Bulletin of the Royal Entomological Society Volume 45 (4) 2021

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COVER PICTURE

Dragonfly in flight, from 'Tips for insect photos from a total amateur' by Bernie Roitberg (p176-189).

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EDITORIAL

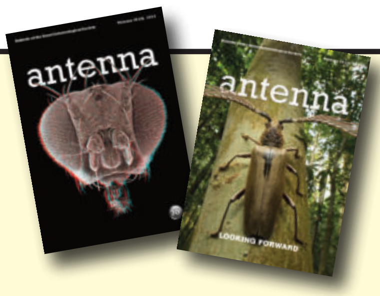
Hello and welcome to *Antenna* 45(4). Writing this in early October, there's a definite feeling of change in the air. The last weekend of September gave us some glorious later summer sun (I was rock pooling in Whitley Bay!), but the weather since feels very much more autumnal. The last few weeks have also heralded a return to in-person teaching for those of us working in academia, representing a long-awaited transition back to campuses across the country for many, but bringing with it understandable concerns for potential impacts on Covid transmission. It's been great to see so many familiar faces around Newcastle over the last fortnight, though recognising them in the corridor can sometimes be a challenge when everyone has a mask on!

Regrettably, however, not all of us will return to teaching this term. The news of the death of Prof. Simon Leather at the end of September will have come as a shock to many, not least the staff and students of Harper Adams University where Simon has nurtured and inspired countless emerging entomologists over the years. Simon's enormous contribution to entomology, education and the RES is, quite simply, far too great to encapsulate here. The phrase 'entomological hero' has been mentioned several times in recent correspondence on Simon's passing; an accolade not given lightly, but won many times over in Simon's case. Whilst we mourn an 'entomological hero' now, here and in this issue's Letter from the President, we plan to celebrate Simon's career and contribution to entomology in more depth in an *Antenna* next year.

Other copy in 45(4) includes the next instalment in Stuart Reynold's Spotlight series on insect haemoglobin, plus articles from Tilly Collins, John Feltwell, Bernie Roitberg and John & Anita Hollier on topics ranging from eating insects to photographing them. We also feature several updates from The Mansion House, including multiple reports from our Director of Communications and Engagement, Luke Tilley, on the recent Grand Challenges workshop, Membership Consultation and RES Elections. Society News also contains a report on ENTO'21, and an article on what the RES is hoping to do to remember Eleanor Anne Ormerod, and how you can help if you happen to know a good stonemason. Internet issues have scuppered an Honorary Fellow interview from Peter Smithers in 45(4), but this regular run will return in 2022.

This issue also includes a selection of book reviews and correspondence, the latter featuring a poem from one of our readers whose sleep patterns were disrupted earlier this year by a entomological emergence! We'd also like to draw your attention to an opening for Associate Editors of Physiological Entomology on page 198, with further details available at https://onlinelibrary.wiley.com/journal/13653032.

Dave George



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Index and online copies

Index

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Correspondence

Searching for the first winged insects in Scotland

Dear Editors,

Figure 1. A fossil scorpion of Tournaisian age, found in the plant bed at Willie's Hole, Chirnside, Scottish Borders. NMS G.2015.32.848, length of preserved remains 50mm. Photo by Bill Crighton, NMS volunteer.

Figure 2. Yours truly searching for arthropods in the plant bed at Willie's Hole in July 2015.

I was interested to read the correspondence in the latest issue of *Antenna* 45(3) by Ed Jarzembowski and Stuart Reynolds on the first winged insects and encouraging people to look for them. Ed recommended the Mississippian (early Carboniferous) of Scotland as a potential hunting ground and Stuart mentioned new arthropod and vertebrate fossils from the Tournaisian (earliest Carboniferous). I would like to use the opportunity to expand on this and point out that I have looked for Mississippian insects in Scotland, but without success.

Over a decade ago, the late Stan Wood, a local collector, discovered a rich site of vertebrate and other fossils in the bed of the Whiteadder River at Willie's Hole, near Chirnside in the Scottish Borders. Stan was already famous for finding 'Lizzie' (*Westlothiana lizziae*) from East Kirkton in West Lothian, which, at the time, was considered to be the oldest fossil lizard in the world. The exciting thing about the Willie's Hole site is that it is of Tournaisian age, older than East Kirkton (of Viséan age), and within "Romers Gap" which, as Stuart indicated, was a time when hardly any terrestrial vertebrates were known from anywhere in the world. The most significant vertebrate fossil that Stan found at Willie's Hole was a 1m long articulated tetrapod that he nicknamed 'Ribbo', which has not yet been formally named. Other fossils that he found included the remains of plants, millipedes, scorpions, crustaceans and eurypterids.

National Museums Scotland (NMS) subsequently acquired the material and a large NERC consortium grant was awarded to study these fossils and to look for more. The project was entitled *TWeed (Tetrapod World, early evolution and diversity)* and was led by the late Prof. Jenny Clack from Cambridge University in collaboration with NMS, the British Geological Survey and the universities of Leicester and Southampton. For more information see- https://www.nms.ac.uk/collections-research/our-research/highlights-of-previous-projects/the-tweed-project-evolution-s-missing-chapter/.

The grant enabled part of the Whiteadder River to be barricaded off and drained, and we spent three mostly sunny weeks in July 2015 digging up the riverbed. Many more fossil bones were found in a horizon known as the 'amphibian bed'. I concentrated my efforts on a bed below this that was rich in plant fossils and filled many crates with specimens. Apart from the plants, the bed also yielded non-marine crustaceans (eumalacostracans, spinicaudatans and ostracods), bivalves, and my most exciting discovery was a small scorpion (Fig. 1). The matrix is fine-grained, so ideal for preserving fossil insects. I looked very hard (Fig. 2), but sadly didn't find any. There have been several papers subsequently published on the fossils from this and other non-marine Tournaisian Scottish sites (e.g. Clack *et al.*, 2019); the millipedes were described by Ross *et al.* (2018).

Searching for fossil insects at other non-marine Carboniferous sites in Scotland has also been unsuccessful, though admittedly I have not always made repeat visits as Ed suggested. So, the grand total of five Carboniferous (Pennsylvanian) insects from Scotland remains unchanged (Ross, 2010). One avenue worth exploring is the several tonnes of unsplit rock from East Kirkton in the NMS Collections Centre. This site also yielded fossil scorpions (Jeram, 1994), millipedes (Shear, 1994) and a harvestman (Dunlop & Anderson, 2005), so hopefully funding can be sought for a future project to process this rock.

Of course, there may not have been any flying insects at that time, which would account for not finding any, but we can never be certain and that doesn't account for not finding any fossil apterygote insects either. "Romers Gap" has been filled, but the "Hexapod Gap" remains. The search continues…

Andrew J. Ross FRES
Principal Curator of Palaeobiology
National Museums Scotland

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Ode to a Cicada Symphony: Overture to Finale

I am a physician, violist, songwriter, poet and newfound insomniac compliments of the nocturnal roar of cicadas in my backyard. Initially ruffled by the incessant rumble of their collective cicadallic cacophony, I consulted my physician/composer friend and British entomologist mentor Dr Martin Heyworth. He enthusiastically enlightened me that these certain circadian sounds were a special event to be embraced, and that Brood X emerges anew years from their last prolonged rest.

Upon further research and reflection, rather than being irked by their clamour and appearance on my car, hat and sidewalk, these insects were seen in a different light. In accordance with Dr Heyworth's general philosophy regarding entomology, I realized it was a privilege to witness the beauty and wonder of a natural phenomenon that made me more aware and in awe of the environment and what is rattling about in it.

These ancient visitors graced me during their brief stay, listening to their love calls in the treetops. I was inspired to compose this poem in tribute to Brood X cicadas, and the 17-year encore performance of their enraptured musical symphony.

As they approach their quiet demise in the woods of New Jersey, I will miss my new friends, but rest assured that they shall awaken me once more 17 years hence.

Until then, I bid them adieu for their "Farewell Symphony."

Ode to a Cicada Symphony: Overture to Finale

Silent in earth's soil you lay
staying seventeen years
waiting to play

emerging from prolonged
rest so deep, excited your
overture commences as you creep

dusting off gossamer wings
nature conducts
sweet musical flight

toward the treetops
fluttering under
Heaven's light

dancing serenade
sun shines bright
singing love's call into the night

like Dvořák's New World
to which you soared
a Cicada Symphony builds and roars

until cacophonous crescendo
diminuendos once more

Written by: Dr Mary Rorro

Letter from the President

Helen Roy

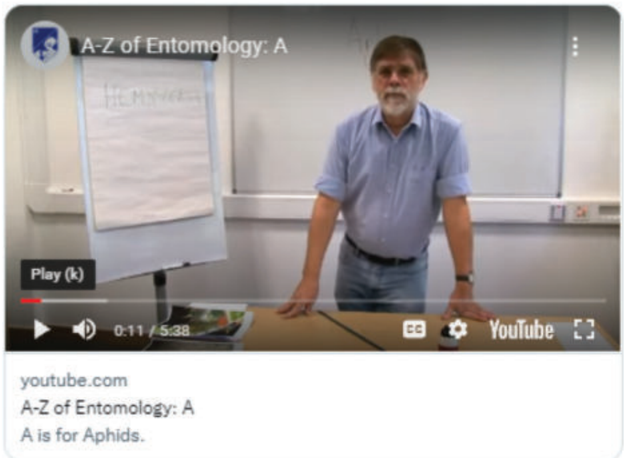
Entomologists are inspiring

It is always a pleasure to meet with other entomologists and enjoy shared excitement for the wonders of the insect world. Whether chatting while delving into a sweep net on a field trip or exchanging ideas through publications or social media, it is such a privilege to learn from one another but also to enjoy friendships too.

Douglas Boyes and Simon Leather were two people who I had immensely enjoyed meeting with over the years. I am deeply saddened by the loss of these two simply incredible entomologists. Both hugely knowledgeable and incredibly generous with their knowledge. Both just lovely people.

Countless times Douglas responded to my "I am confused by this moth" tweet. The most recent being a double-striped pug resting on the door of the Cornish holiday cottage I stayed in during September. His recently published research on the effects of light pollution on moths* was met with huge media interest and highlights the need to think about solutions to environmental issues that embrace the complexity of natural systems. LED lights are energy efficient but are more harmful to moths than traditional sodium bulbs. This research involved Douglas counting and identifying more than 2,000 moths.

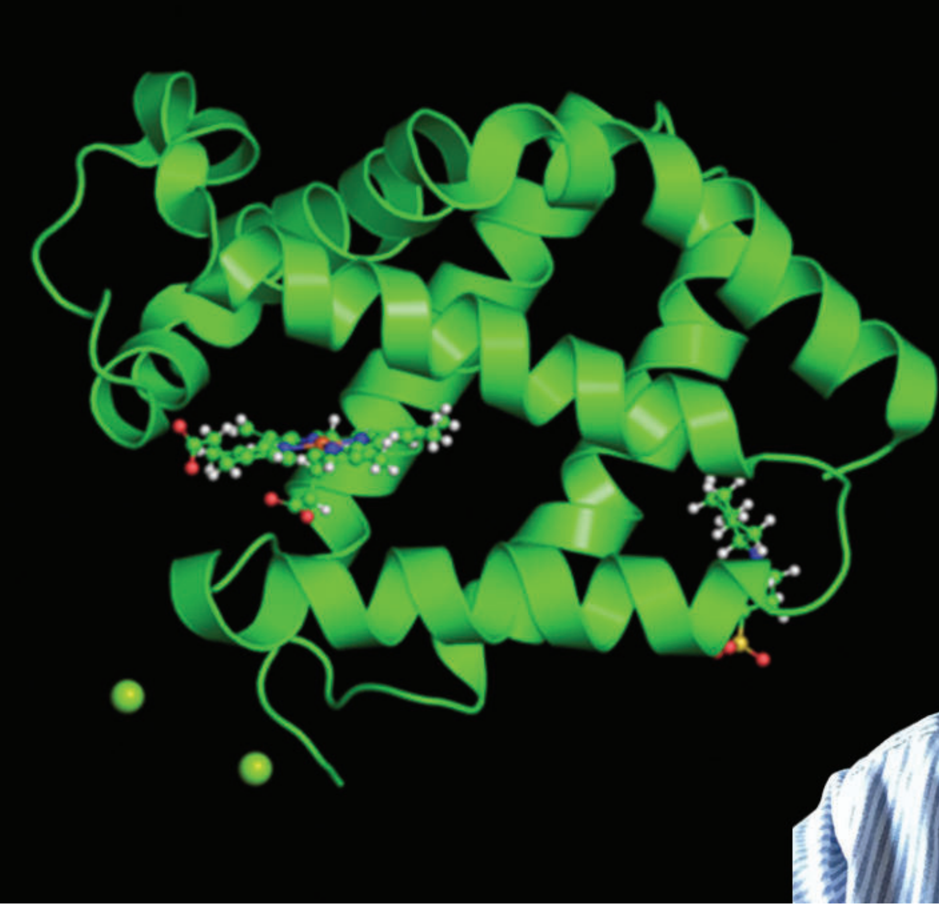
Simon ensured that my fascination with aphids went beyond their role as ladybird prey. Aphids are captivating and Simon made them all the more so (for a great example see 'A is for Aphids' here: https://www.youtube.com/watch?v=liBt59teaGQ). Admittedly, my studies on aphids were motivated by curiosity about defensive responses to predatory ladybirds and ways in which aphid-specific fungal pathogens manipulated the behaviour of these little insects! I had the privilege of meeting Simon many, many times from the early days of my PhD studies to field meetings in recent years with the Entomological Club. In July 2021 I attended a workshop at the Royal Entomological Society with Simon – as always he contributed his immense expertise with warmth and generosity. His ideas are making a major contribution in informing the future direction of our Society.



