright yellow coloration has been blocked using RNA interference. Darron Cullen



An eye-catching grasshopper from Cát Tiên National Park. It looks as if it should be in the Oxyinae, but is in fact a *Caryanda* sp. (Caryandinae). Roy Bateman

is protecting the real spring as, in resilin-reduced individuals, 28% suffered tendon breakages when the legs were stimulated electrically, while none of the control insects suffered this fate.

Desert Locusts are champions of phenotypic plasticity. The solitary form is cryptic, but the gregarious form has warning colouration advertising its toxicity to potential predators. To become toxic themselves, gregarious locusts ingest plant matter containing toxins. One such toxin is atropine. The ingested toxins must be extruded by the Malpighian tubules (MTs) to prevent them damaging cells and tissues in the internal environment. Jeremy Niven (University of Sussex) and collaborators tested MTs' function *in vitro* using rhodamine dye, which is extruded by the same detoxification pathway as atropine. When locusts were fed diets with and without atropine, those fed atropine were better at removing rhodamine, demonstrating up-regulation of the detoxification pathway, but this happened only in the gregarious locusts and in solitary forms that were deliberately crowded. Solitary locusts, which rarely eat plants containing atropine and so do not require detoxification, did not up-regulate their detoxification pathway when left uncrowded.

The anti-predator warning colouration of gregarious, juvenile Desert Locusts is switched on again in adult males, which turn bright yellow upon sexual maturity, but the adaptive reason for this colour change was previously unknown. SIG Convenor Darron Cullen (University of Lincoln) used RNA interference to manipulate the colour of mature gregarious males, making them light brown like the females. In mate-choice experiments, there was no preference for male colour shown by females, but in male–male encounters, the yellow colour was shown to prevent attempted mating. More than 50% of tested males attempted to mount brown males, but only 2% attempted to mount bright yellow ones. Darron's work was recently published in *PNAS* (https://www.pnas.org/doi/10.1073/pnas.2200759119).

Now for a nice trip to Hawaii, where Kerry Shaw (Cornell University) has been studying behavioural evolution in crickets. There are three groups: tree crickets (Oecanthinae), ground crickets, including many cave forms (Nemobiinae) and swordtail crickets (Trigonidiinae). Kerry specialises in the swordtail genus *Laupala*. Thirty-eight species are recognised but many are morphologically and ecologically cryptic but acoustically distinct. They are flightless and endemic to single islands. Males have two types of spermatophore: microspermatophores and macrospermatophores. The former are transferred to females during several repeats of the courtship behaviour but they have been found to contain no sperm. Finally, a single macrospermatophore is transferred and that contains the sperm. In an experiment where a female which had received microspermatophores was switched during courtship with a virgin female, transfer of sperm from the macrospermatophore to the virgin was less successful than to females which had already received microspermatophores. Thus, microspermatophore transfer appears to aid release of sperm from the macrospermatophore.

Another fascinating overseas perspective came from Roy Bateman (Cát Tiên National Park, Vietnam & Imperial College), who described his work on encouraging eco-tourism and supporting the

Leptomantella cf. tonkinae from Cát Tiên National Park. Roy Bateman

Marmessoidea liuxingyuei from Cát Tiên National Park. Roy Bateman

identification and recording of orthopterans in the Cát Tiên National Park. This remote part of Vietnam now has better-defined boundaries, containing 826 km^2 of lowland seasonal tropical forest and wetlands. For more information I refer you to Roy's excellent article in *Antenna* 44(3) 126–131.

The Distributed European School of Taxonomy (DEST; https://cetaf.org/dest) offers education and training opportunities to worldwide students and professionals interested in the field of taxonomy, biodiversity, geodiversity and conservation. Luc Willemse (Naturalis Biodiversity Centre, The Netherlands) outlined his planned 2023 DEST course in Greece on grasshopper biodiversity and field methodologies. This will involve five or six days of lectures, demonstrations and fieldwork, and four online modules covering the ecology and conservation of grasshoppers; an overview of European grasshoppers; the ethics, laws and regulations of collecting; and identification tools and bioacoustics. Sounds great!

The response of orthopterans to land-use and climate change is being studied by Franz Löffler (University of Osnabrück). In Central Europe, large-scale habitat loss in the 20th century severely affected the ranges of habitat specialists. By contrast, mobile and thermophilic species increased their distribution range in response to global warming over the last 30 years. This frequently increased the species richness of mobile, generalist species, especially in well-managed grasslands. Key challenges in conservation are to maintain large-scale habitat networks and to increase habitat connectivity and heterogeneity so that orthopterans can keep up with climate change. Monitoring to assess population status and detect threats at an early stage is very important.

The DRUID (Drivers and Repercussions of UK Insect Declines; https://www.ukri.org/news/nerc-funding-to-help-protect-uk-insect-populations/) project uses machine-learning algorithms to predict the distribution of the UK's insects down to a 1 km^2 resolution, on the basis of their traits, and environmental drivers such as weather, land use and topology. It tries to explain where insects may occur even though no evidence is available from recorders. So far, it

Pseudophyllus titan from Cát Tiên National Park. Roy Bateman

Grub's up. Nick Rousseau

has mainly used butterfly data from the UK Butterfly Monitoring Survey and moth data from the Rothamsted Insect Survey's light-trap network. James Bell (Rothamsted Research) appealed for expert opinion to validate their predictions.

Crickets are described by psychologist Nick Rousseau (UK Edible Insect Association [Woven Network]) as a 'super food'. They are 59% protein and contain all nine essential amino acids and a full range of B vitamins, as well as being a source of iron, calcium, zinc, copper, potassium, magnesium, manganese, Omega 3 fatty acids and folates. The growing demand for meat is unsustainable, but insects require less water and land than other meats. Eating insects is normal in many cultures and is beginning to take off in the UK, moving from just being a novelty snack to an ingredient in a growing number of products. The European Commission, however, classified insects as 'Novel Foods' in 2018, resulting in expensive approval procedures to bring them to market. As a result of the UK Food Standards Agency adopting the same position post-BREXIT, the number of species being sold in the UK is down from 18 to two, and some companies have been forced to close. The Woven Network argues that the regulations are overkill and, as a result of the evidence they have submitted, a scheme to re-enable UK trade is being discussed in Parliament. Nick is a true champion of insects as food and feed and has contributed hugely to the Society's Special Interest Group on this topic. Many thanks to him and his wife, Sarah, who baked some cricket cookies for everyone to try, along with some other edible insect products!

Curtis Lakin has reared many orthopteran species. He brought in some examples from around the world and described a range of feeding and breeding techniques. Curtis encouraged the use of rooted food plants where possible and described how false floors can help direct females to the same level as their laying substate, leading to more successful breeding. There were also exhibits from Jon Delf, Mike Strick and Stephen Lee Thomas.

Many entomologists have been interested in insects since childhood. This was the case with Roger Hawkins, who came to

A railway enthusiast fascinated by *Anacridium aegyptium*, photographed in Spain in 1968 but identified at the RES-SIG meeting in 2022. Roger Hawkins

orthopterans via train spotting from grasshopper-rich sidings in France. He described people and books which had inspired his lifetime of 'dabbling' in Orthoptera. For 20 years, he was able to identify many through their songs but, in his mid-50s, he lost the ability to hear them. He, no doubt, will have been excited by Tom Austin's assertion that the very organisms he loves might hold the key to understanding why he can no longer hear them and, perhaps, suggest a cure.

That brings us full circle. There was something for everybody in this wide-ranging, hugely fascinating meeting, and everybody will be looking forward to the next meeting of this longest-running and most regular Special Interest Group.

Monthly Evening Meetings

Richard Harrington
(Chair of Meetings Committee)

Back in the Queen's Gate days, the mainstay of the Society's programme was its evening meetings on the first Wednesday of each month. They began with a convivial chat over tea upstairs in the library. We then descended into the magnificent, if not somewhat daunting, wood-panelled meeting room in the basement, admiring or ignoring the staircase pictures of stern-looking past presidents. The current president would bang his (with only one exception) gavel, swear in new Fellows, invite any Society business and introduce the guest speaker. After a (usually) good talk and fulsome discussion, we'd adjourn to the library again and enjoy a glass of sherry provided by "an anonymous donor" (our first female president).

Whilst online gatherings can't recreate the atmosphere of those heady days, the resurrection of evening meetings on the first Wednesday of the month provides a new opportunity for many members to engage and has the advantage of being able to attract top-notch speakers from around the world without huge expense.

It was appropriate that the first in the series was presented by new president, Jane Hill (University of York), who spoke on the insects which are winning and losing under climate warming. Jane concluded that UK butterflies show considerable variation in their responses to climate change, *i.e.*, there are winners and losers. Many species are shifting their ranges to track climate. Habitat availability affects expansion rates, and management of sites to boost local populations is also vital. It is also evident that habitat (re)creation and improving connectivity help some butterflies. Butterflies are disappearing from sites that become climatically unsuitable for them, and we need to work out how to slow-up these declines to prevent losses. Translocations and re-introductions are likely to be increasingly important, but how do we decide which individuals to move, and to where, and what are the best practices to ensure introductions and translocations succeed?