It is humbling to consider the legacy of entomologists through the centuries. It is also exciting to think about the future and the new discoveries on the horizon. The diverse and amazing contributions made by our global community of entomologists in enhancing our understanding of the natural world are critical to addressing the problems facing our rapidly changing world. The wonderful friendships and kindness that span our entomological community underpin these discoveries, ensuring we have a Society in which we can all thrive.

With thanks to Douglas and Simon for their inspiring contributions to our entomological community. Further tributes to Douglas and Simon can be accessed via the web pages of Newcastle (https://www.ncl.ac.uk/press/articles/latest/2021/10/tributetodouglasboyes/) and Harper Adams (https://www.harper-adams.ac.uk/news/204717/tributes-paid-to-harper-adams-professor-emeritus-simon-leather) universities.

* Douglas H. Boyes, Darren M. Evans, Richard Fox, Mark S. Parsons, Michael J.O. Pocock. 2021. Street lighting has detrimental impacts on local insect populations. Science Advances. DOI: 10.1126/sciadv.abi8322



RESEARCH SPOTLIGHT

Insect haemoglobins: from oddity to ubiquity

Stuart Reynolds

Department of Biology and Biochemistry
and Milner Centre for Evolution
University of Bath

The insect haemoglobin problem

I have always found it to be an attractive feature of insects that they do things differently to other kinds of animals. When I was a student of entomology in the late 1960s, the main thing I learned about the oxygen-binding protein haemoglobin, essential to vertebrate animals, was that with just a few exceptions, the iron-containing protein was hardly present in insects at all. I discovered essentially all that was known about insect haemoglobin by reading just a couple of pages of Wigglesworth's magisterial *Principles of Insect Physiology* (1965), the remarkable textbook that was my bible. In considering the haemoglobin problem, Wigglesworth stressed that the tracheal system's ability to supply air directly to the tissues rendered mass transport of oxygen using haemoglobin unnecessary. Tracheoles, the finest branches of the system, approached within micrometres of where the gas was needed, and diffusion did the rest. Nevertheless, Wigglesworth dutifully reported that just a few insects did use haemoglobin for special purposes.

The general strategy of *The Principles* was led by function. This is unsurprising; the whole approach of the Wigglesworth school was based on the idea that insects are subject to the general laws of physics and chemistry but are also peculiar in the physiology and biochemistry that they make use of. The problem, only dimly evident to me at the time, was that such a strategy pays little attention to either evolution or genetics. The apparent phylogenetic isolation of those few insect haemoglobins still seems odd; we don't expect the evolutionary solution to a generally important physiological function to be arbitrarily re-invented on multiple occasions while being ignored by most species.

Today, the general strategy of biological science is quite different to that of Wigglesworth's day. Evolution is what connects everything together; as Dobzhansky (1964) observed, without it nothing makes sense. The revolution in biological science initiated by Watson and Crick's 1953 discovery of DNA's double-helical structure has transformed everything. Wigglesworth's textbook doesn't even mention DNA, yet today genomics is always waiting in the wings whenever we think about any particular aspect of an insect's life.

Thus, our six-legged science has moved on, and as a result we now understand that insect haemoglobins are not odd at all; thanks to the use of computers to analyse billions of DNA sequences, haemoglobin turns out to be ubiquitous among

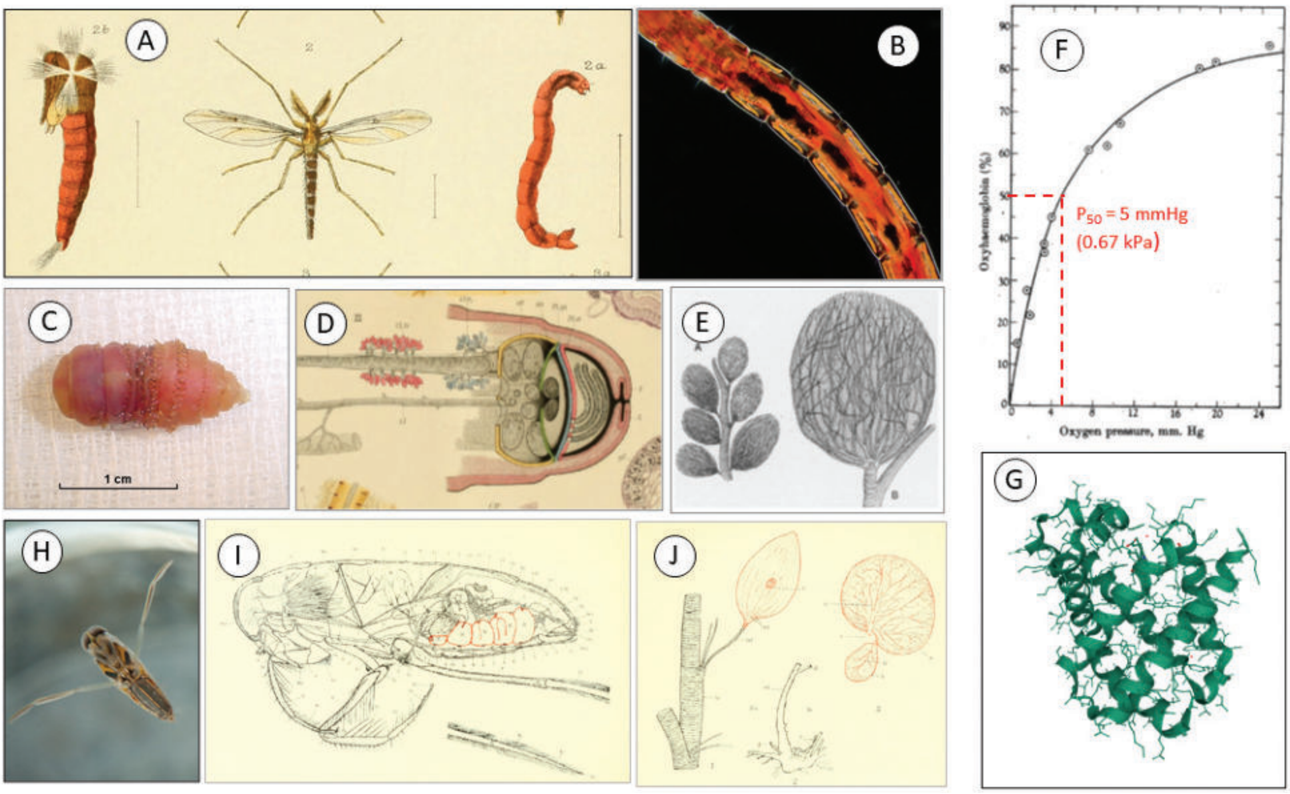


Fig. 1. **A.** Various life stages of *Chironomus zealandicus*. Image: from Hudson (1892); Source: Wikipedia, CC BY 2.0. **B.** Chironomid larva showing red haemolymph. Image: Jasper Nance; Source: Wikipedia, CC BY-SA 3.0. **C.** Larva, *Gasterophilus instestinalis*. Image: Kalumet; Source: Wikipedia, CC BY-SA 3.0. **D.** Respiratory adaptations, *G. intestinalis* larva, tracheal trunks from abdominal terminal spiracles; Haemoglobin cells of *organes rouge* shown in pink. Image: Plate III, from Portier (1911). **E.** Drawing of *G. intestinalis* haemoglobin cells to show detail of intracellular tracheation. Image: from Keilin & Wang (1946). **F.** Oxyhaemoglobin dissociation curves for *Gasterophilus*, haemoglobin. Figure from Keilin & Wang (1946); **G.** X-ray crystallographic molecular structure of *Gasterophilus* haemoglobin. Structure determined by Pesce *et al.* (2009). Image from Protein Data Bank: https://www.rcsb.org/structure/2C0K. **H.** An anisopine backswimmer, *Buenoa* sp. Image: Rebecca Marschall, licence: Attribution-NonCommercial 4.0 International (CC BY-NC 4.0). **I.** Sagittal section through adult female *Buenoa margaritacea* to show haemoglobin cells (outlined in red). Image: Plate XLIV, from Bare (1928). **J.** Drawings to show details of haemoglobin cells of *B. margaritacea* (shown in red). Image: Plate XLVII, from Bare (1928).

insects, and has been there all the time, even if we didn't know it. What is the function of this previously invisible insect haemoglobin? We still don't know. What a research opportunity for ambitious young insect physiologists!

Three kinds of insect that obviously have haemoglobin

First, the old function-led view. It has long been known that there are exceptions to the idea that insects don't have haemoglobin. These few insects provide clear illustration that when it is present in an insect, haemoglobin can play a useful role in supplying the oxygen needed for metabolism. But it doesn't appear to be used as a mobile, circulating oxygen transporter like the haemoglobin of vertebrate red blood cells.

The best-known insect haemoglobin by far is that of the aquatic larvae of chironomid midges (Diptera; Family Chironomidae), which have bright red haemolymph due to the presence of large amounts of haemoglobin (Fig. 1A). Their obvious colour conceals an important difference from other animals with haemoglobin. In chironomids, haemoglobin is dissolved freely in the insect's haemolymph, and is not confined within specialised red blood cells, as it is in vertebrate erythrocytes. The possession of haemoglobin by chironomids is clearly an important adaptation because its synthesis represents an astonishingly large investment by the insect; haemoglobin can represent up to 90% of total haemolymph protein (Thompson & English, 1966). Few other organisms find it necessary to synthesise so much of a single protein.

Although the Austrian biochemist Alexander Rollett (1861) seems to have been first to investigate an insect haemoglobin by extracting a red crystalline substance (which may well have been pure haemoglobin) from chironomid larval haemolymph, he didn't call it haemoglobin, and his paper showed little sign that he understood its respiratory function or even that it was a protein. In fact, the word "haemoglobin" was only coined in the following year for the human protein by Felix Hoppe-Seyler (1862), who certainly appreciated both of those points. Only several years later did E. Ray Lankester, then working at Oxford, take advantage of newly developed microspectroscopic techniques to investigate the red pigment of *Chironomus* larvae, quickly recognising (Lankester, 1869) that this substance was spectroscopically indistinguishable from human haemoglobin.

What does it do? Elegant experimental work by Isabella Leitch (1916) and R.F. "Griff" Ewer (1942) showed that while the haemoglobin of *Chironomus* larvae is very good at taking up oxygen, it is extremely reluctant to give it up again, only unloading the bound gas under extremely low oxygen conditions, when O_2 partial pressure (pO_2) falls to less than about 1 kPa[1]. The chironomid pigment binds oxygen exceptionally tightly compared to that of

[1] I have converted all numerical values of oxygen concentration to pO_2 values using the SI unit (kPa) most often used today.

vertebrates; its dissociation curve is a simple hyperbola, consistent with the uncomplicated binding kinetics to be expected of a monomeric protein. This is quite unlike what happens in mammalian haemoglobin, where the dissociation curve is sigmoidal, indicating the existence of both positive and negative binding cooperativity between the subunits of the tetrameric protein. Because of this, the affinity of chironomid haemoglobin for O_2 is about 180 times greater than that of human haemoglobin, the insect protein being 50% fully loaded (P_{50}) with oxygen at pO_2 = 0.02 kPa, a value much lower than is the case for the human protein (P_{50} = 3.6 kPa). Since water fully equilibrated with atmospheric air has a pO_2 value of 21.2 kPa, *Chironomus* haemoglobin can only give up its oxygen to the insect's tissues after 95% of O_2 in free solution has already been used. This makes it unsuitable to be a circulating oxygen transporter like the human protein.

Instead, it now appears that the dual function of chironomid haemoglobin is much the same as that of vertebrate myoglobin, a monomeric form of haemoglobin present at high concentration in highly aerobic tissues like striated muscle. Myoglobin binds oxygen with high affinity and without cooperativity and it does not act as a circulating transporter. Instead, its most important function is to facilitate diffusion of O_2 within actively metabolising cells through diffusion of oxymyoglobin within the cytoplasm, and also by exchanging bound O_2 molecules from one myoglobin molecule to another. Because oxygen is rather insoluble in water, most of the O_2 in such cells is actually bound to myoglobin (Wittenberg and Wittenberg, 2003). The extremely high affinity of O_2 binding doesn't matter as long as the oxygen can be taken up by local mitochondria with even higher avidity. Another way of thinking about this is that the local store of myoglobin is like a bucket chain that speeds up the mass transfer of O_2 from one place to another by passing the buckets from hand to hand; the role of myoglobin is to increase the quantity of oxygen that can be carried in each bucket. Such facilitation has been shown to occur in mammals; it is relatively unimportant when pO_2 is high, but it greatly increases the rate of O_2 delivery when the ambient oxygen concentration is low, as it is in peripheral sites when oxygen is being actively consumed by mitochondria (Wittenberg, 1970). Myoglobin also provides a local store that can release small amounts of O_2 where and when it is needed at times of high demand (Merx *et al.*, 2001), but the length of time that such stores can last is short. Since *Chironomus* often inhabits hypoxic mud in still water environments, both types of myoglobin-like function are likely to be adaptive.

But does the *Chironomus* haemoglobin actually contribute to the maintenance of metabolism? Ewer (1942) used carbon monoxide (CO) as an experimental tool to reveal the extent to which normal metabolic activity in *Chironomus* larvae relies on haemoglobin to supply oxygen; the gas irreversibly inactivates haemoglobin by converting it to carboxyhaemoglobin, a condition only very slowly reversible. She found that depression by CO of O_2 consumption by *Chironomus* was slight when there was plenty of oxygen, but the sensitivity of O_2 consumption to CO increased as pO_2 declined, and was maximal when the surrounding water was only 22% saturated with O_2 (i.e. when pO_2 was about 2.9 kPa). Under these conditions, she estimated that one third of total O_2 consumption of the larva was dependent on the presence of functional haemoglobin.

Another insect long known to possess appreciable amounts of haemoglobin is the bot fly, *Gasterophilus intestinalis* (Diptera; Family Oestridae), which like chironomid larvae lives part of its life in places where oxygen is in short supply. During most of its larval life this parasitic insect lives attached to the lining of the stomach wall of horses and other equids (Dinulescu, 1932). Unlike in chironomids, bot fly haemoglobin is confined to intracellular locations; although in younger insects it is distributed more generally, in mature larvae it is found only in dedicated, highly-tracheated cells associated with fat body (Figure 1D, E). The obviously red cells are clustered together in assemblies that look like tiny bunches of grapes; their anatomy was intensively studied by Enderlein (1899), Prenant (1899; 1900) and Portier (1911), the latter two authors calling them "*organes rouges*". The association of bot fly haemoglobin cells with the tracheal system immediately suggests a respiratory function. Keilin & Wang (1946) purified enough crystalline haemoglobin from *Gasterophilus* larvae to produce a beautiful oxyhaemoglobin dissociation curve. Although bot fly haemoglobin associates with oxygen slightly less enthusiastically than chironomid haemoglobin, it has a very high affinity for oxygen (about 0.67 kPa - see Fig. 1F). The simple hyperbola of the dissociation curve indicates that cooperative binding does not occur. Keilin and Wang suggested (from its molecular weight) that *Gasterophilus* haemoglobin is dimeric. This has since been confirmed (it is a homodimer) by Pesce *et al.* (2009), who showed it is homodimeric and determined its molecular structure (Fig. 1G). Bot fly haemoglobin thus again functions like myoglobin; it is well adapted to facilitate the transfer of O_2 from the poorly oxygenated air within the tracheae inside the *organe rouge* into the oxygen-hungry interior of the insect, and also to supply O_2 from a local store at times of unusually low availability or high demand.

The third classical example of an insect with easily visible deposits of haemoglobin is that of backswimmers from the genera *Anisops* and *Buenoa* (Hemiptera; Family Notonectidae; Subfamily Anisopinae) (i.e. Fig. 1H), in which an insect haemoglobin plays an entirely different functional role. Exactly like bot fly larvae, these insects have specialised red tracheal cells associated with fat body (Fig. 1I, J). The physiological role of this type of insect haemoglobin turns out, however, to be quite different. These energetic diving insects make their living as active underwater predators, carrying down their own supply of air in the form of a gas bubble that is carried on their anatomically ventral surface (this is why they swim on their back). Such diving is limited in duration by the fact that the bubble's volume continuously decreases during the dive (Rahn and Paganelli, 1968). Unlike many other diving insects, their dive features a long period during which they are neutrally buoyant. It was first suggested by Bare (1928) that this is dependent on the presence of stored oxygen associated with haemoglobin, which is used to buffer the volume of the insect's bubble during a dive. He posited that O_2 would be taken up by haemoglobin from the bubble during the first half of the dive, only to be released in the latter half. This would require the oxygen affinity of the haemoglobin to be adaptively matched to a pO_2 value roughly half-way between that in the bubble at the beginning of the dive and at the end.

Bare's hypothesis was tested for *Anisops pellucens* by Peter Miller (1964; 1966), who found that treatment with CO effectively eliminated the neutrally buoyant period of the dive, shortening it from 5 min to 1 min. Significantly, he noted that the haemoglobin of free-diving *Anisops* visibly darkens in colour from about the time that the neutrally buoyant phase of the dive begins, indicating that this is when oxygen unloading begins. Miller also determined that the oxyhaemoglobin dissociation curve *in vivo* is roughly sigmoidal, with a P_{50} value of about 3.7 kPa. This is significantly higher than seen in any other insect haemoglobin and is obviously different from either *Chironomus* or *Gasterophilus*. Matthews & Seymour (2011) have further confirmed this model of *Anisops* diving by using fibre-optic probes to measure pO_2 within the gas bubbles. Dives featured an initial period during which pO_2 declined at a constant rate due to the insect's respiration, followed by a long period in which pO_2 was almost constant at about 4 kPa, due to release of O_2 from the haemoglobin store. You'll notice that this is a value close to the P_{50} value from the dissociation curve, exactly as predicted. At the end of the dive, when the store was exhausted, the bubble's pO_2 again fell.

The *Anisops* protein has unusual properties for an invertebrate haemoglobin. Wells *et al.* (1981) purified haemoglobin from *Anisops assimilis* and investigated its interaction with oxygen. When tested at a protein concentration similar to that within the insect's own haemoglobin cells (about 30 mmol l^{-1} on the basis of subunit molecular weight), the dissociation curve was markedly sigmoidal, exactly as Miller had seen *in vivo*. But the kinetics of binding cooperativity were inconsistent with the usual allosteric model for interactions within the stable tetramer formed by mammalian haemoglobins; instead, Wells *et al.* found evidence that the *Anisops* protein undergoes progressive oxygen-dependent aggregation that affects its affinity for oxygen, forming complexes of up to six subunits. This is a form of cooperativity similar to that seen in the monomeric haemoglobins of agnathan lampreys and hagfish, ancestral to both myoglobin and haemoglobins of jawed vertebrates (Pillai *et al.*, 2020); this suggests that the aggregative cooperativity of backswimmer haemoglobin has convergently evolved to be like that of jawless vertebrates.

The haemoglobin-dependent neutral buoyancy of the Anisopinae also appears to be an evolutionary innovation. Diving bugs of the other notonectid subfamily are less agile divers and don't have haemoglobin cells (one can only wonder why they have not been outcompeted by the anisopine strategy). Interestingly, there is a single report by Havilland Brindley (1929) that another diving hemipteran, the lesser water boatman *Corixa punctata* (in her paper, the author used an obsolete synonym, *Macrocorixa geoffroyi*) also possesses haemoglobin. This insect, only distantly related to notonectid backswimmers, appears however to use its haemoglobin for a completely different purpose unrelated to buoyancy. Instead, *Corixa* haemoglobin is found only in the red-coloured secretions of the male accessory glands, implying that the protein has a reproductive function. As far as I know, this observation has never been followed up, and although it is occasionally cited, nothing more is known about the function of the putative oxygen-binding protein. The observation on *Corixa* is particularly interesting because of what has recently been learned about a possible role for haemoglobin in *Drosophila* testis (see below).

Even with these additional examples, however, insect haemoglobin still looks like an oddity. Most insects just don't have a visibly red pigment of this kind. If these are the only hexapod haemoglobins, then it is clear that insects as a class don't make extensive use of haemoglobin. With only 7278 species of chironomids, 171 oestrids, 438 notonectids and 466 corixids (https://www.gbif.org/) out of an estimated total of 5.5 million species of insects (Stork, 2018), an estimated 99.71% of insects don't make sufficient use of haemoglobin to make them look red.

The previously unknown haemoglobins of *Drosophila*

But if insects with haemoglobin are rare and unrelated, where did the genes come from? The rapid advances in DNA sequencing technology and computational genomic analysis of the 1990s supplied an unexpected answer to this conundrum. Contrary to previous ideas, it now turned out that haemoglobin genes are present in almost all insects.

The first hint of this was the unexpected discovery by Burmester & Hankeln (1999) that a typical haemoglobin gene, *glob1*, was present in that ubiquitous laboratory genetic model organism, the vinegar fly *Drosophila melanogaster*. The protein is notably similar in its sequence to the *Gasterophilus* haemoglobin, which is reasonable since both are schizophorous dipterans. The homologous gene also occurs in eight other *Drosophila* species (Burmester *et al.*, 2006). The presence of the *glob1* sequence in EST (expressed sequence tag) libraries indicates that the gene is transcribed and therefore presumably translated into the corresponding protein. No-one had been expecting this discovery. In a statement unusually candid for a scientific paper, the authors commented that their finding was "rather surprising".

What does the Glob1 protein do? Hankeln *et al.* (2006) soon showed both at the mRNA and protein levels that Glob1 is expressed in both fat body cells and tracheal cells, much like the situation in the "classical" examples of insect haemoglobins. As in *Gasterophilus* and *Anisops*, but unlike *Chironomus*, the *Drosophila* haemoglobin is not exported into the haemolymph. Recombinant *Drosophila* Glob1 protein binds O_2 with high affinity (P_{50} = 0.2 kPa), which is consistent with the myoglobin-like function of the better-known insect haemoglobins that were discussed earlier in this article. Antibody staining shows that Glob1 is concentrated in cytoplasm of the cells of the tracheal walls. If Glob1 is involved in facilitating O_2 transfer from the tracheal lumen, as has been suggested by the Burmester-Hankeln research group in now numerous papers, then the protein could not be located in a better place.

Comparison of the oxygenated and deoxygenated optical absorption spectra of recombinant Glob1 indicates that the protein is hexacoordinate (i.e. in the deoxygenated state, the Fe (II) atom in its haem prosthetic group is coordinately bound not only by the four nitrogen atoms of the tetrapyrrole haem molecule, but also by two separate histidine residues in the globin chain). This is in contrast to the situation in all of the more highly expressed classical insect haemoglobins, which are pentacoordinated (in these proteins, the Fe (II) atom of the haem group makes contact with only a single globin histidine residue). Since then, *Drosophila* Glob1 has been structurally characterised, confirming that the protein has the typical globin fold, and that its hexacoordinate condition involves two conserved histidine residues His61 (E7) and His96 (F8) (De Sanctis *et al.*, 2005). The functional significance of this structural and biophysical feature of *Drosophila* Glob1 in particular, and of hexacoordinate haemoglobin structures in general, is not yet clear (Kakar *et al.*, 2010).

Interestingly, four distinct transcripts of the *Drosophila* gene are detectable, although the protein coding regions of all four are the same (this means that in the end there is only one *Drosophila* Glob1 protein). They are evidently differentially regulated, presumably according to the cell type in which they are expressed and/or physiological context of expression. The presence of putative hypoxia-regulated transcription factor binding sites within the gene indicate that its expression is probably regulated by pO_2. Again this indicates a probable respiratory function. Hankeln *et al.* (2006) remark that "oxygen supply in insects may be more complex than thought previously"; this seems a masterly understatement.

The physiological role of *Drosophila* Glob1 remains unclear. Neither the overexpression, nor the RNAi knockdown of Glob1 in flies, had any significant effect on their development or longevity, but knockdown experiments did indicate that the protein protects adult flies from the lethal effects of hypoxia (pO_2 1.0 kPa and below) (Gleixner *et al.*, 2016). It was speculated that this effect may be mediated by the protein's role in facilitating O_2 transfer across tracheal walls, thereby alleviating the problems of insufficient oxygen, but at present there is no evidence that specifically points to this conclusion. In the same study, it was shown that Glob1 knockdown significantly increased survival of flies exposed to the herbicide paraquat, a known generator of reactive oxygen species (ROS). This was unexpected but may be explained by supposing that when less oxygen is present due to Glob1 knockdown, less ROS is generated. It was tentatively concluded that the protein is probably not involved in protecting the insect against oxidative stress. Other work has shown that Glob1 may also help to maintain the integrity of the F-actin cytoskeleton, and Glob1 was shown to co-precipitate with actin in antibody pull-down experiments (Yadav *et al.* 2018), but whether these effects depend on O_2 binding is unknown.

It wasn't long before two more globin genes, *glob2* and *glob3*, were found to occur in *Drosophila* (Burmester *et al.*, 2006). These haemoglobins are significantly different in sequence from Glob1 and obviously diverged from them long ago. The Glob2 and Glob3 proteins are expressed only in developing male adults, specifically in the testis, and not at all in females (Gleixner *et al.*, 2012). This alone is sufficient to allow the conclusion that it is not only the sequences of these genes, but also their functions that have significantly diverged from those of Glob1. Experiments in which all three *Drosophila* globins were overexpressed in cultured *Drosophila* cells have suggested that Glob2 may play an antioxidant role, but its role in male reproduction is unclear (Burmester *et al.*, 2018).