The November lecture was given by Sophia Ratcliffe (Data Manager for the NBN [National Biodiversity Network] Atlas). She gave a similar presentation at the Aquatic Insects Special Interest Group meeting (*Antenna* **46**(3) 135) but it was worth repeating to a wider audience because it is relevant to all insect groups. The NBN is the UK's largest partnership for biodiversity recording, with over 200 contributing organisations, resulting in 205 million records to date (32 million insect records). It is the UK hub for the Global Biodiversity Information Facility, which has similar aims worldwide and holds more than 2 billion records. NBN Trust has teamed up with the Biological Records Centre and the Marine Biological Association to form iNaturalistUK, the UK partner in iNaturalist. Sophia described the processes for submission and retrieval of NBN Atlas data, and the daily import of records from iNaturalistUK into iRecord and the monthly export of verified records from iRecord to the NBN Atlas for many recording schemes. Her presentation inspired a lengthy and informative Q & A session. It is clear that the potential to map species distributions is increasing rapidly and facilitating an improvement in our knowledge of factors affecting changes in distribution, phenology and abundance.

Unfortunately, the December meeting had to be cancelled at short notice because the speaker was indisposed, but many excellent speakers are lined up, so please see the diary page herein or the events page of the website (www.royensoc.co.uk/events), and sign up!

International Online Evening Meeting, 26th November 2022

Alien species in the Maltese Islands

Professor David Mifsud, Director – Centre for the Liberal Arts and Sciences, University of Malta and President of the Entomological Society of Malta

Convenor: Kimberly Gauci, International Representative for Malta

Report by Richard Harrington

A little piece of RES history was made on the final Saturday in November, with the first of what will hopefully be many meetings organised by our International Representatives. These meetings aim to inform us about key entomological issues in various parts of the world and to foster our international links. Kimberly Gauci has kindly taken on the role of International Representative for Malta and was very quick off the blocks to organise this meeting, presented by Professor David Mifsud, Director of the Centre for Liberal Arts and Sciences at the University of Malta, and President of the Entomological Society of Malta (ESM).

Kimberly Gauci.

Professor David Mifsud.

The Maltese archipelago comprises three main islands (Malta, Gozo and Comino) in the central Mediterranean basin about 100 km south of Sicily. With a population of about half a million (roughly 1,300 per square km), it is one of the most densely populated places on Earth, but still has some unspoilt areas. David ran through some of the most damaging invasive pests and the biological control agents used to keep them in check. Pests included: Grapevine Phylloxera (*Daktulosphaira vitifoliae*); Cottony Cushion Scale (*Icerya purchasi*); two eulophid wasps (*Leptocybe invasa* and *Ophelimus maskelli*), which form galls on *Eucalyptus*; Woolly Whitefly (*Aleurothrixus floccosus*); Castilloa Borer (*Phryneta leprosa*), a huge, polyphagous cerambycid beetle which arrived in Malta some 20 years ago on logs intended for the timber industry and has developed a liking for Black Mulberry (*Morus nigra*) and White Mulberry (*Morus alba*) in Malta; Citrus Leafminer (*Phyllocnistis citrella*); American Serpentine Leafminer (*Liriomyza trifolii*), a pest of chrysanthemums; Black Soldier Fly (*Hermetia illucens*), which has now made itself useful in breaking down chicken and pig manure, the pupae being used for chicken feed; Western Flower Thrips (*Frankliniella occidentalis*), which transmits Tomato Spotted Wilt Virus; Geranium Bronze (*Cacyreus marshalli*), which has become Malta's commonest butterfly; Red Palm Weevil (*Rhynchophorus ferrugineus*) and various wasps forming floret galls on *Ficus* species.

Invasive species arrive as a result of trade in agriculture, horticulture, forestry and apiculture, and through human transport. The rate of arrival has increased in recent years and, whilst biological control methods have been very successful where plant-protection products are not used, Malta is powerless to invoke the full range of quarantine measures it would like, because of EU regulations on the free movement of goods. Entomologists are kept very busy indeed!

Although the meeting was only attended by seventeen delegates (the World Cup may have played a role!), it was a truly international audience, including one member from Japan, for whom the meeting began at 04:00 on a Sunday. That's what I call dedication and inspiration, so a special mention for Eko Andrianto. I hope that the meeting will lead to further collaborations between the RES and the ESM. We currently have International Representatives in Chile, Denmark, southern India, Malta and Zambia. If you would like to consider representing the Society in your part of the world, please contact Richard Harrington (richard@royensoc.co.uk). Many thanks to David and Kimberly, and to Bianca, Fran and Luke from the RES.

The Society at the 2022 ESA, ESC and ESBC Joint Annual Meeting

Vancouver, Canada, 13th – 16th November 2022

Indigenous inspiration and societal collaboration

Report by Luke Tilley, Director of Communications and Engagement

Indigenous representations of dragonflies featured throughout the conference as the logo.

With the hum of sea planes landing and departing in front of it, the stylish Vancouver Convention Centre hosted the annual meeting of not just one entomological society but three, as the Entomological Society of America (ESA), the Entomological Society of Canada (ESC) and the Entomological Society of British Columbia (ESBC) hosted their joint annual meeting last November. This was, no doubt, the largest gathering of entomologists since the beginning of the Covid-19 pandemic. It was a joy to return to a convivial conference atmosphere and the benefits that brings for sharing and advancing insect research from North America and around the world.

An obvious innovation from the beginning, delegates were offered a new way to think about plenaries and what is needed to improve grassroots entomology and the scientific landscape. There were three panel discussions as plenaries rather than traditional presentations, each challenging attendees to explore diversity in science and share experiences of inclusion and perspectives from indigenous peoples about nature and science.

Agricultural and Forest Entomology Editor-in-Chief, Hefin Jones (right), at the RES/ESA joint publishing workshop.

The opening plenary invited attendees to hear 'Perspectives on diversity' from a panel of guests. Chaired by outgoing ESA President, Prof. Jessica Ware, they held fascinating discussions about what their careers had taught them, each highlighting the difficulties they experienced as scientists of colour facing structural bias. It was both refreshing and challenging to hear the experiences of senior researchers and the obstacles they face to improve diversity in the sector. Some solutions were offered such as improving the training and framework for mentors in science, and the open acknowledgment and celebration of differences in background. From the opening, the tone was set for the conference making it clear that better science not only requires the usual resources, rigour and innovative thinking but also a focus on maximising equity, diversity and inclusivity to draw from the widest possible pool of talent and experience. Science cannot offer the best solutions for society if societal discrimination limits its catchment.

The second plenary session took the same innovative panel format, with delegates treated to 'Indigenous perspectives' from a panel of indigenous scientists. This strongly highlighted the benefits of a full community approach to research, where deep indigenous knowledge and understanding of a landscape or ecological system can provide science with fresh conclusions and improved impact. Michael Blackstock used his First Nations heritage to explain why taking a wider perspective on nature can improve public understanding of science and the research itself.

The closing plenary comprised a panel of the three Cannings brothers, Rob, Syd and Dick, well known environmentalists in Canada. They led the audience through their long careers as biologists, growing up together in the spectacular and diverse habitats of British Columbia. Collectively, they have worked on museum collections, science communication, national park development, conservation research and, in Dick's case, even national politics as a Canadian MP. It was interesting to be led through their career paths, how they were distinct and how they intertwined.

After each day's plenary panel, there were dozens of parallel sessions of talks. The breadth of the scientific topics was astounding, and it was clear that many people had a great deal to share, not having attended many, if any, meetings since the beginning of the pandemic. There was facility during the conference to record talks so that they could be accessed by delegates with schedule conflicts during a particular day.

Several RES journal editors and some of the Society's staff team were at the conference and there was an eye-catching RES stand in the large exhibition hall. The stand attracted delegates at all stages of their careers, from undergraduates to retired professors, coming from a wide range of countries. It was an excellent opportunity to welcome new members to the RES, with many joining during the conference. It was also great to catch up with longstanding members and hear the excitement from them about the Society's strategy, activities and our vision to 'enrich the world with insect science'.

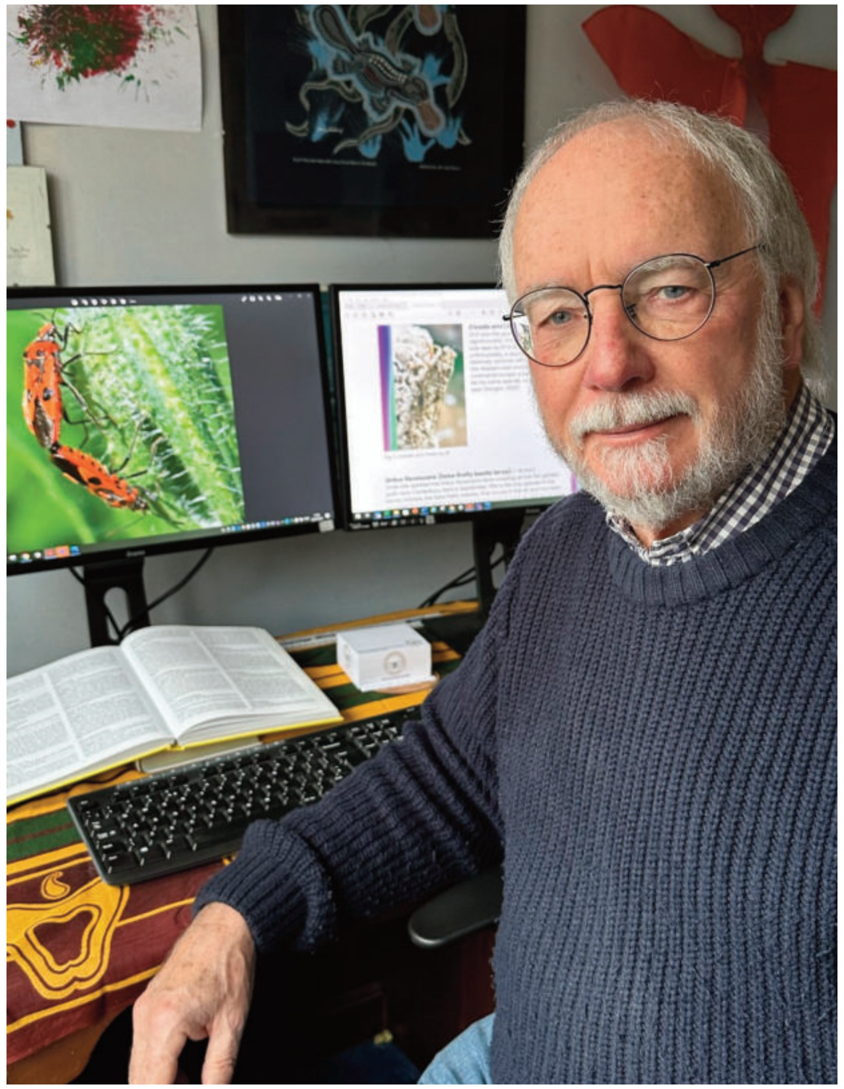
As well as membership, the stand focused on RES publications. Editors and staff engaged with authors, new and established, and commissioned articles for the journals. *Agricultural and Forest Entomology* had a particularly strong contingent of editors in attendance and the large number of researchers present who work in that area led to particularly productive discussions and plans for that journal.