Ubiquitous occurrence of insect haemoglobins

Following the surprise discovery of Glob1 in *Drosophila*, other previously unsuspected haemoglobin genes were soon discovered by similar bioinformatic searching methods in several other insects. One of these cases is the honeybee, *Apis mellifera* (Hankeln *et al.*, 2006). As in *Drosophila*, honeybee haemoglobin (AmeGb1), related to the fly's Glob1, is

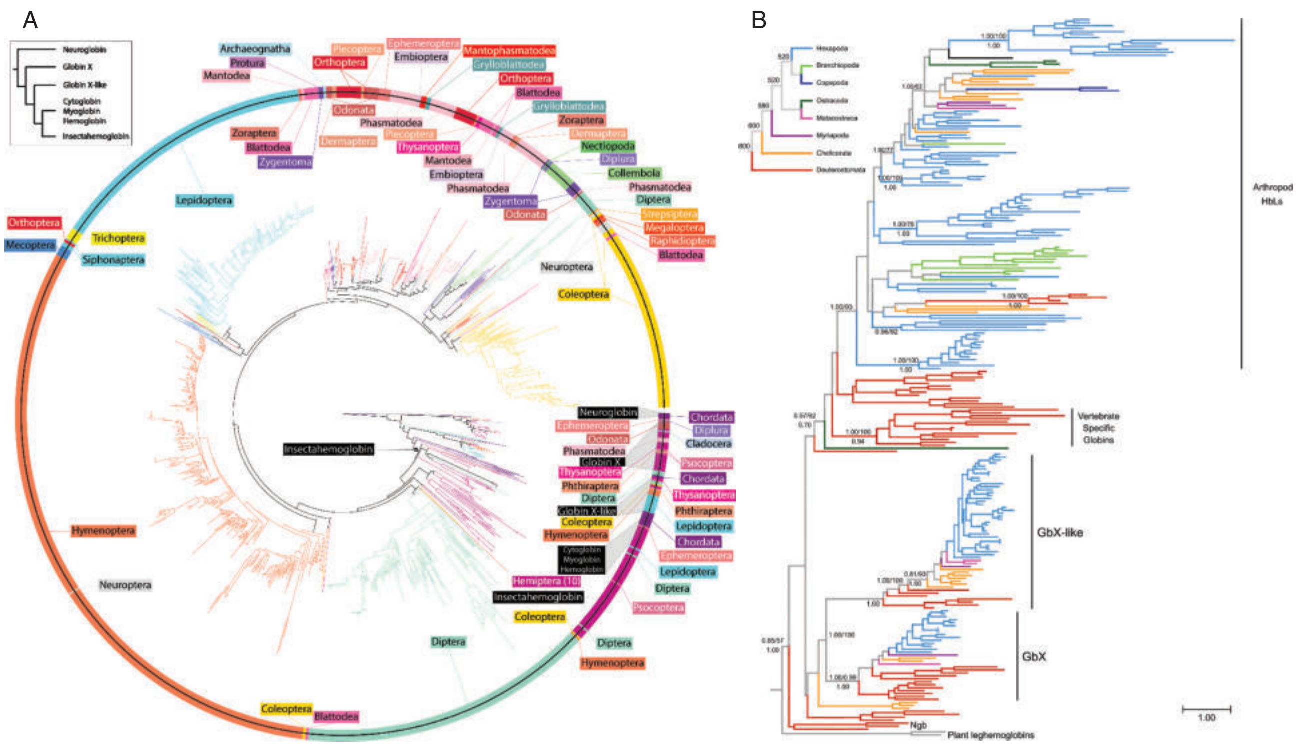


Fig. 2. **A.** Circular haemoglobin gene tree of 1,382 coding sequences, maximum likelihood inference, denotes relationships of different globin types across chordates and the 32 hexapod orders. Colours are order specific. Relationships among orders roughly correspond with current understanding of hexapod relationships. A simplified tree showing globin relationships in the circular tree is shown (inset) at the top left. Figure and (abbreviated) legend from Herhold *et al.* (2020). License: Attribution 4.0 International (CC BY 4.0) **B.** Maximum likelihood phylogram for globin genes from representative arthropods and deuterostomes. Numbers above nodes correspond to support from the aBayes test and 1,000 bootstrap pseudoreplicates, numbers below nodes correspond to Bayesian posterior probabilities from MrBayes. The tree was rooted using plant globins as outgroup sequences. The inset (top left of panel) shows a conventional organismal phylogeny for the representative arthropod lineages included in the analysis. Terminal branches are coloured following the organismal tree. Figure and (abbreviated) legend from Prothmann *et al.* (2020), Creative Commons Attribution License (CC BY).

expressed principally in the bee's tracheal system but is also present in the Malpighian tubules. Two haemoglobin genes *Agagb1* and *Agagb2* were found in the genome of the malaria mosquito, *Anopheles gambiae*, as well as their homologues *Aae1* and *Aae2* in the yellow fever mosquito, *Aedes aegypti* (Burmester *et al.*, 2007). Expression of both mosquito proteins is again mainly located in the tracheal system, but expression of *Agagb2* was also detected in the visceral muscles of the gut.

In addition to the above, Hankeln *et al.* (2006) also reported that partial gene sequences with haemoglobin-like features could be found in the genomes or ESTs (expressed sequence tags) of the aphids *Acyrthosiphon pisum* and *Aphis gossypii* (Hemiptera), the beetles *Dascillus cervinus* and *Tribolium castaneum* (Coleoptera), the silkworm *Bombyx mori* (Lepidoptera) and the tsetse fly *Glossina morsitans* (Diptera). By now, it was becoming clear that many, perhaps all, insects might be expected to possess one or more haemoglobin genes.

There could be no more obvious next step than to embark on a massive hunt for haemoglobin genes in insects using bioinformatic tools. Two research groups have undertaken this task. Herhold *et al.* were the first to report on their findings in June 2020. 845 hexapod transcriptomes from 716 species were retrieved from the database; using transcribed sequences means that that they could be sure that the genes they found were capable of being expressed. Bioinformatic techniques were used to search them for haemoglobin-like sequences, and species from all the 32 recognised orders of hexapods (29 orders of insects) were found to have at least one globin gene. Although 164 of the 845 transcriptomes did not contain discoverable globin sequences, there were a number of reasons why many of these transcript collections may have been less suitable for the analysis (e.g. transcripts from specialised tissues). A much smaller set of 29 transcriptomes from a wide variety of orders was negative for haemoglobins despite the apparent suitability of the samples. The authors' tentative conclusion is that most hexapod species are likely to possess haemoglobin genes, but that it remains possible that some do not.

Cellular localisation of the proteins was predicted from the amino acid sequences; the majority of the haemoglobins were predicted to be intracellular, but extracellular haemoglobins were predicted to occur in 38 species. A phylogenetic tree of all the analysed globin sequences (it is shown in Fig 2A) found many examples of haemoglobin gene duplication within the insects. A monophyletic clade of insect haemoglobins was recovered and given the name "insectahaemoglobins" (I suspect that this name will not last!); the clade shares its origin with an adjacent clade of chordate globin genes that includes myoglobins, cytoglobins and haemoglobins. Herhold *et al.* comment that the insectahaemoglobin clade shares many structural features with this group, and that these traits are likely to have evolved convergently.

A second paper reporting the results of an independent but similar study was published in August 2020, only nine weeks after the first. In it, the group of Burmester and Hankeln has looked at the whole of the arthropod phylum, identifying 245 globins with 272 globin domains from 84 species (Prothmann *et al.* 2020). They found at least one haemoglobin gene (the average was more than two) in every one of the species for which there was a fully sequenced genome available. They conclude that "globins are part of the standard gene repertoire of the arthropod genome". They reconstructed a phylogeny which identified three major globin lineages in the Arthropoda, and which indicated that the last common ancestor of the phylum as a whole must have possessed at least two globin genes. I have reproduced in Fig. 2B a version of this tree, but it is not possible to show all of the available detail (for which the reader is referred to the original paper and its supplementary data). Some salient points made by the authors are as follows:

All the main lineages of arthropods possess globin genes. Three globin classes are widespread and conserved in arthropods: haemoglobin-like (HbL), globin X (GbX), and globin X-like (GbXL) protein lineages. A small number of arthropod globin genes do not fall into these three classes, and their phylogenetic affinities are unclear. The largest number of arthropod sequences are in the HbL class; this arose prior to the appearance of the arthropods, so that genes of this class are widely distributed in both protostome and deuterostome animals. In arthropods, these genes are particularly liable to lineage-specific gene duplication events. This class appears to be the same as the "insectahaemoglobin" class of Herhold *et al.* (2020). Some HbL genes (e.g. the *Drosophila* gene pair *glob2* and *glob3*) are particularly fast-evolving, indicating their involvement in novel adaptive functions. It is probably not an accident that these particular genes appear to be involved in reproduction. By contrast, the GbX and GbXL classes of globin genes display high evolutionary stability. GbXL genes are present in single copies in all arthropod groups except brachyceran flies, while genes of the GbX class are ubiquitous in all arthropods except holometabolan insects. Some GbX and GbXL genes show nervous system-specific expression. Many arthropod haemoglobin genes in all classes, but especially in GbX and GbXL genes, have sequence motifs associated with N-terminal acylation of the protein. All arthropods except brachyceran Diptera have at least one gene of this kind. The authors suggest that this indicates the existence of a conserved globin function that is associated with cell membrane-anchored proteins. Arthropods appear to lack any representative of the neuroglobin class of globins, and while some proteins occur in arthropods that have sequence similarity to androglobins (a class of globins associated with male reproduction in vertebrates), these genes lack a typical globin domain.

To these points, I might add that the taxonomic congruence between Prothmann *et al.*'s arthropod haemoglobin tree and the phylogeny of the animals themselves is sometimes quite disturbed, especially within the arthropod HbL class. It is likely that some of these misfits are due to the existence of gene duplications that have given rise to distinct functional classes within this clade (as in Herhold *et al.*'s "insectahaemogobin" class). Additionally, some, perhaps many, haemoglobins may have been subject to strong directional selection, which would not be surprising, given their potential importance for physiology and biochemistry. Another point common to both studies is that, as yet, we are unable to predict hexacoordinate structure for haemoglobins solely from inferred amino acid sequence data. Without this, we can't yet tell how the pentacoordinate/hexacoordinate structures are placed on the phylogenetic tree. This seems likely to be important in the long run.

I confidently predict that these two impressive bioinformatic studies will provoke still more research on insect haemoglobins, about which we plainly have much more to learn. Wigglesworth would have been fascinated!

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Eating insects in the modern world

(‘Palm Weevil Protein: the past and the future, a tale of perspectives’)

Tilly Collins

There is more and more discussion surrounding the nutritional qualities and sustainability of insects as ‘good food’ in both the general media and in academia. This growth, far from being ‘puff’, is now underpinned by a rapidly developing industry, where this year the RES hosted its fourth SIG on Insects as Food and Feed. This very-well-attended meeting ran over several days and brought together manufacture, advocacy, law, ethics and academic entomologists in a framework which identified barriers and opportunities for the future of this industry.

Humans have eaten insects for millennia and they remain an important part of the diet in many rural areas of the world. They also feature in ceremonial dinners in the monied echelons of Asian and African societies – sometimes even with gold leaf applied – representing the height of taste and sophistication. In the Western world, and increasingly more broadly, the picture is different; we mostly regard insects as unfamiliar, unpalatable or even dangerous, and tend to prefer vertebrate meat. In many places, eating insects is currently associated with poverty and a lack of sophistication, where aspirations to perceptions of ‘Western luxury’ may also be contributing to a waning consumption of insects and to a cultural prejudice against them.

Throughout history most consumption of insects has been through ‘wild catch’ and they have often been a seasonal delicacy associated with regional ritual. It is likely that increasing agricultural intensification and the widespread use of pesticides over the past century has also contributed to a decline in availability, and to a decline in the intimate contact that many small-holder farmers once had with their crops. Manual pest-control (picking-off the caterpillars or beetle larvae) has been substituted by chemical control, which then makes the insect inedible. Not only is this kind of pest control waning, but with it is lost the language associated with insect consumption, the regional names, the preservation techniques, the recipes and traditional rituals. This is perhaps less entomology than anthropology, but is a loss to the richness and diversity of our societies and to our human interaction with the natural world.

We now come to insect farming and to the rapid development of an increasingly technologically sophisticated industry. In Asia, invertebrate farms are common, often simple in their structure and systems, and a part of rural recycling and optimisation; they are businesses in which saleable protein is produced from marginal agricultural wastes. Modern farms in the Western world, which exist in a very different regulatory context and have little local history, are mostly very different, with increasingly controlled environments and inputs which lead to few pest and disease challenges and to a more predictable and consistent product. Many of these farms are dedicated to producing animal feed rather than human food and have real potential to contribute significantly to the broad sustainability of the agricultural sector. Fish or chicken, captive-raised on insect larvae which were themselves raised on other crop wastes, become part of a more efficient, circular production system, where the insects can also co-produce frass to be used as a high-quality soil conditioner.