Future events, awards and the fantastic RES library were promoted at the stand to showcase the activities and role of the Society. Several connections were strengthened with other entomological societies too, particularly the ESA. These connections are vital to ensure that societies support the entomological community in a relevant and collaborative way. In that vein, there was a productive talks session on 'Harnessing international policymaking strategies to address grand challenges: inspiring cooperation' where I gave a talk on the RES Grand Challenges initiative and worked with ESA colleagues to provide a forum to discuss the importance of international and interdisciplinary collaboration to effect policy change and improve public understanding of entomology, and the role of entomologists in improving the human condition. RES Head of Publishing, Emilie Aimé, also co-chaired a successful 'How to get published in entomology' workshop with Matt Hudson, ESA Director of Publications, Communications and Marketing, using the combined experience from both societies' journals and editors to help attendees sharpen their skills at getting papers accepted for publication.

To showcase what the Society does to improve public understanding of our science, a poster was presented by Fran Sconce, RES Senior Outreach and Learning Officer, on 'Outreach activities at the Royal Entomological Society'. This outlined many of the events and initiatives led by the RES, including Insect Week and EntoSci, that are great examples of how to improve the quality and access to insect information for the public.

The meeting was very productive for the Society and provided fresh insights, new members, new journal papers, new international collaborations, new approaches to plenaries and new perspectives on our scientific community and its diversity. A huge welcome to those new members who joined the Society in Vancouver. We look forward to seeing you at future meetings in person or online.

HONORARY FELLOW INTERVIEW



Jim Hardie

The informal entomologist

I first met Jim at the Ento meeting in Brighton. A group of people had gathered in the garden after the formal dinner, drinks still in our hands. Leaning against the wall I fell into conversation with the gentleman next to me. He introduced himself as Jim and we discussed the day's talks but then slipped into a radical, even heretical discussion on the rather formal atmosphere within the Society. I remember saying "What we need is a president with a more relaxed attitude".

"Well", said Jim, "I am the next president and have every intention of carrying out those duties in relaxed fashion". I deferentially touched my forelock and wished him every success.

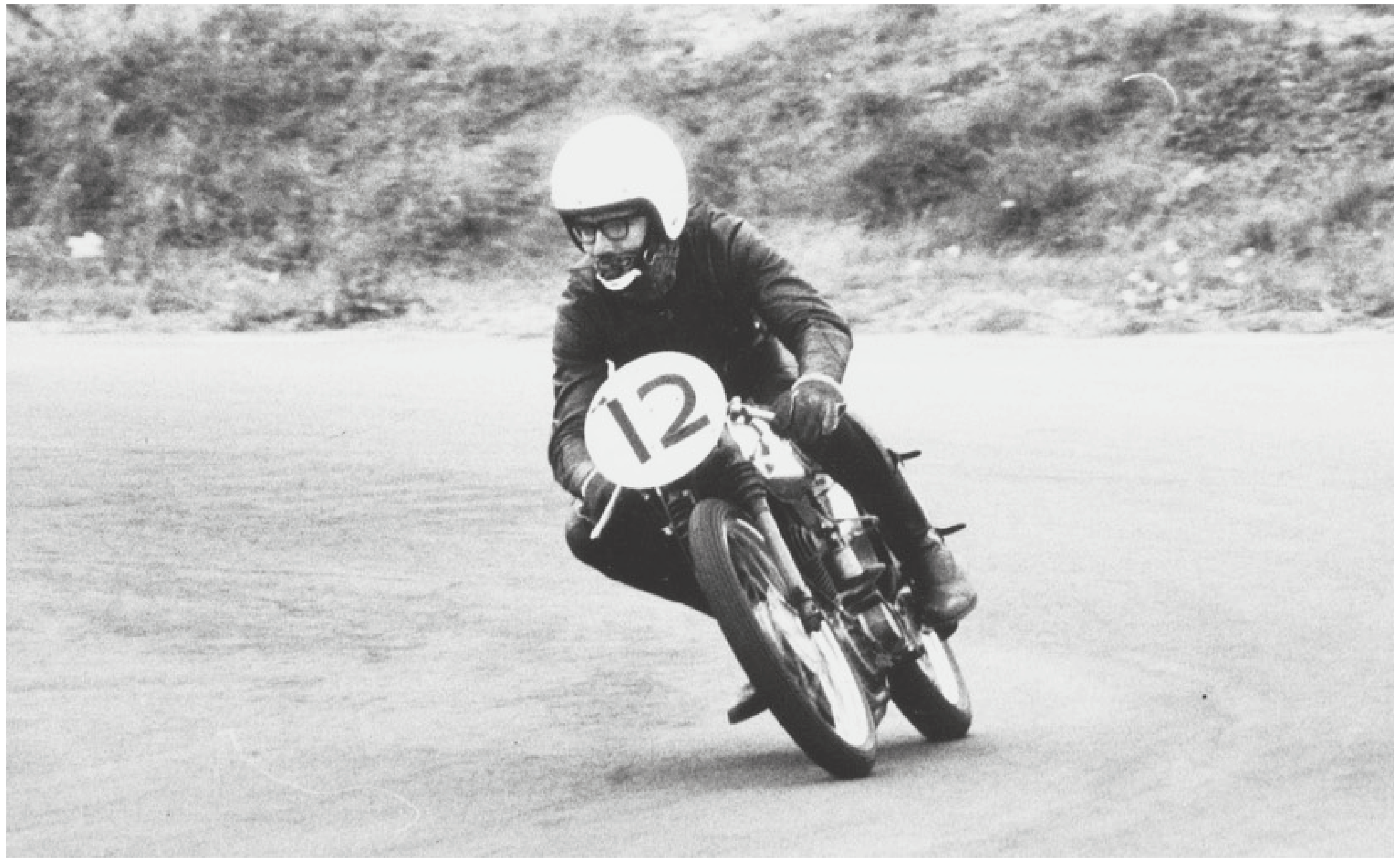
As president Jim wrote a regular column in *Antenna*, the first president to do so since I had been editing it and they were always informal and informative. So, many years later as I walked the 100 yards from the local train station to Jim's house I knew that this would be a very informal meeting. In fact, we had booked lunch in the local pub where most of the interview would take place. This short stroll should have been, as they say, "a walk in the park" but it was in a downpour and the rain was bouncing off the pavement. At least my trousers were dry. But as I approached Jim's front door a bus drove through a puddle, sending a tsunami of rain water in my direction. When Jim opened the door, the water was still running off my coat and trousers. Ditching my coat and shoes I declined Jim's kind offer of dry trousers and relaxed into his sofa. Coffee was served across my steaming trousers and we began to explore Jim's career.

School and College

"I was raised in Walsall, in the Black Country, and natural history was important in my childhood but in a limited way. In those days you took off in the morning and mum did not know where you were till you returned home for tea. I did a lot of fishing in the local canals and lakes, which gave me lots of time while I waited for a fish to bite to observe the wildlife around the water's edge. I mainly used maggots as bait, so I developed a fondness for dipteran larvae. We also played on the common land at the top of the road where we came into contact with many insects, along with the frogs, toads, newts and the occasional grass snake.

I made it to the local grammar school but there was no taught biology until the sixth form, where natural history turned into dissections of formaldehyde-impregnated rats and dogfish, with the occasional fresh frog. However, a large fish tank had recently been installed in the foyer next to the biology lab and I managed to persuade Mr A.J.A. 'Drac' Wiggin, the biology teacher, that it should contain native fish. He agreed, so I would catch a few Roach and Perch in the canal and place them in the tank. This was a great success, but it was an error to add a handsome small Pike and I quickly returned it to the lake.

While fishing, I became intrigued by water scorpions, *Nepa cinerea,* and set up a colony in an old sink at the bottom of the garden. This meant that if we were asked to bring something interesting in to school, I could take live samples of each life stage and get good marks. I also kept stick insects from the age of ten and still have a couple of species. Unfortunately, the sixth form also coincided with an age where other interests intervened, academic performance dropped and my plans to study Agriculture at Glasgow were thwarted. I looked around and applied to do a Higher National



On the Brunel Bantam. Cadwell Park 1970.

Diploma (HND) in Applied Biology at Barking Regional College of Technology, which was a very practical course and good fun. The two parasitology lecturers, Brian Elce and Roland Terry, were excellent."

Early Work

"I left the HND course with a keen interest in parasitology and managed to obtain a job as a technician at the Wellcome Laboratories of Tropical Medicine in Beckenham. On arrival, the head technician, who had not been at my interview, told me he had no idea why I had been taken on as there were no jobs available. So, to get me out of the way, I would work in the different labs in turn; a prospect that I thought sounded rather good, and it was – from nematodes, helminths, amoebic dysentery, trypanosomes, to malaria. The work was interesting but the people running the labs all had degrees and were having more fun than the technicians who were not involved in experimental design or interpretation of the data, so I decided that a degree was what I needed."

University

"I applied to Brunel University two years after it transformed from a College of Advanced Technology. The Applied Biology degree was a four-year thin-sandwich course, which suited my finances, and they offered first-year exemption if you had an HND. Two of my fellow technicians from the Wellcome Labs plus a couple of students from the Barking HND course also started at Brunel along with other HND holders, so there was a ready-made 'mature' students' group. Also, the parasitology lecturers who had inspired me during the HND were now working at Brunel. As I had received a grant (it was grants not loans we received to study in those days) for my HND I could only get a grant to cover my final year. Brian Elce became my tutor and somehow managed to get the University to waive the fees for two years, but I had to sell my old van to cover living expenses and I built a motorcycle from parts in the motorcycle club shed in order to get around. As the degree was a sandwich course, it was six months in college, then six working in industry where we were paid. One of these six months was spent with Murphy Chemicals based in Wheathampstead but working in the orchards of Kent, where we applied fungicide and insecticide treatments that were being trialled. However, we could only spray when the weather conditions were just right so for the rest of the time, too hot, too sunny, too windy or too rainy, we and the Land Rover took time out. The second six months were spent at the Tropical Products Institute, Grays Inn Road, London, where I reacquainted myself with *Biomphalaria glabrata,* the freshwater-snail secondary host of the schistosome that causes bilharzia, which I had previously encountered in Beckenham.

I've had a passion for motorcycles since my early teens and Brunel allowed me to re-engage with motorised two-wheel enthusiasts. I became involved with the motorcycle club and eventually became president. We used to race BSA Bantams which we built and modified to see who could go round in 'circles' fastest. So, I travelled around the country attending race meetings. I still ride motorcycles on the road but there are only three in the current collection ranging from 2–72 years old.

At Brunel my interest in parasitology was frustrated as, despite having the parasitologists from Barking on the staff, there was no parasitology course, so I opted for entomology in the final year as there was an overlap between the two subjects. I also opted for the physiology course. I remember we did a neurophysiology practical using a crustacean. It did not work but this did not matter, I was hooked. This was really interesting stuff. So, initially I applied for an MSc in Neurobiology at Birmingham but as this was happening I was offered a PhD place at Brunel to study the neurophysiology of drug addiction in rats. I then received an invitation to do a PhD on neuromuscular physiology of body-wall muscles of maggots at Birmingham University. I wasn't confident in my neurobiology grounding but at the interview in Birmingham, my soon-to-be supervisor, Dr Mike Osborne, suggested that I could attend the first month's lectures of the MSc while starting the PhD – brilliant. I went to Birmingham.

I began by looking at the innervation of my chosen larval muscles using light and electron microcopy but also conducting intracellular recordings of membrane potential. There were two motor neurones innervating the muscle fibres. The muscle fibre/cell was relatively large, 1 x 0.5 mm, and eventually I acquired enough skill to dissect the single fibre with the nerves intact. I could attach the muscle to a home-made force transducer and record the tension produced while stimulating the nerve at the same as recording the electrical activity inside the cell. By the end of the PhD, I had experience in electrophysiology, light and electron microscopy, as well as steady hands, all of which turned out to be very useful."

Post Doctoral

"I was interviewed for a job at the Rowett Institute in Aberdeen to work on the structure of pig muscle but then I spotted an advert for a postdoc position with the Insect Physiology Group at Imperial College, Silwood Park. The group was set up in the Ashurst Lodge at Silwood in 1967 when J.S. Kennedy and A.D. Lees moved from Sir Vincent Wigglesworth's lab at Cambridge University. In 1975 I was invited for interview by Tony Lees and quickly realised that my ability to drive an electron microscope was of interest. Tony's group was looking at the environmental and physiological control of aphid polyphenism and after a successful chat I gradually became an aphid biologist.

In temperate climes many aphids have an annual life cycle that comprises asexual female forms that give birth to live young at prodigious rates during spring and summer and male and female sexual forms in autumn and winter. This sexual reproduction leads to the laying of overwintering eggs. Daylength controls the mode of reproduction, with long days in spring and summer promoting parthenogenesis and the short days of autumn inducing sexual forms. I worked for many years on these photoperiodic effects, initially looking for ultrastructural evidence for a role of brain neurosecretory cells but moving on to the role of the corpus allatum and juvenile hormone where it seems that high juvenile hormone titres mimic long days, probably controlled via the brain neurosecretory cells. We also looked at other aspects of aphid photoperiodism using a great variety of light–dark cycles to try to tease apart the photoperiodic clock mechanism that measured day, or more accurately night, length as well as the photoperiodic counter that accumulated the information

A light-bulb moment for Jim at the Ciba Foundation symposium on photoperiodism in 1984. Other RES Fellows seated are A.D. (Tony) Lees (left), Bill Mordue (second from right), David Saunders (right); standing to my left and above Bill Mordue are Graham Goldsworthy and John Brady. Stuart Reynolds is on the far left, and Jim Truman behind Tony Lees.

Hair getting shorter.

from consecutive light–dark cycles. Modelling the data (Marlies Vaz Nunes) assisted our thoughts on what might be happening inside.

The winged–wingless polyphenism seen in aphids did not escape interest, particularly when this was controlled by day length, and we developed an automated, vertical wind tunnel where aphids could be flown for many hours, attracted by an overhead light, while a downward airflow was balanced against the upward flight so that the insect was held stationary while flying (a modification of a John Kennedy manual flight chamber and ingeniously automated by Charles David, also working in the group). A laterally-placed plant-mimicking visual target illuminated for a few seconds during each minute of flight allowed us to examine flight behaviours that, in the field, carried the insect long distances (upward flight) and the targeted/foraging flight that led the insect to land on a plant. Comparison of flight times before foraging flight showed an extended migratory flight in short-day-induced autumn winged forms of the Black Bean Aphid, while long-day, crowd-induced summer winged adults responded almost immediately to the plant target.

Financial support for the Insect Physiology Group continued until 1987 under the successive leadership of John Kennedy up to 1977, Tony Lees until 1982 and then John Moorhouse. In 1987, the Agriculture and Food Research Council (AFRC) began to look again at the various research groups that they were funding and decided to cease funding the Silwood-based group. However, they offered a lifeline to me and Charles David. It was suggested that we contacted the entomologists at the AFRC Institute of Arable Crops Research, Rothamsted Experimental Station (now Rothamsted Research), and put together a research proposal. So, we talked with Trevor Lewis, John Pickett and Lester Wadhams, and there were strong common interests in aphids and chemical ecology. Charles had been working on moth pheromones and flight behaviour while John and Lester's group had recently identified the first aphid sex pheromone. We put together a proposal to study the chemical ecology of aphid–plant and insect–insect interactions. The first submission was bounced so we rewrote it and received the funding. By this stage Charles had decided to move his family to Guernsey, where he grew up, and I was now head of the Silwood branch of an AFRC Linked Research Group in Aphid Biology.

This liaison proved to be extremely rewarding and we examined the species specificity of the aphid sex pheromone based on the few related compounds that could be identified, but lab and field trials showed specificity was certainly present. There were also sex pheromone and plant volatile interactions. We showed that aphid parasitoids from the genus *Praon* were attracted to the aphid sex pheromone in the field. There were studies of the behavioural responses to host and non-host plant volatiles by walking aphids in olfactometers and flying aphids in wind tunnels (Steve Nottingham). The mode of action of antifeedant compounds using video and electrical recordings of aphid probing behaviour were also rewarding (Glen Powell).

We managed to get an extension to the funding for the Linked Group and in 1991 I was lucky enough to be awarded one of the first

Biotechnology and Biological Sciences Research Council (BBSRC) five-year Postdoctoral Fellowships. This gave me an independence which allowed me to continue the Linked Group projects but also apply for other research funding in my own name to explore my curiosity on outstanding questions on aphid polyphenism, which had not gone away. So, we now had an Aphid Biology Group which grew in size with postdocs and students with parallel areas of interest. We continued to work on photoperiodism and had designed environmental chambers controlled by BBC computers that altered the photoperiod and light intensity so we could simulate seasonal day–night changes, including dawn–dusk transitions, anywhere in the world rather than the more usual on–off static light–dark regimes used before (Marlies Vaz Nunes). Projects involved host location by aphid parasitoids as well as the influence of parasitoids on wing development (Petra Christiansen-Weniger) and the identification of putative photoreceptors in the aphid brain responsible for the photoperiodic response (Gao Nong). Kye Chung Park developed an ultrasensitive electroantennogram to record the response of antennal olfactory cells to plant and aphid volatiles. We also developed, with Stephen Young, a two-camera video set-up to examine aphid flight tracks in three dimensions in lab and field.