Insects, as ectotherms, grow very efficiently and, of the animals, insects with high reproductive capacity and short generation times are very tractable to intensive farming systems. Per kg of useable product insects outperform vertebrate meats, especially beef, by many magnitudes in almost all environmental measures. Their space requirement is less, their water consumption is less, their greenhouse gas production is less… With insects we tend to use a much greater proportion, if not all, of the body mass, rather than specifically-selected premium muscle tissue, leading to an often superior nutritional profile.

A project on which I am a collaborator is looking at many ways in which we might support emerging palm production in West Africa to develop in a more sustainable direction than has been the case across swathes of South East Asia. The umbrella project 'Sustainable palms for Africa' was initially funded by the Research England Global Challenges Research Fund to bring together agronomists, molecular biologists, palm breeders, social scientists and entomologists from across Europe and Africa. Viewing palm production through a systems lens, we sought together to identify areas with circular and sustainable potential and the co-production of palm weevils is one avenue being explored. From naïve beginnings we [the entomologists] began to understand many of the barriers to this proto-industry.

Many of the factors briefly touched-on above are amply illustrated in the entomological part of this project. Palm weevil larvae, or Akokono if you are in Ghana, are a traditional delicacy that were a by-product of manual pest control and can occasionally still be found for sale in markets and at roadside stops roasted on skewers as a rapid snack. Their decline in use is partly due to younger people now having more 'urbanised' and 'classical development pathway' aspirations, which move them away from foods associated with rural lives or poverty. The knowledge base of language, recipes and cooking techniques surrounding Akokono now lies with an ageing demographic on a continent where life expectancy is rarely over 65, and where over 60% of the population is under the age of 25. There is thus now an urgency in capturing this culture and we are applying for funding that would enable recording of these names and culinary traditions. Together, we are aspiring to create a West African Insect Cookbook that mixes cultural history and delicious fare – certainly not something I had anticipated in my entomological career! Another contributor to waning Akokono availability is the increasing use of chemical pesticides that has accompanied an increasing commercialisation of the African palm crop. This has made the weevil larvae both less available and less likely to be a healthy snack.

Palm has been a component of small-holder, diverse farming systems in many parts of the African continent and is now becoming a commercial monoculture for export. On larger farms, some crop maintenance workers are local, though others are increasingly peripatetic and follow harvest

Sustainable Palms Team; inset: team chat (image credit: author's own).

A delicious Akokono (image credit: GAYO – Green Africa Youth Organisation).

cycles (in addition to regular oil/nut cropping the crop is cyclically felled and renewed), setting up village-like camps in which they live for a period and where they use felled trunks to make palm wine. Incorporating weevil farming into both permanent local communities and to the mobile workers requires a mind-shift back from pest to co-product.

Essential too is the 'know how'. Several collaborators on the project have experience in this and have worked to develop simple weevil farming systems, developing and delivering training and stakeholder outreach and engagement programmes. They know how to do this effectively at pilot scales to inform uptake, and expansion presents many challenges, not least for scalability and investment. We planned to develop a set of simple guidelines for farming weevils that could be disseminated during training activities and dispersed more widely, but immediately met barriers of literacy and language diversity. To overcome this, the guidelines became 'the cartoon guide to weevil farming'. This sounds great, but again was challenging. I was raised with comic strips and can read sequence, abstraction and illustrative whimsy. This is not the case where unfamiliarity with the medium makes simplified drawings very hard to interpret and where cultural nuance captured inadvertently can mask the message. Two examples of this were that the type of detail (e.g. dwellings in the background) matters as, if it is not culturally correct, it may be taken that the whole booklet doesn't apply. This was also true of facial shapes and tribal distinctions. Another was a confusion over perspective; chickens in the foreground of an illustration were perceived as giant chickens. Our social-science learning curve is steep and continues; there is so much we do not know.

A woman with a giant hand (image credit: author's own).

Another part of this project looks at promoting intercropping through increased palm row spacing which provides greater biodiversity and locally-relevant food crops over a greater part of the palm crop cycle. Palm canopies come together eventually and then only the most shade-tolerant species, such as climbing peppers, will thrive, but before then wider immediate benefits can be derived. Yet another aspect looks at rapid breeding techniques through enhanced use of molecular biology. This has a specific aim to improve drought tolerance, and thus the types of soils on which palm can be productive. The hope here is that future palms will be more resilient to the predicted effects of climate change in the region and that marginal lands can become more productive and relieve the pressure of crop expansion on primary forests and areas of conservation importance. The collaboration is fertile and exciting. We support each other in developing work packages to address challenges and assist each other in writing funding applications. The intercontinental co-development and laughter are helping us all.

Baby palms and a clearfell site (image credits: author's own).

Palm wine (image credit: author's own).

Sustainable Palm Futures for Africa : Project partners

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The port of Nelson, South Island.

Should New Zealanders worry about a 'second wave' of Great Whites? Yes, they should

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Introduction

The Large White butterfly (*Pieris brassicae* L.) has now been successfully eradicated from New Zealand, yet it continues to be of concern to authorities because of the potential damage it could cause to crops and native flora and fauna. Based on experience of this 'first wave' of invaders, and our knowledge of this and similar species, this article explores whether this concern is justified.

This globally successful butterfly evaded all stringent border controls and managed to slip into New Zealand in 2010. It had 18 months of freedom, but was eventually eliminated from the port of Nelson, South Island, albeit not without a considerable manhunt and a big budget.

This article sets out the background, the economic and nature conservation risk posed by this butterfly and the methodology of eradication. My own contribution was that I visited New Zealand in February 2012 to assist the Nature Conservancy in their protection of endemic plants.

World distribution that has never included New Zealand

The Great White Cabbage Butterfly, as *P. brassicae* is known in New Zealand, is present in at least 70 countries (Feltwell, 1973, 1982). It had never been recorded in New Zealand, having been confirmed as absent from Australia and New Zealand in the past (Bartholomew, 1911). The record given by R.L.E. Ford that *P. brassicae* was once in Australia is now regarded as being incorrect (Ford, 1976). It is, however, extremely surprising that the butterfly never made it previously to New Zealand, considering that the Nelson Acclimatisation Society (formed in 1863) introduced so many mammals, birds and fish to the country. *Pieris brassicae* might have therefore been expected to have slipped into New Zealand via the crates of wildlife imported throughout the life of the society (Nelson Acclimatisation Society, 1909). The town of Nelson is still a major port, however, and it was perhaps inevitable that *P. brassicae* would find a way in eventually.

Arrival of an 'Unwanted Organism'

Pieris brassicae arrived in New Zealand in May 2010 (Brown, 2011). The first recorded sighting was of larvae found on Nasturtium, *Tropaeolum majus* L., on 14 May 2010 in a private garden 1.5km from the Port of Nelson, South Island, as reported in the local press (Moore, 2010). It is not known how the species arrived, but imported goods entering the area at that time included foodstuffs, fruit and forestry products (Port of Nelson, 2012).

Pieris brassicae is an 'Unwanted Organism' under the New Zealand's *'Hazardous Substances and New Organisms Act (HSNO Act)'* (New Zealand Government, 1996). It is also subject to the Biosecurity Act as an 'Unwelcome Visitor' (New Zealand Government, 1993). Both these acts are regulated by The Ministry of Agriculture and Forestry (MAF).

MAF's action to the biohazard

On arrival of *P. brassicae* in New Zealand, MAF created a 'Response Strategic Leadership Team' and put in motion i) an *Eradication Strategies and Feasibility Report*, and ii) a *Cost-Benefit Analysis* report (Department of Conservation, 2011).

Large Whites are strong fliers, and very successful colonisers, aided by an abundance of possible larval food plants. Some plants are exploited more than others including Nasturtium, *Tropaeolum majus L.*, which has now spread through New Zealand as an escapee from gardens.

MAF originally proposed that the eradication programme would run for two and a half years and opted for a) visual surveillance, b) aerial and ground spraying, and c) movement controls. Nevertheless, MAF closed down these operations 18 months after *P. brassicae* had arrived, when the population seemed to be decreasing.

As part of visual surveillance, over-wintering pupae within 20km of Nelson were checked for at 27 potential sites, initially shortly after the butterfly's arrival and again in December 2010 to target second generation larvae. During this time, press coverage and passive surveillance to increase public awareness continued. *Pieris brassicae* adults were again on the wing in their second spring (November 2011) when, by the end of the month, 14 positive sites had been identified and treated (all from overwintered pupae). All of these sites were within the Nelson area.

At the end of the second summer (end of March 2012) *P. brassicae* had appeared in three new locations in central Nelson, with one 6km to the north and another 5km to the south. When found, the methods employed for their eradication included spraying, following visual searching of all potential foodplants within 150m of a positive identifcation.

The eradication project progressively wound down and finished in 2012. Border detection continued, however, and the butterfly was last found in New Zealand in 2014 (Erik Van Eyndhoven from MPI.govt.nz pers. comm. 29 June 2020).

Threats – commercial crops and nature conservation

Pieris brassicae posed both commercial and nature conservation threats in New Zealand. Worldwide it has over 114 larval foodplants and five main plant families are known to be exploited. The most utilised hosts are known to be the Brassicaceae (Feltwell, 1982), where the value of brassica crops grown in New Zealand is estimated to be well over $100 million *per annum* (MAF, 2010). The introduction of this foreign organism therefore posed a threat to New Zealand's flora, including its crops.

In addition to the threat posed to brassicas, the Department of Conservation (DOC) listed 35 species of endemic members of the pea family which are now under threat due to *P. brassicae* (Department of Conservation, 2011). Of these, 21 species are *'Nationally threatened and uncommon native species'* and include 15 species of *Carmichaelia*, three species of *Sophora*, two *Clianthus* species and the Scree Pea, *Montigena novae-zelandiae*.

Lessons learnt from another pierid invader

New Zealand does not have any native pierids amongst its 17 butterfly species (Butterflies of New Zealand, 2021). It already had an introduced pierid, however; the Small White, *Pieris rapae*, the only pierid in New Zealand.

A lot can be learnt from *P. rapae*, which was accidentally introduced into New Zealand in 1929-30. It took only six years to spread through the islands and managed to 'jump' from North Island to South Island, not by natural spread across the water to Marlborough region, but aided by internal trade to Timaru. This highlights the need to have effective control measures for invading species at internal trade ports in New Zealand.

For a species that exploits the same general range of foodplants as *P. brassicae*, it is curious that evidence has not been found for any loss or exploitation of a wide range of endemics by *P. rapae*. Damage to endemics could have been overlooked, or perhaps there has been no significant damage. The implications of the latter are that *P. brassicae* might not actually be a threat to endemics but, if the former, then the threat could be significant. I am not sure that field research on effects of *P. rapae* on the wide range of New Zealand

Honesty, *Lunaria annua* L., is another favourite species of Large Whites and abundant in New Zealand as an escapee from gardens. Here the aposematic yellow ova have been oviposited on a developing seedpod.

endemics has been addressed by anyone and, assuming this to be so, this could be strongly recommended as an area for study. It is known that *P. rapae* has already started to attack the iconic Cook's scurvy grass, *Lepidium oleraceum* (Hasenbank *et al.*, 2011) on an island *c.* 250m from the North Island mainland. Hasenbank and colleagues have drawn attention to other workers' results showing that eggs of *P. rapae* were greater in number on plants that grew in more isolated stands than in more aggregated stands. This has potentially significant implications with regard to endemic species, which often grow in isolated populations.

Effective publicity and physical control

The perceived decline in the population of *P. brassicae* in Nelson was one of the reasons why MAF decided to close down their control operations in 2011. Reasons for this decline may have been multifaceted, with the following perhaps all involved to varying dgrees: i) effective publicity and physical control, ii) parasitism, iii) climate stresses, iv) lack of dispersal success.

The effectiveness of the MAF eradication programme on the population of *P. brassicae* has not yet been further investigated. What is known is that this butterfly prospered in its first six months in New Zealand (between May 2010 to November 2011) and expanded out to 12km from its main point of entry, the Port of Nelson (MAF, 2011). *Pieris brassicae* was found in 37 localities, mostly around the port. Over 350 individuals were destroyed in these 37 localities, where nearly all were larvae (easy to find). Only 10 pupae were found (difficult to find) and only 4 adults were captured and destroyed. Interestingly, no ova were ever recorded (relatively easy to find).

Of the 37 locations where *P. brassicae* was found and destroyed, all were associated with garden brassicas, with the exception of four, where in these cases they were found on nasturtiums. Nasturtiums are garden plants, introduced to New Zealand, which are widely grown and have naturalised on vacant land. As nasturtiums do well on vacant plots, it is essential that vacant plots are checked as they will offer key places for *P. brassicae* propagation out of the normal gaze of gardeners.

Summarising success

Pieris brassicae has the habit of crossing borders and is a very successful pest of brassicas. Once through border control, successful eradication in New Zealand relied upon two government departments working together, MAF and the Nature Conservancy, to act quickly via a media campaign, poster displays and local eradication of larval food plants over a wide buffer zone. If *P. brassicae* arrives again these two government departments are well prepared to eliminate it, and save endemic brassicas.

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Tips for insect photos from a total amateur

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Total amateur, co-Editor In Chief, Ecological Entomology.

This article is meant for those of you who enjoy shooting images of arthropods but who don't have a lot of experience doing so. The tips I provide below should hold, whether you use an expensive macro rig or the camera that comes with your mobile phone. And, regardless as to whether you set out to achieve macro-photo stardom or simply wish to share your images with friends and family, the number one objective should be to have fun; relax and enjoy the world around you. I don't think that I need to tell entomologists that the tiny world of arthropods is stunning, whether captured by camera or not.

Confessions and disclaimers: (i) I am a total amateur. Though I have received a few cash prizes for my images, I have never set out to take photos for money. I shoot photos for the pure joy of it. (ii) I am relatively recent to macro photography; I started taking arthropod images about fifteen years ago, soon after I purchased my first digital camera. (iii) I mention a few brands below, but I am not a spokesperson for any of them.

Here are some tried and true tips that I have developed, mostly from trial and error. Nearly all the images that accompany my tips were taken a few metres from my front door within the past year. I use an Olympus OD-E camera, often with an Olympus or Laowa macro lens.

Beating the breeze

I hate breeze. When working at a macro scale, any movement by you or your subject will be exaggerated and could spoil that perfect picture. Take the aphid-herding ants opposite – almost a good picture but spoiled by the plant swaying in the breeze. Unfortunately, plants move very readily in response to any breeze. What to do? Take a deep breath, try to shoot between gusts, shoot in the morning when breezes are less pronounced or clamp (or 'Plamp', from Wimberly) the host plant to a tripod or stationary object. Shoot at a high speed if possible. Holding the plant with your non-shooting hand will generally not work; even slight movement from that hand will be badly exaggerated. Finally, if possible, set your

How to find your subject

Many arthropods are very small and not easy to find using your camera. My approach is to focus first, from a distance, locate the subject in the scene and then home in (this also works well for birds or small mammals at a long distance). Below, I first located the sweat bee, with the full flower in my viewer, then I composed my image, moving in and out until I was happy with the focus and magnification. In addition, once I achieved the proper focus on my subject, I then moved my camera side-to-side, up-and-down, to get the composition that I wanted.

camera to take multiple images in burst mode; one of those images just might work plus, two or three images in, there will be no shake from initially depressing the shutter button. Using this burst approach might require that you come up with a good filing system so that you can track all those images.

A sturdy stance

Make yourself into a 'tripod' – nearly all the images in this article were taken handheld but, in each case, I tried to find a way to brace my body (against a stationary object if possible) to reduce motion. Taking a deep breath before shooting also helps.

Focused focus

Ever had one of these?

You notice a beautiful bee approaching a colourful aster, you grab your camera and shoot, already thinking about the praise you will receive from friends and colleagues. Then, to your horror, your image shows a well-focused aster with a fuzzy little bee-like thing flying by it. Arrrgh – again? Unless you tell your camera to focus on your small subject, it will grab the more obvious background host. Try setting your camera to Spot Focus or at least Centre Weighted. I often manually set my camera at a particular focus and then move the camera in and out until the subject appears sharp. For panning a moving subject, set a low shutter speed, move the camera in step with the subject, generating a sharp subject and blurred background.

Don't oversharpen

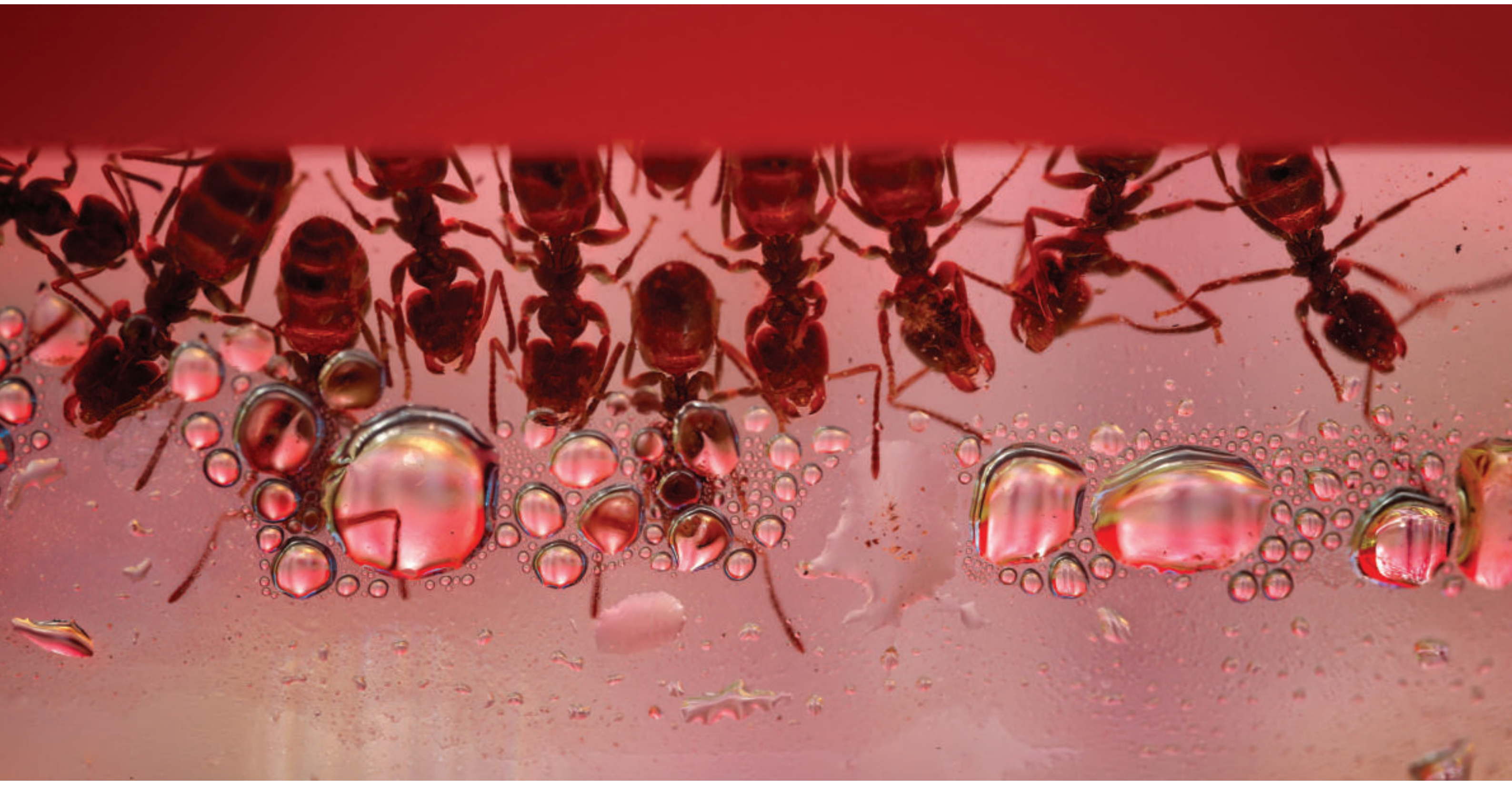
Most photo editing software will allow you to sharpen your image, however, it is really easy to over boost that sharpness and create an artificial, crunchy image. To paraphrase Jeff Schewe, co-author of *Real World Image Sharpening*, to undersharpen is a mistake but to oversharpen is a big mistake. One little trick, when editing, is to magnify your subject and sharpen just below the point that it looks artificial. In the cross orbweaver image here, I purposely oversharpened the subject, giving it an artificial look.

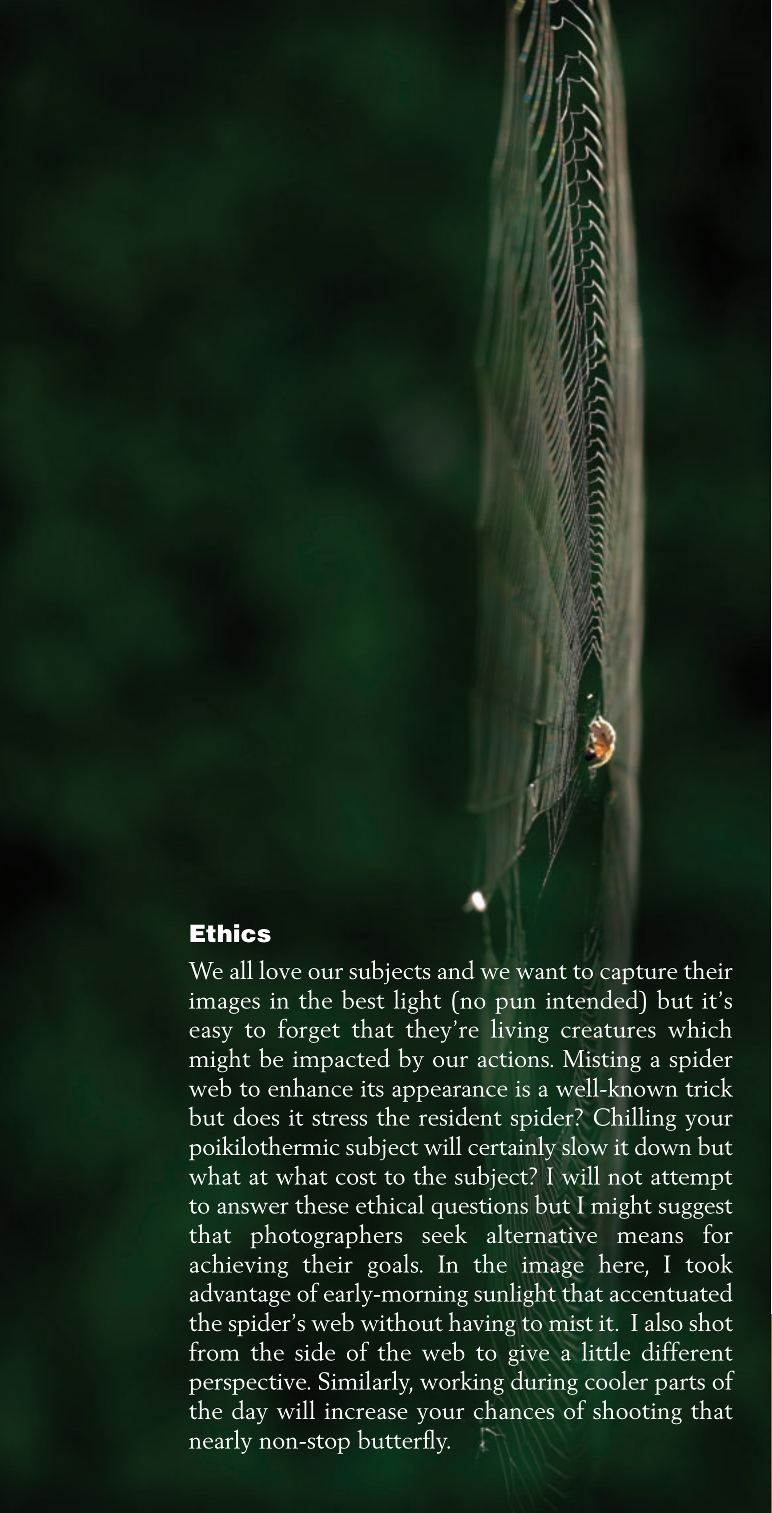
Don't oversaturate

Arthropods come in amazing shapes and colours and it is very easy to get caught up in those delightful wavelengths and try to express them at their max; don't do it. Oversaturated images look unnatural. If you are using an image editor, start at the lowest saturation setting and slowly increase until you get a natural look, or work with individual colours to emphasize them. You might also play with the vibrancy setting to generate a little punch without oversaturating. The sweat bee image on the right below is, in my opinion, oversaturated.

Colour casts

Casts or tints are common in photos when insects are found on colourful hosts such as flowers. Shooting a small insect on a bright yellow flower will often fill the image with a yellow cast. Most photo editing software will allow you to remove colour cast; that should be one of your first jobs when you start editing an image. On the other hand, sometimes a cast tells an interesting story. In the image below, I shot ants feeding inside my bright, red hummingbird feeder and chose to leave most of the cast.





Ethics

We all love our subjects and we want to capture their images in the best light (no pun intended) but it's easy to forget that they're living creatures which might be impacted by our actions. Misting a spider web to enhance its appearance is a well-known trick but does it stress the resident spider? Chilling your poikilothermic subject will certainly slow it down but what at what cost to the subject? I will not attempt to answer these ethical questions but I might suggest that photographers seek alternative means for achieving their goals. In the image here, I took advantage of early-morning sunlight that accentuated the spider's web without having to mist it. I also shot from the side of the web to give a little different perspective. Similarly, working during cooler parts of the day will increase your chances of shooting that nearly non-stop butterfly.

Create tension

A picture should tell a story. You can direct the viewer's eye to your story by exposing any tensions that might be present. This could be due to light contrast, opposing colours, size differences, gravitational tension and more. In the image below, the honeybee is hanging from a borage blossom creating gravitational concern.

Document first then go for the artsy

Many entomologists want to do both, i.e., document the presence of some special creature and create a beautiful shot. I suggest that you first grab an image for posterity and then take your time getting that perfect shot. If, in the meantime, the subject flies or crawls away during your planning session at least you have your record.