In 1996 the BBSRC Fellowship ended but there was the possibility of an extension, so I applied. It didn't go well. I'd managed to obtain research funding during my tenure, even from BBSRC, but the panel explained that I was not supposed to do that but to do my own, personal research rather than build up a group. Fortunately, successfully applying for funds and setting up a research group was recognised as positive by Imperial College and Mike Hassell, Head of the Biology Department, offered me firstly a department-funded Fellowship for 12 months with the prospect of a permanent position the following year when a colleague, John Brady, retired.

The transition from postdoc to member of staff had been a 21-year apprenticeship. I had been involved in teaching on a voluntary basis but then a member of staff, who was due to return from sabbatical, announced he was not coming back. I immediately acquired his teaching load, including the final-year Animal Behaviour course, which began in a few weeks' time; a steep learning curve and I realised the advantages of being a postdoc for so long. Fortunately the research continued. I then became the coordinator for the Biology with a Year in Europe degree where students spent a year at a partner university in Europe. The bonus of this position was that it was considered best practice for me to visit them during their placement to see how they were progressing. I could also catch up with colleagues working at the partner universities. To promote this degree, each year I organised a party where interested new students could meet the students who had just returned from Europe. This was always a great success and there was a stream of very enthusiastic returnees. I was then invited to become Chair of the Board of Examiners, which was a rather more demanding position but with some rewards. In 2009 an email came round asking for volunteers to take early retirement, so I volunteered. I continued until the end of the year, completed my final Animal Behaviour course but was allowed to retain my office and lab space. I could organise the course exam and my final PhD student's studies were not disrupted. Simon Leather became his new official supervisor and I could empty my office!

Working at Silwood was great, it was very friendly, there was a good number of social events and everybody mucked in. In those days we had half an hour for coffee in the morning and again for tea in the afternoon. We had a tea lady Mrs Ellis (who you did not argue with) and her husband Jack was the handyman at Ashurst Lodge. It was like a village, so you had to be a bit careful as people knew what you were up to almost before you did.

On my first day I met Dick Southwood, then Head of Department, while walking across campus. He greeted me with a cheery "Hello Jim" and then engaged me in conversation, which was a little puzzling until I realised that he had mistaken me for Andy Crump who had also started at Ashurst that day. Dick knew both of our histories and rapidly readjusted."

RES Roles

"Despite my Head of Department at Brunel being Professor J.D. Gillett OBE (RES Treasurer 1975–77 and President 1977–79 – I recently read that he failed all his school exams and started his working life as a technician) and mingling with a multitude of entomologists whilst at Birmingham, I only became aware of the Society when I moved to Silwood Park where they would run a minibus into London to attend the monthly meetings. I became a Fellow in 1979 and in the 1990s I was asked to sit on Council and had two terms. I was an editor of *Physiological Entomology* for 12 years and spent 18 years as a member of the editorial board as well as being Consulting/Assistant Editor on *Antenna* for the past 11 years. I sat on the Finance, Meetings and Publications committees. I was a Vice-president 1999–2000, Treasurer from 2009–2011 and President from 2006–2008. The latter appointment was a great delight – I was following in the footsteps of my entomological heroes who had greatly influenced me – Professor Sir Vincent Wigglesworth, Professor John Kennedy, Professor Tony Lees, Professor J.D. Gillett and Professor Dick Southwood, amongst others.

My presidential term of office coincided with the Society's move from 41 Queen's Gate, London, to The Mansion House. The sale of the London property put the Society on an extremely sound financial footing even after allowing for the purchase and restoration of The Mansion House plus grounds. This was a tremendous undertaking, skillfully managed by the previous Registrar/CEO, Bill Blakemore. Only the outer walls of The Mansion House remained untouched, everything else was pretty much replaced. The restoration took some 8–9 months, with the first Council meeting in the new building in October 2007 and the grand official opening on May 22 2008 with the Rt Hon Hilary Benn MP and the Society's vice-patron, John Palmer, the 4th Earl of Selborne."

Director of Science / Resident Entomologist

"When based in London, there were no entomologists on the Society's staff to answer queries about insects. After the move of headquarters, it became possible to employ someone to deal with

INTERVIEW

At the official opening of The Mansion House on May 22 2008.
L–R. Professor Lin Field - President Elect, the Rt Hon Hilary Benn, Professor Jim Hardie – President, John Palmer the 4th Earl of Selborne, Vice-Patron.

these enquiries and it was also decided that the Society should produce a book of British insects. Peter Barnard, who had just retired from the NHM, was employed as Director of Science/Entomologist in Residence to undertake both tasks. After three years Peter had completed the book and decided to fully retire. I stepped into the role part-time. In those early days there was a moderate flow of enquiries, but numbers increased with a web presence and eventually the Insect Identification Service started with a dedicated webpage. Over the eleven years I have been in this post there has been a wide range of enquiries; from insects that members of the public have seen on walks or around their houses and gardens, to questions from builders and architects as to why flies have invaded their buildings, to parcels of clothing that arrived asking me to find the insects that are biting the sender. I have also helped to write a script for Holby City and validate answers for TV quizzes. I was even asked to suggest a Jamaican insect that could be used as the basis for tattoo design – maggots and aphids didn't make the grade. It's been a very enjoyable second career."

Jim is still a busy man and while these days he works mainly from home, he still has three offices within his house; an indication that the downsizing he began when he retired from Imperial is an ongoing process. His career has been dominated by two insect groups, which Jim sums up in his usual practical way "Maggots gave me fishing and a PhD while aphids paid the mortgage".

"When I retired, I looked back and wondered why I had spent so many weekends and evenings writing grant applications and papers plus travelling around the world to attend conferences and work with colleagues. But on reflection I decided, yes it had been worthwhile and good fun. The family could join in at times and my eldest daughter had a memorable, although she doesn't remember, road trip down the west coast of the USA at 11 months, and we tagged on holidays to my trips when we could, *e.g.*, Australia, Japan and the Netherlands."

Jim's relaxed, informal approach to life has eased him through a career in which he took all the opportunities that life offered. Driven by his fascination with how things work, he has survived the endless changes that academia has thrown at him and now, eleven years into his second career, he is still enjoying this role, bombarded with enquiries that range from requests to identify blurred blobs to those that want all of the invertebrates in a garden named. Customers range from the public through business to the press, requests that require patience, detailed research and often diplomacy. Jim is the calm, friendly and professional face of our Society that much of the wider world interacts with. We hope that Jim will continue to reassure and inform this audience for many years to come.

His annual review of enquiries received can be found on pages 51–54 of this issue.

Generating a buzz: The RES goes to Chelsea

The Royal Entomological Society Garden, designed by Tom Massey and supported by Project Giving Back, will be unveiled at the RHS Chelsea Flower Show 2023 (23rd – 27th May) before being relocated as a teaching garden and long-term opportunity for insect study.

Simon Ward, RES CEO, has commented on the opportunity, "The Royal Entomological Society Garden at the RHS Chelsea Flower Show 2023 presents an incredible platform for us to engage with a wide audience about the benefits of insect science and we are hugely grateful to Project Giving Back for giving us the opportunity. The garden will help us highlight the role gardeners play in providing food and habitats for a wide range of insects, whilst balancing the need to control a small number of insect species responsibly. We will show the exciting connections between people and insects, and how innovative science allows better understanding of those connections. Through public engagement at the show, and the wider publicity opportunities Chelsea offers, we hope to significantly raise the profile of insect science and its importance to everyone who values our planet."

The garden forms part of the Society's vision to 'enrich the world with insect science', by supporting work to increase public understanding and appreciation of insects, including less well-known ones, and in highlighting the diverse and important roles they play in our global ecosystems. The garden will provide an inspiring place in which insects can be studied, researched, and observed in a beautiful and natural environment, aiming to stimulate those who visit to see how they can consider insects in their own gardens.

Antenna spoke to designer Tom Massey about the vision for the garden.

Tell us a bit about you. What inspired you to work in the horticultural industry? How would you describe your style of garden design?

"I have always loved the great outdoors and been inspired by landscapes. This led me to pursue a career in landscape design. At 16, I spent 6 months working with a landscape gardener, then went to university to study animation. Following university and an eclectic range of jobs, I decided to return to horticulture and retrained at the London College of Garden Design. I set up my practice – Tom Massey Studio – in the summer of 2015, and now employ four designers who work alongside me from our base in Mortlake, southwest London.

I would describe my style as eclectic, influenced by the site and context rather than trying to adhere to a certain style. However, all my designs are ecologically focused and consider sustainability, biodiversity and the local environment."

Why is it timely that the RES will be able to highlight the crucial role of insects with the planned garden?

"The future of our planet hangs in the balance and a better understanding of insects could provide the answers to many of our climate and biodiversity-crisis questions. I am really excited to be working with the RES to raise awareness of insects and their importance in gardens, the wider UK landscape, and the global environment. Insects are key species in our ecosystems, but many are suffering mass global decline. We have a vital role to play in their recovery and survival, just as they do in ours."

What is the theme of the garden, and what inspired the garden design?

"The theme centres around insect science, study and education, while the design is inspired by the rich biodiversity found on brownfield sites. These areas of perceived wasteland are full of habitats, topography and plants beneficial to insects. We can create low-environmental-impact gardens that emulate these qualities, repurpose waste materials, support insects and provide opportunity for research and study."

What key features have been worked into the garden design?

"The main focal point is an outdoor laboratory built into a hillside, with a roof inspired by a compound iridescent insect eye. This accessible structure will be made from recycled steel, sustainable exterior-grade cork and biodegradable glazing, with 'modules' permeable to insects that will provide an accessible opportunity for on-site research, study and identification of insects visiting the garden. The space takes visitors down into the landscape, offering an 'insect-eye view' and a space in which to study. There will also be a movable projector screen linked to the microscopes in the lab, giving the opportunity to show enlarged insects, revealing their fascinating morphology and offering a chance to educate and inspire visitors. During the week of the show the lab will be used for live scientific research, monitoring and studying insects visiting the garden."

How will the design and materials make space for insects?

"Every material used in the garden, from pathways, to retaining walls or the lab roof, and all the chosen plants and trees, have a function, providing food, habitat, opportunity for study and research potential.

The diverse topography across the site – from rammed-earth floors, compacted gravel and clay pathways and dead wood, to piles of rubble, bare sand and gabion walls (wire mesh baskets filled with recycled materials) – provides numerous and varied habitats for insects. A dead-tree 'sculpture', cut into rings elevated on steel poles, will 'float' over biodiverse planting, with the open structure allowing ease of access for study. A standing dead tree and tree stump will provide further sculptural habitat and visitor interest, while showcasing the importance of dead wood as insect habitat. Water in still pools and flowing streams will provide additional important insect habitats as well as added interest to the aesthetic and soundscape of the garden.

Planting for pollinators and a wide range of other beneficial insects has been designed with our changing climate in mind, adapted to showcase a beautiful and resilient scheme that will provide year-round food, habitats and interest, while naturalistic planting areas towards the rear of the lab will provide an undisturbed environment which is crucial for many visiting insects and other beneficial wildlife."

You mentioned that the design reflects the changing climate. What sustainable approaches will be used in the design to help minimise the garden's environmental impact, and improve its resilience?

"Hard materials have been selected that are low impact and mainly recycled. These recycled and reclaimed materials are championed across the scheme, from recycled aggregate mulches to the creative use of dead wood as sculptural habitat.

The live planting will be both biodiverse and designed to support and attract insects whilst still being interesting, immersive and aesthetically attractive. Importantly, the planting scheme has also been designed to be climate resilient and able to deal with drought and extremes of weather. Further, recycled aggregate mulch will be applied to the soil to lock in moisture, and create a harsh environment, for resilient and adaptable plants.

The naturalistic pond and flowing stream act as a swale, collecting excess rainfall that will help keep some areas moist. The pond itself will be planted with a range of aquatics and marginals, important habitat for many insect species."

You can't talk about the RHS Chelsea Flower Show without talking about the plants. What can we expect from the planting?

"The garden should feature some 2,500 plants. At the front of the garden, colourful and textural drought-resistant planting, mulches with mixed recycled aggregates, will be representative of plants found on brownfield sites. Naturalistic planting behind the lab will evoke native woodland-edge meadows, buzzing with insect life. The planting will contain a mix of native and non-native plants, extending the garden's flowering season and providing a mix of food sources for pollinators and other beneficial insects.

Plants have been chosen to be attractive to insects through pollen and nectar or edible leaves and other foliage. We will be including a lot of 'unsung heroes' in the scheme, too; plants commonly considered weeds! These can be important food sources, so we will be including non-invasive weeds such as clovers (*Trifolium* spp.), Foxglove (*Digitalis purpurea*), Dark Mullein (*Verbascum nigrum*), Kidney Vetch (*Anthyllis vulneraria*) and Common Knapweed (*Centaurea nigra*), to name a few.

There are also larger 'feature' plants, all chosen with insects in mind. Scots Pine (*Pinus sylvestris*) supports rare insect species including Pine Hawkmoth (*Sphinx pinastri*), Scottish Wood Ant (*Formica aquilonia*) and Rannoch Looper Moth (*Macarea brunneata*). Silver Birch (*Betula pendula*) provides food and habitat for more than 300 insect species. It also attracts aphids, which provide food for ladybirds and other species. Common Hawthorn (*Crataegus monogyna*) is another tree that supports several hundred insect species. Its flowers provide nectar and pollen for insects and are also eaten by dormice. The haws are rich in antioxidants and are eaten by migrating birds and small mammals. Hazel (*Corylus avellana*) is an important food source for the caterpillars of several moths. In managed woodland, where Hazel is coppiced, the open, wildflower-rich habitat supports several species of butterfly, while Hazel flowers provide early pollen as a food for bees. The Judas Tree (*Cercis siliquastrum*) supports several pollinator species, providing an important early source of pollen and nectar, while Quince (*Cydonia oblonga*) has nectar- and pollen-rich flowers that attract pollinators."

What one message would you like visitors to take away from the garden?

"The understanding that we are important to insects, in the choices we make and the way in which we design and maintain our garden spaces, and that in turn, insects are important to us and the ecosystems we rely on for survival."

What is the most important thing to do in a garden or green space to support wildlife?

"I am not sure there is one stand-alone thing to do; it is more about a holistic and considered approach. For example, allowing areas of the garden to be less maintained or more wild provides habitat and shelter for wildlife and removes reliance on chemical pesticides, instead encouraging predators into the garden such as toads or frogs with a pond, or birds by supplying feeders. A gentler, more relaxed approach to maintaining our gardens is important to allow wildlife a chance to inhabit our green spaces too."

Who are you working with to create the garden?

"I am the lead designer and project coordinator, pulling all the consultants and fabricators together. We have been working

Royal Entomological Society

with Thread Architects on wider plans for the RES and they have been inputting into the design for Chelsea too. Landscape Associates are the main contractor; they are headed up by Richard Curle, who has a wealth of show-garden experience and has built my previous two Chelsea gardens. Cake Industries are building the lab; they are specialist fabricators and have been collaborating with Spaceplates (N55, Anne Romme and Anne Bagger) architects and engineers based in Denmark with a specialism in geodesic structures. Ross Broughton of Surrey Ironcraft is fabricating other metal elements such as habitat panels. Ben Garner of Water Artisans, a specialist in aquatic ecosystems, is involved in the water-feature design. Hortus Loci are supplying plants; I have worked with Mark Straver for many years, and we challenged them to grow organic plants for the Yeo Valley Garden in 2021. This time, we are asking them to be peat- and pesticide-free, given the role of pesticides as a major factor in global insect decline."

How can we engage with the horticultural industry to use more sustainable materials and landscaping practices?
"I think there is already a growing shift towards more sustainable practice in industry. I have just written a book, titled *RHS Resilient Garden*, which talks about gardening and garden design in response to climate change. It was written in close collaboration with the RHS science team and is by no means the only book on the subject. There is an increasing dialogue on sustainability and sustainable practice in the industry. Clients seem to be more engaged too, from private individuals to local councils and planning officers. Keeping the dialogue going and sharing information is important to move things forward."

And, to finish off, what is your favourite insect?
"It would have to be a majestic Stag Beetle (*Lucanus cervus*). I remember being hugely excited to see them as a child, particularly in flight. It's sad they are far less common now, but hopefully with changing attitudes to removing dead wood from landscapes numbers will increase."

Tom Massey. Photo courtesy of Yeo Valley Organic.

Royal Entomological Society Insect Identification Service 2022

Jim Hardie [1]
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People continue to be interested in, horrified by (usually mistakenly) or delighted by insects that they encounter indoors and outdoors. We try to enlighten them by telling them what the insects are, along with providing some information on their biology/life history. Interested parties can then search further details. In 2022 we provided 2,184 responses to queries (Fig. 1), 36% fewer than last year as perhaps people catch up with virus-delayed commitments.

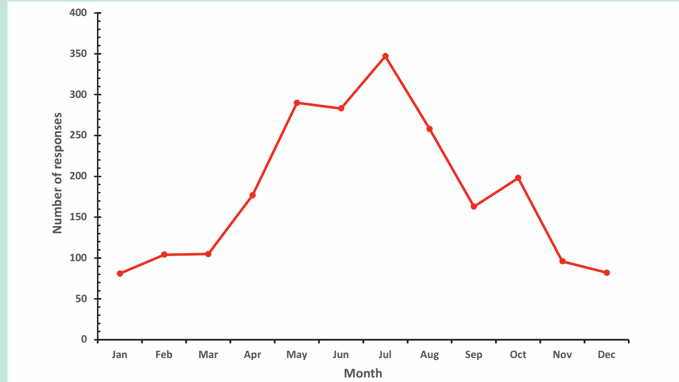

Fig. 1. Monthly responses to insect identification queries during 2022.

Fig. 2. *Cicada orni*. Photo by EP.

***Cicada orni* (Ash Cicada)** (*c*. 25 mm)
2021 saw the appearance in Wales of a Large Brown Cicada (*Graptopsaltria nigrofuscata*), which is native to East Asia (Hardie *et al*., 2022). Another cicada was seen by EP in August 2022 sitting by a roadside in Boscombe, Dorset; not, unfortunately, a wayward and extremely elusive New Forest Cicada but a relatively common Ash Cicada (*Cicada orni*) from southern Europe stretching into Western Asia and North Africa. It is possible that this individual flew in from continental Europe or perhaps was imported with soil. Another cicada, likely to be the same species, was reported in the local press on the Isle of Wight this year (Morgan, 2022).