Be willing to crop

The human eye and brain have an amazing ability to notice tiny little creatures and their details. The same thing happens when we look through a lens. Even a subject that takes up maybe 10% of the field can look amazing and so we shoot away. Later, we are often disappointed how insignificant that creature now appears on our computer screen. It is almost always possible to crop away extraneous parts of the photo and increase the size of the subject. Doing so also gives you the chance to move the subject around until it sits in the best position (e.g., move from direct centre to upper third). Of course, you could always 'zoom with your feet' but getting closer to the subject might stress it and/or cause it to leave. Side tip: if possible, shoot in RAW; that will give you much greater flexibility when editing. Side tip 2: notice in the cropped image in the photo on the right, below, I did not constrain myself to the original length:width ratio – pick a ratio that works for you.

Be willing to desaturate

Some images just look better with little or no colour, especially those with lots of contrast. Try desaturating your image to see if it appeals. Many digital cameras (e.g., Olympus) allow you to see the image in black and white before shooting. I often use the black and white setting to get a different view of the world.

Try different perspectives

Your first look at a photo situation is not necessarily the most appealing. Try different angles, different looks, different heights to see what might emerge. Get on a knee, look underneath, from the side and so on; I know that I've had a good day if I come home with dirty knees. In the image here, I shot nearly the entire tulip flower to show my audience just how small a thrips can be, relative to its host plants.

Depth of field issues; watch your background

I often shoot at modest depth of field, that zone in the picture that is in focus (e.g., f value = 6.3 on an Olympus, micro 4/3 camera) sacrificing some focus for a nice, creamy background. Again, this is a matter of taste. I generally want tack sharp on the critical parts of the image, but I don't feel the need to do so throughout. In fact, I often want the sharp part to stand out from the rest. There is some risk using a modest depth of field. Given the small size of my subjects, if I err, even a little, I will miss the critical elements wherein they fall outside the shallow focal zone. Regarding backgrounds, some simply look better than others, so keep an eye on the background as well as the subject (Side tip 3: use the Preview button on your camera to see, in advance, how the background will appear).

In some cases, you might even wish to place a coloured sheet of paper or cloth in the background if the natural background is complex (distracting) or unpleasing. Of course, greater depths of field (e.g., f11) will bring more of the background into focus. Cameras with smaller sensors generate greater depth of field and thus emphasize the trade-offs discussed above. The two images above illustrate the importance of background, one creamy (f5) and the other (f11), in my opinion, distracting – but they both tell a story. These shots also illustrate the difference in perspective via vertical vs. horizontal shots.

Bin the background

If you don't like the background, consider changing it. Here, the original background was bland and uninteresting, so I cropped a little and then made a quick substitution that, in my opinion, spruces up the image and enhances the story e.g., this is a garden shot. I regularly take pictures of walls, sky, fabric, etc. for use in the future as backgrounds.

Slow down your brain ***(see point on documenting)***

I get excited when I see something interesting; I want to shoot right away. However, if possible, one should take a moment to ask oneself what it is you want to achieve – you just might change your approach. You might only get one chance before your subject moves away so take a moment to decide how to proceed. In this example, I spotted this beautiful spider on a daisy in the classic sit-and-wait mode but then noticed that the spider was moving around so I just sat and waited for it to do something less typical. The two shots inset, in my opinion, are more interesting.

Stack stationary figures

Many cameras and some phones can take several images from slightly different focus distances and then stack them together to increase resolution. There is also some good software on the market that allows you to stack images yourself (e.g., Helicon Focus). If you have a stationary subject, focus stacking can provide a very nice effect. In the image to the left, I incorporated 12 individual shots (each with shallow depth of field) to generate this very detailed shot of a stink bug with a soft background. I could never have generated this image with a single shot.

Don't centre your focal organism

Placing your favourite insect right in the middle of the frame is generally not an interesting perspective. Instead, you might try shifting toward the left where one's eyes normally first search. Also, if your subject is moving, give it a chance to move into the frame i.e., if the subject is moving to the right, your photo will look best if you leave lots of space on the right.

Rules are made to be broken

'Rules' (or tips) are just guidelines and don't fit every situation. Regarding the "centre-is-usually-boring" observation, sometimes it just works. Here, this syrphid sits near centre with the visual lines from the arugula giving it tension that provides a story.

Which lens to use and watch your foreground

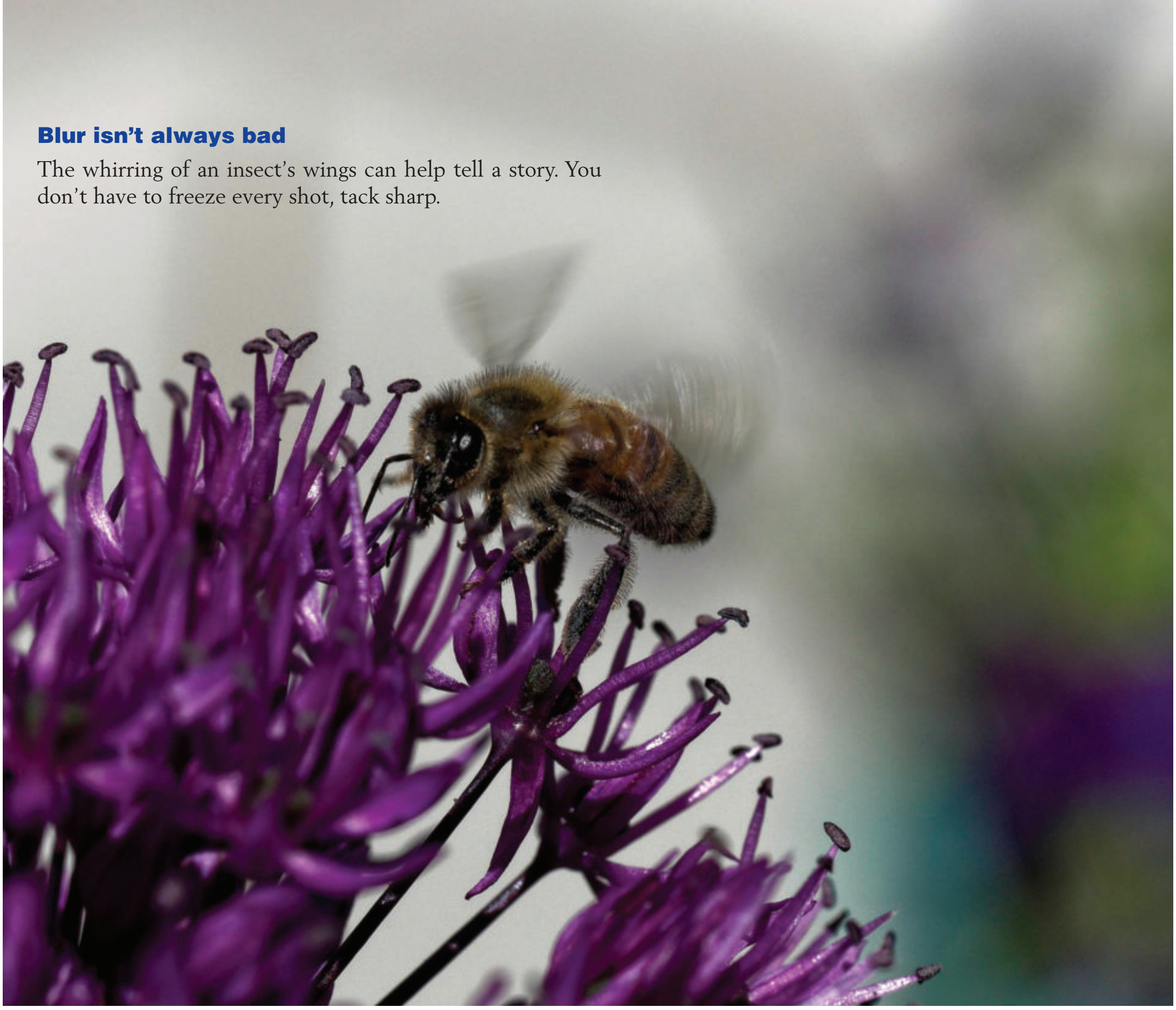
Mostly, we use macro lenses to capture macro images, and these lenses tend to be in the 100 mm range. There are occasions where you might want to use something longer (e.g., a telephoto lens) so that you can stand further back and not disturb shy creatures or maybe pan wider to give a different perspective. With the latter, an attractive foreground can really enhance your photos.

Beware reflections

Many arthropods have smooth, shiny exoskeletons that reflect natural and/or artificial light in a manner that is exaggerated by closeup view (especially beetles, ants and wasps). There are several ways that one might mitigate this problem: (i) choose a position where reflection is minimal, (ii) place a diffusion screen between the light source and the subject (e.g., Neewer soft discs or just make one yourself with soft fabric), (iii) avoid shooting at midday when the sun is most harsh, (iv) shoot in shadows, (v) use a polarizing filter or, (vi) fill in with artificial light that is diffused. In this image, I employed a small LED light (Litra) that was covered with a diffusing cap. My goal was to emphasize the translucent nature of the syrphid exoskeleton without generating distracting reflection.

Blur isn't always bad

The whirring of an insect's wings can help tell a story. You don't have to freeze every shot, tack sharp.



Tell a story

Like many research papers, the most compelling images are those that tell a story. Try to find situations where the viewer is asked to interpret the scene. In the image of the hoverfly below, there is focus on the primary subject's eating habit and in the photo inset to the right, the story might very well depend upon one's perspective.


Use vignetting

Vignetting occurs when there is a change in brightness towards the periphery of an image. Most software packages, including those that come with phones, allow one to place a vignette around a primary subject to accentuate that creature in or near the centre. I often set a subtle vignette around my subject, just enough to direct the human eye to the subject without making it obvious. In the images above, I set a subtle, dark vignette on the image on the left and a subtle, light vignette on the image on the right. Both focus the viewer's eye on the fly but in different ways.


Look for light

I try to look for how the light impacts my image. Is the subject, frontlit, backlit, sidelit, is it focused, diffuse, etc.? There is no right nor wrong, but you might wish to think about how the light helps you tell your story. In the earlier image with the thrips, I waited until late afternoon when the sun would shine through the tulip to give a nice glow and emphasize the thrips. Further, should you employ an artificial light source, move it around to see if it increases the appearance of depth. In the two images above, the light really helps tell the story.

Shoot for the eyes

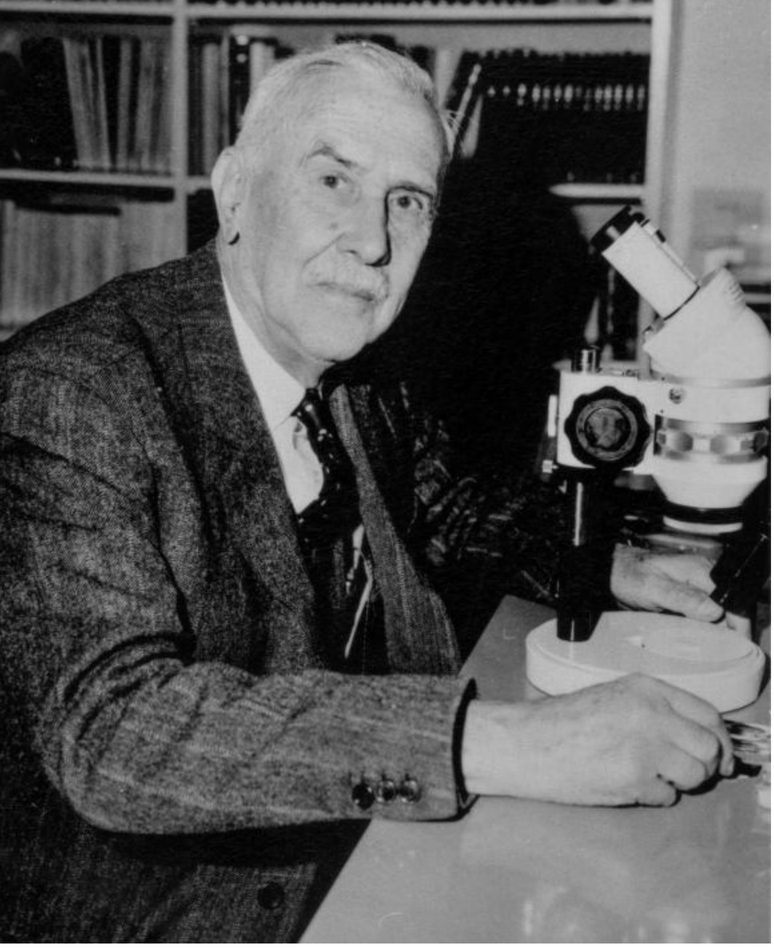
The axiom for photographing humans is "shoot for the eyes". That holds for arthropods as well. The two images above illustrate the importance of this axiom.

And finally know your target

Get to know your subjects and learn to anticipate what they are going to do next. In many cases (and this works for birds too) point your camera where you expect the focal creature to move to next. Territorial insects such as male dragonflies regularly return to certain positions, which can be anticipated. Some species are very sensitive to movement (e.g., butterflies) whereas others (e.g., honeybees) are not. For the former, try moving very slowly, stay in the shadows, use telephotos, etc. Knowledge of the natural history of the subject will go a long way to improving your shots.