***Drilus flavescens* (false firefly beetle larva)** (< 16 mm)
Linda Ellis spotted this *Drilus flavescens* larva crawling across her garden path near Canterbury, Kent in September. This is the only species in the family Drilidae, the false firefly beetles, that occurs in the UK and has been reported in south-east England from Hampshire to Kent. As with some other firefly and glow-worm species, the larvae are predators, feeding on snails during the two or so years of development. Like the glow-worms, adult females are larviform while males have a typical adult beetle form. Unlike their namesakes, the false firefly beetles are not bioluminescent, and the males locate females using pheromones.

Some may have noticed that this beetle larva graces the cover of the recent insect handbook on *British Coleoptera Larvae* (Barclay *et al*., 2019).

Fig. 3. *Drilus flavescens*. Photo by Linda Ellis

Fig. 4. *Lestodiplosis vorax.* Photo by Richard Harbird

Lestodiplosis vorax (gall midge) (*c.* 3 mm)
In July Richard Harbird photographed this rather attractive gall midge in his bathroom basin and the following day found it dead on a landing windowsill in Redditch, Warwickshire. It was unusual for Cecidomyiidae in the UK but appeared to belong to the genus *Lestodiplosis.* The specimen was eventually sent to Dr Marcela Skuhravá, a cecidomyid expert in Prague, who identified it as *Lestodiplosis vorax*, which is known to be a predator of other gall midges. The species has been reported previously in the UK (Harris, 1976).

Cossus cossus (Goat Moth caterpillar)
(90–100 mm)
This Goat Moth caterpillar (*Cossus cossus*) was seen on bare ground near Earith, Cambridgeshire by David Freear in September; probably the largest caterpillar of a resident moth species in the UK which, like close relatives in the family Cossidae, feeds inside trunks and branches of a variety of deciduous trees including willow, birch and oak. They take up to five years to mature and enter the wandering stage in late summer when they leave the host tree to search for a suitable overwintering site and pupate under the soil.

This is a nationally scarce species but widespread in Britain, although there are fewer records in the north.

Goat Moth caterpillars are also famous for having 4,041 separate muscles - a figure published by Pierre Lyonet in 1760 and still much quoted.

Fig. 5. *Cossus cossus.* Photo by David Freear

Fig. 6. *Praon* sp. cocoon beneath an aphid mummy.
Photo by Duncan Martin Photography

Aphid parasitised by *Praon sp.* (3–4 mm)
Duncan Martin sent this image taken in June near Slough. It shows an aphid that has been parasitised by a braconid parasitoid wasp from the genus *Praon.* The female wasp lays her eggs into an aphid nymph and the wasp larva develops inside, consuming the soft tissues. When mature, the wasp larva emerges from the underside of the now dead host and creates a silk 'pedestal' cocoon in which it pupates. Most aphid parasitoids pupate inside the host body after attaching it to a plant surface. Only the outer cuticular layers of the host remain and form the aphid 'mummy'.

This aphid had reached adulthood before its demise indicating that it was parasitised as a late-stage nymph.

OUTREACH

Fig. 7. *Xerophyllum* sp. Photo by David Jose Basz

***Xerophyllum* sp. (groundhopper)**
(*c.* 15 mm)
This rather impressive groundhopper/pigmy grasshopper from the family Tetrigidae, genus *Xerophyllum* was submitted by David Jose Basz; possibly *X. platycoris simile.* It was seen in a field near Uyo, Nigeria in June.

Eriozona syrphoides (hover fly) (*c.* 12 mm)
Neil Symonds captured this image in June near Great Yarmouth. It shows a larva of the hoverfly *Eriozona syrphoides* on a willow branch feeding on Giant Willow Aphids (*Tuberolachnus salignus*). The adult is a rather attractive black, white and orange banded species, possibly a bumblebee mimic. It is nationally scarce and was reported in Wales in the 1960s with the current distribution in Wales and Scotland, but there are scattered, mainly unconfirmed reports from England. There may be an association with spruce plantations (at least on continental Europe) where the host aphid is reported to be *Cinara pinea*.

Fig. 8. *Eriozona syrphoides.* Photo by Neil Symonds

Fig. 9. *Dermestes* sp. larva. Photo by Jim Cobb

***Dermestes* sp.**
(dermestid beetle larva) (*c.* 10 mm)
This beetle larva from the genus *Dermestes*, possibly *D. peruvianus* (Peruvian Larder Beetle) or a close relative, was seen by Jim Cobb near Dundee in January. This insect feeds on material of animal origin that is dry or in a state of decomposition, *e.g.*, feathers (birds' nests), skins, hides, also commodities such as cheese and meat. However, it can survive on a diet of vegetable material alone (*e.g.*, cereal-based foods, grains, pasta, *etc.*). It is a minor domestic pest but more commonly associated with premises used to store or prepare food. The larvae will make chambers (where they pupate) in materials on which they do not feed and can cause extensive and sometimes structural damage to timber.

Seasonal pattern of queries for the identification of *Melolontha melolontha* (Common Cockchafer)

Fig. 10. *Melolontha melolontha.* Photo by Lewys Jones

The Common Cockchafer (*Melolontha melolontha*) is a large scarab beetle (20–30 mm) and easily recognisable. Fig. 10 shows a female with the antennal club comprising six lamellae, rather than seven seen in the male, which was spotted in May by Lewys Jones close to Solva, South Wales. The typical scarabaeiform larvae are impressive when mature, having spent some 3–4 years feeding on the roots of various plants. They can cause significant damage when present in large numbers. The cockchafers pupate underground, and the adults are also known as May Bugs in the UK as they emerge and begin to fly in May. Records from the Insect Identification Service show that timing matches precisely with query responses over the last eight years, starting and peaking in May, reducing in June through July (Fig. 11). The adults feed on leaves from a variety of trees. The beetles are common with a widespread distribution in southern Britain.

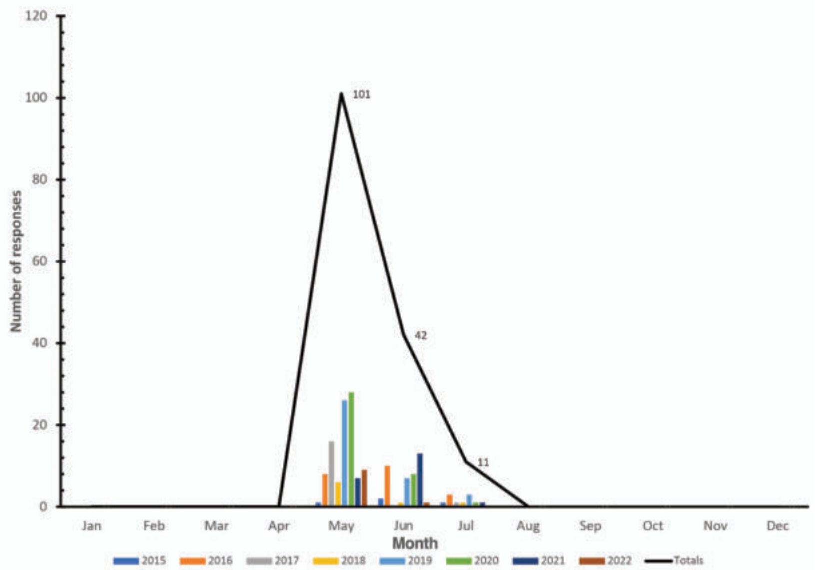

Fig. 11. Identifications of the Common Cockchafer, *Melolontha melolontha,* over the last 8 years.

We thank Members and Fellows who have helped during the year and in particular Liam Crowley, Andy Salisbury, Helmut van Emden and Judith Marshall.

We continue to receive appreciative comments along with the occasional donation. In October we identified the tough, silken, cocoon mass of a Wax Moth that was impressively anchoring wooden panels to the wall of a shed. The enquirer's reply included -

"Thank you very much for responding so quickly – I'm so impressed that you have replied already and with such a thorough answer (I really hope that doesn't come across as patronising but in this modern society, you are something of an anomaly!)." We took it as a compliment.

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Royal Entomological Society — Antenna Reviews

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

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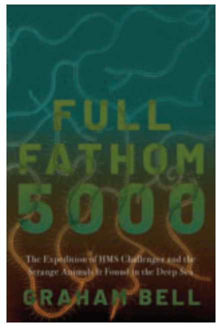

Full Fathom 5000: the expedition of HMS Challenger and the strange animals it found in the deep sea
Graham Bell
Published by Oxford University Press
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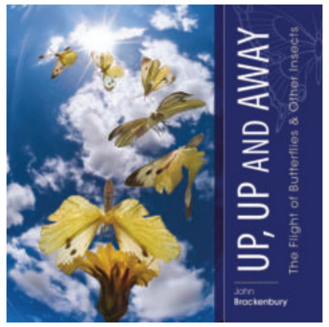

Up, Up and Away: the flight of butterflies and other insects
John Brackenbury
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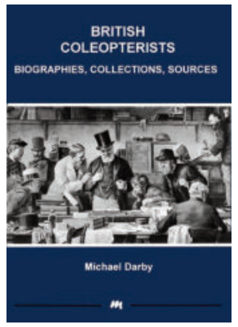
Reviewed by Richard Jones



British Coleopterists: biographies, collections, sources
Michael Darby
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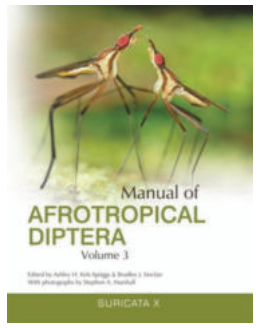
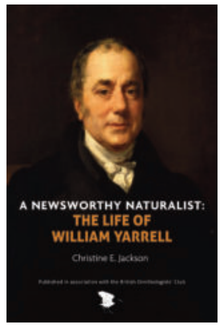
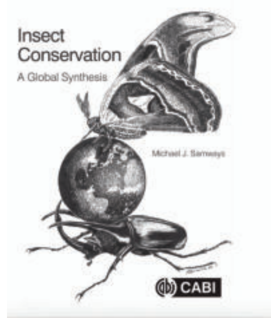


Manual of Afrotropical Diptera: Volume 3 (Brachycera—Cyclorrhapha, excluding Calyptratae)
Ashley H. Kirk-Spriggs & Bradley J. Sinclair (eds)
Published by SANBI Publishing
ISBN 9781928224136
Reviewed by George C. McGavin



A Newsworthy Naturalist: the life of William Yarrell
Christine E. Jackson
Published by John Beaufoy Publishing
ISBN 9781913679040
Reviewed by Richard Jones



Insect Conservation: a global synthesis
Michael J. Samways
Published by CABI
ISBN9781789241686
Reviewed by Alan Stewart

Insect Conservation: a global synthesis

Michael J. Samways
Published by CABI, 2020
ISBN 9781789241686 (hardback) / 9781789241679 (paperback)

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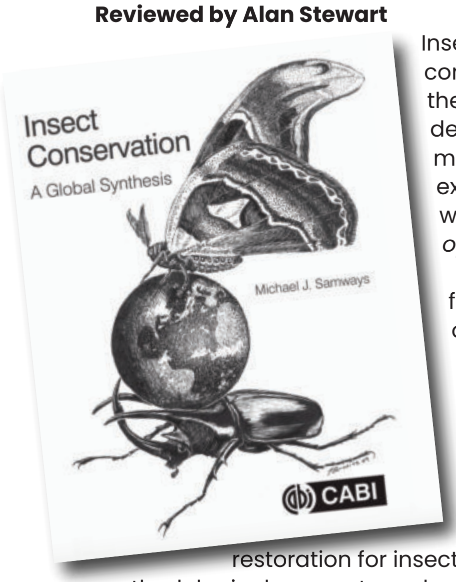

Insect conservation, once a Cinderella subject in traditional conservation circles, has come of age. No entomologist will need reminding that many of 'the little things that run the world', in E.O. Wilson's memorable phrase, are every bit as threatened with population decline and extinction as some of the more charismatic big mammals that engender so much public support. Michael Samways has been the torchbearer for this rapidly expanding field through his research, books, talks and popular writings. He had already written several books on various aspects of insect conservation, but this *magnum opus* is certainly the largest (540 pages) and most comprehensive.

The book contains thirteen chapters that can be divided into three broad themes. The first of these sets out the main foundations of insect conservation and the three operational scales which are then dealt with in separate chapters: whole landscapes (coarse filter), landscape features including habitat patch size, connectivity and heterogeneity (meso-filter) and species focus (fine filter). This is followed by a chapter that considers the general approaches to insect conservation, including setting priorities, red listing, defining conservation units and strategic planning. The next section contains chapters that are each devoted to the insect conservation issues and challenges of four broad habitat categories: agricultural; forest, grassland and cave; freshwater; and urban. This section then finishes with a consideration of habitat restoration for insects and the ecosystem services they provide. The final section considers some methodological concepts such as global through to local assessments of insect species and diversity, species inventories and mapping, as well as the concepts of surrogacy and bioindicators. The final chapter considers what the future holds for insects in the new Anthropocene, with its twin challenges of global biodiversity declines and climate change. The last sentence of the book asserts that, whilst we have the conservation tools to rescue the situation, based on knowledge gained from research, what is needed now is the will and determination for action.

The beauty of the book's format is that it provides the reader with access to the subject matter at three different but complementary levels. Firstly, the text is rich in detail and densely supported by references to the primary literature, providing an in-depth analysis of each topic. Secondly, there are detailed line drawings throughout to illustrate the main points, fully supported with extensive explanatory legends; a good appreciation of the main points of each chapter could be gleaned from these graphics alone. Thirdly, each chapter finishes with a long list of key bullet points, included as a revision guide for undergraduate students but equally suitable and useful for time-pressed lecturers and researchers.

The book has appeared at a highly opportune time, when scientists, conservationists and the general public have been alerted to the possibility of widespread declines in insects and the ecosystem services that they provide. Three of the initial studies about global insect declines that generated so much recent attention in the media, and indeed controversy amongst insect ecologists, are referred to in the book: the 'Krefeld study' (Hallmann *et al.* (2017) *PLoS ONE* **12**, e0185809) showing a 75% decline in biomass of insects caught in a network of Malaise traps in Germany over 27 years; one of the first global reviews of insect declines by Sanchez-Bayo and Wyckhuys (2019, *Biological Conservation* **232**, 8–27); and the apparently climate-driven collapse of insect abundance in a tropical rainforest (Lister and Garcia (2018) *PNAS* **115**, e10397). However, the book must have gone to press just as the subsequent cascade of papers and reviews on long-term changes in insect populations started to appear. Thus, important reviews and meta-analyses that have appeared since are missed, such as by Wagner (2020, *Annual Review of Entomology* **65**, 457–480), Seibold *et al.* (2019, *Nature* **574**, 671–674) and Van Klink *et al.* (2020, *Science* **368**, 417–420). Whilst this is perhaps unfortunate timing, no doubt these will be dealt with if a second edition is produced in due course.

It is hard to find topics that have been missed in a book with such broad and comprehensive coverage. The chapter devoted to restoring insect habitats contains a wealth of information and discussion about the principles and practice of restoration. I could not find any reference, however, to the concept of 'rewilding'. At least in Europe and North America, rewilding has caught both the public imagination and the enthusiasm of many in the broader conservation field, with its emphasis on withdrawing from objective-driven management of habitats and allowing nature to take its course unconstrained by any requirement to achieve a particular target community or state. Opinion amongst insect conservationists, however, is strongly divided about whether insects will benefit from such a strategy, many being concerned that a completely *laissez faire* approach will result in certain early and mid-succession habitats that harbour important and rare insects being quickly replaced by tree-dominated landscapes. We may not yet have sufficient research evidence to draw definite conclusions, but it is a major, albeit controversial, theme in nature conservation circles and therefore one on which insect conservationists will need to formulate an opinion.

This book is a monumental achievement by any standard. It should be required reading for anyone with a serious interest in insect conservation. There is a very useful 26-page glossary of terms followed by a reference list that stretches to no less than 112 pages. The book will be an indispensable source of information not just for those actually working in the field of insect conservation as researchers or practitioners, but also for anyone who wants an authoritative introduction to any particular facet of this diverse subject. The preface indicates that the book has been written primarily for undergraduates, but it will also be an invaluable source of reference for entomologists with an interest in conservation and other conservationists who simply want to learn why insects are important and how best to meet their requirements alongside other taxa.

EVENTS

Details of the meetings programme can be viewed on the Society website (www.royensoc.co.uk/events) and include a registration form, which usually must be completed in advance.

Offers to convene meetings on an entomological topic are very welcome and can be discussed with the Chair of the Meetings Committee (richard@royensoc.co.uk).

March 2023

Thu 30 — 30 March – 31 March
Student Forum 2023 (hybrid event)
Glamorgan Building, King Edward VII Ave, Cardiff, UK Glamorgan Building, Cardiff

April 2023

Wed 5 — 5 April
Online talk – Arnold van Huis (virtual event)

Wed 26 — 26 April
Behaviour Special Interest Group (virtual event)

Thu 27 — 27 April
Insects as Food and Feed (IAFF) Conference (hybrid event)

May 2023

Wed 3 — 3 May
Online talk – Angharad Gatehouse (virtual event)

June 2023

Wed 7 — 7 June
Online talk – Robert Pyle (virtual event)

Mon 19 — 19 June – 25 June
Insect Week 2023

July 2023

Wed 5 — 5 July
Online talk – Lin Field (virtual event)

Thu 6 — 6 July
Rearing Special Insect Group

September 2023

Tue 5 — 5 September – 7 September
Ento23

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

Ento23

5-7 September

University of Exeter, Penryn Campus, Cornwall

Plenary Speakers

Ellie Leadbetter
Royal Holloway University of London

Jacobus 'Japp' De Roode
Emory University

Registration open

Early Bird Discount
Deadline 29 May

royensoc.co.uk/events/ento23

Topics & Themes

- Pollinators
- Insect genetics & genomics
- Pests, biological control & IPM
- Infection & immunity
- Symbionts & microbes
- Insect behavioural & evolutionary ecology
- Insect conservation & insect declines
- Insect movement and migration

RES members receive significant discounts on events, please ensure your membership is renewed!

Accommodation

Discounted accommodation at Glasney Rooms, Penryn Campus, can be booked with your conference registration

Conference Dinner

Wednesday 6 September
Greenbank Hotel , Harbourside
Tickets £55.00 with coach transport
Places are limited, please book early!

Call for Abstracts

Deadline 17 April

Full details can be found at royensoc.co.uk/events/ento23

University of Exeter

Royal Entomological Society