In conclusion, there are many means by which you might improve your arthropod images, but I hope I have provided a starting point for you regardless of equipment or experience. Notice that none of these suggestions should impact your bank account, but they could prove seriously distracting; beware. Have fun and stay safe.

Thanks to Dave Gillespie and Francis Gilbert for comments on an earlier version of this note and to my muse, Carol, for inspiration and assistance.



Charles Ferrière.

Charles Ferrière of Geneva and his contribution to biological control

John Hollier & Anita Hollier

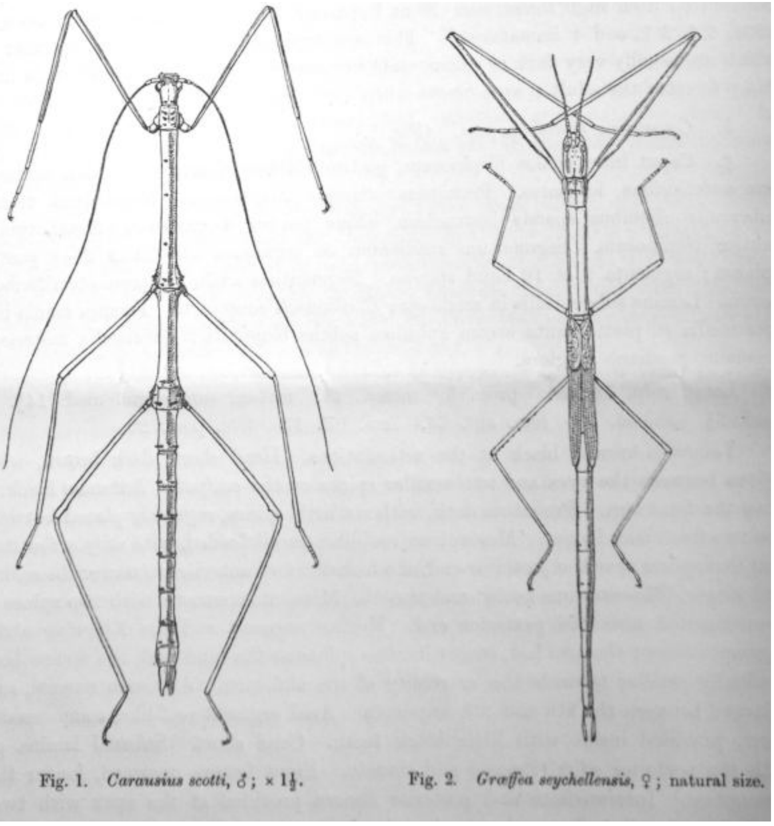
Muséum d'histoire naturelle de Genève, C.P. 6434, CH-1211 Genève 6, Switzerland

Charles Ferrière (1888-1979) specialised in Hymenopteran parasitoids, particularly the superfamily Chalcidoidea, and their importance as possible biological control agents. Polyglot, and with an international outlook, he also made a significant contribution to the collaborative project to advance applied entomology and biological control that culminated in the creation of the International Commission for Biological Control (ICBC). Thanks to his determination, the International Centre for the Identification of Entomophagous Insects was set up at the Natural History Museum of Geneva (MHNG) in 1958, where, for over a decade, it coordinated the interface between applied entomologists and an international team of specialist taxonomists, provided identifications of chalcids, and offered training and mentoring in this important field.

Ferrière's interest in parasitoids ripened during a post-doctoral internship at the Paris Entomological Station under Paul Marchal (1862-1942) in 1914. He was already more experienced than most students; after graduating from the University of Geneva in 1910 he had accompanied Edouard Bugnion (1845-1939), professor at the University of Lausanne, on an expedition to Ceylon (Sri Lanka), acting as assistant and photographer. Ferrière then went to Britain, studying specimens in the Cambridge University Museum (Bolívar & Ferrière, 1912) and spending an academic year at the University of Edinburgh, matriculating in agriculture and forestry in 1912. Returning to Geneva, he prepared a doctoral thesis on Hemipteran respiration, which he defended in 1913. He devoted his career to taxonomic research, and was unusual among entomologists in having little taste for field work; despite being a keen mountain walker, he preferred to study specimens collected by others.

After a hiatus working as a volunteer for the International Agency for Prisoners of War (established by his father, a member of the International Committee of the Red Cross, at the beginning of the First World War), Ferrière became curator of entomology at the Natural History Museum in Bern in 1917. His publications show that he continued to collaborate with entomologists at the Paris Entomological Station while caring for the collection, studying Swiss Hymenoptera, and serving as librarian to the Swiss Entomological Society. In 1927 he took a post at the Imperial Bureau of Entomology in London (later the Imperial Institute, Commonwealth Institute and now part of CABI Bioscience), where he was responsible for the parasitoid Hymenoptera and particularly the Chalcidoidea collection. Ferrière was elected Fellow of the Royal Entomological Society of London in 1939, but war again intervened in his career and in 1940 he returned to Geneva for family reasons. He obtained a temporary post at the MHNG in 1941 and the following year was seconded to a Federal Research Station near Lausanne to work on the control of the Colorado potato beetle, testing the available insecticides and researching biological control. When Hermann Gisin (1917-1967) became curator of arthropods at the MHNG in 1943, responsibility for this huge collection was divided, and Ferrière was appointed as the second curator in 1944.

Ferrière's experience at the Imperial Institute in London made him very aware of the potential economic importance of parasitoids, and of the paucity of specialists able to identify them. In 1948 he took part in a symposium (organised by Paul Vayssière (1889-1984) alongside the 8th International Congress of Entomology held in Stockholm) that examined the need for international cooperation on biological control and led to the foundation of the International Commission for Biological Control in 1950 under the auspices of the International Union of Biological Sciences. As early as 1949 Ferrière proposed a European centre for identification to complement and collaborate with the London body (by then renamed the Commonwealth Institute of Entomology) and the Bureau of Agriculture in Washington. He organised a meeting in Geneva to discuss the idea in 1953, but lack of funds made it seem almost impossible. National governments were already wary of backing the ICBC, which had only

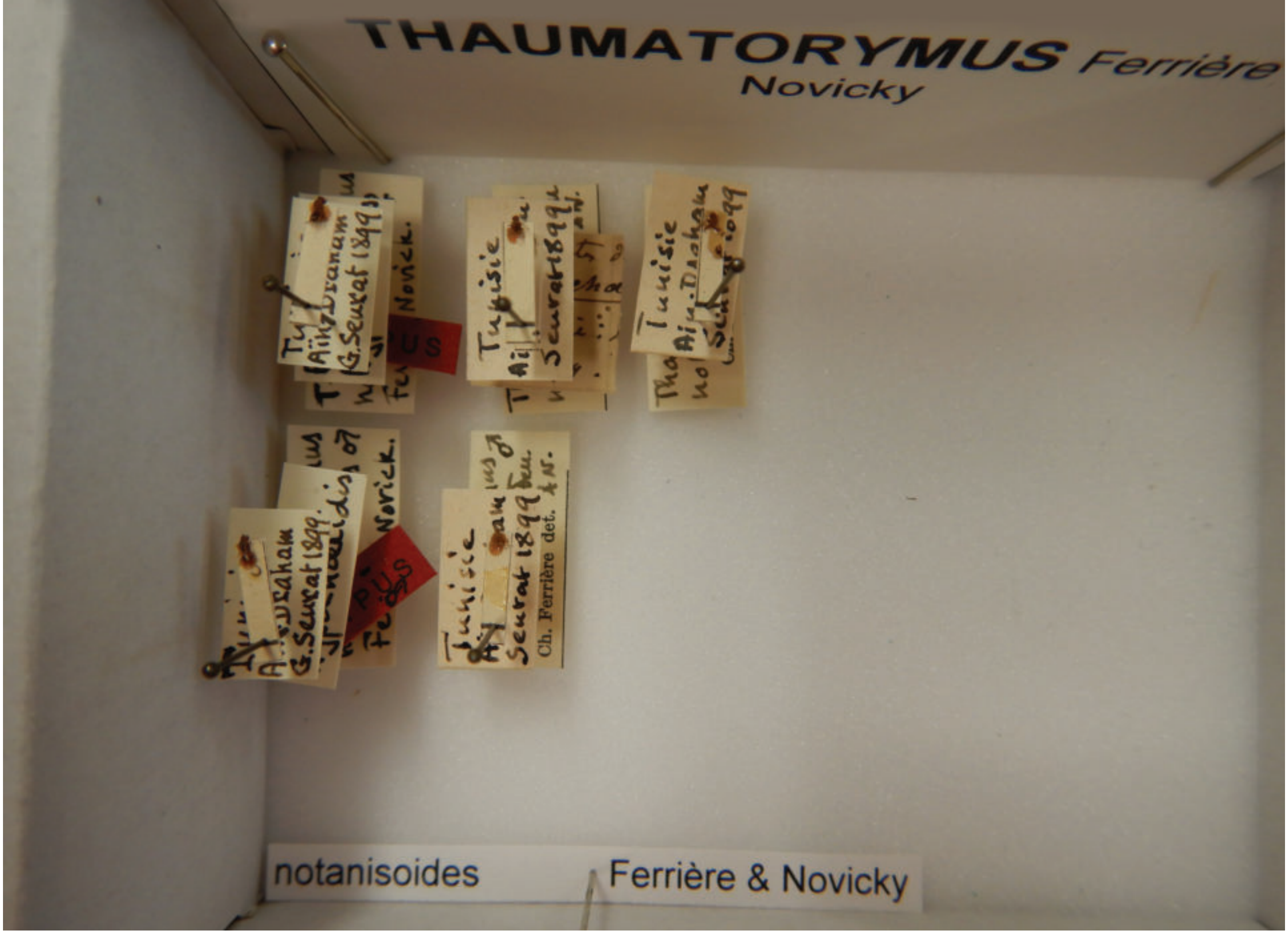


Ferrière's first published illustration, from Bolívar & Ferrière, 1912.

modest funding for a few special projects (Franz, 1988), let alone putting up money for such a centre. A small group of entomologists persevered, however, under the leadership of Ferrière and Alfred Serge Balachovsky (1901-1983), and in 1954 put forward concrete proposals at an ICBC meeting in Colmar, although still without the means to realise them. Meanwhile, until some way was found to finance the centre, Ferrière put his expertise and the MHNG collections and library at the disposal of other workers, and by 1954 was in contact with 88 correspondents in 22 countries.

One problem with expanding Ferrière's operation was the cramped nature of the MHNG accommodation. Geneva's natural history collections had been transferred to purpose-built premises as an independent institution in 1872, but the site soon proved unsuitable for a modern style of exhibition and woefully lacking in storage space. Parts of the collection were stored, or even exhibited, in other buildings, such as the Palais Eynard, just across the Bastions Park; the concierge's apartment was converted into office and laboratory space, but there was no room for expansion. Work on a new building began in 1913, but foundered in the post-war financial crisis, so when a new infant school opened in 1958 to replace an outmoded one at Villereuse, the MHNG's director Émile Dottrens (1900-1990) seized his chance and commandeered the Villereuse building for the Department of Entomology. With six large rooms and spacious corridors, the building rejected as a school seemed luxurious to the entomologists. The main collections of the four mega-diverse orders (Coleoptera, Diptera, Hymenoptera and Lepidoptera) were transferred from their homes scattered around the

Aphelinidae identified by Ferrière.



Types of *Thaumatorymus notanisoides* Ferriere & Novicky, 1954 (Torymidae).

MHNG building, and the regional collection and Forel ant collection were moved from the Palais Eynard. Each order was given one room, with Claude Besuchet (1930-2020), the incoming curator of entomology, billeted with the beetles (his lifelong speciality being the Pselaphids). The fifth room became a library, and Ferrière was installed in the sixth with his specialist library and workspace for visitors or interns.

Finally, Ferrière's plan could be accomplished and on 31 March 1958 the City of Geneva and the ICBC signed a convention setting up the International Centre for the Identification of Entomophagous Insects at the MHNG. By this time, Ferrière had reached the MHNG's mandatory retirement age of 70, but he remained as director of the new centre with Besuchet as secretary and ICBC funding for a technician. The centre acted as a sort of clearing house to facilitate the work of agronomists and applied entomologists by sending specimens of any potential biological control agents they encountered to taxonomic experts in other institutions, who were paid an annual fee by the ICBC proportional to the number of identifications they made. To ensure the data accompanying specimens were as complete as possible, the centre sent forms to numerous entomological stations and institutes early in 1958. In January 1959 André Comellini (1920-2001) was recruited as technician; he received the packages of insects, mounted specimens that had been sent in alcohol, ensured all specimens were clearly labelled and passed the chalcids to Ferrière for identification. Besuchet sorted the other specimens into taxonomic groups and Comellini posted them to the relevant specialist. On their return to the centre, the identifications and most of the specimens were sent back to the inquirer, but duplicates were placed in the MHNG collection whenever possible.

During its first full year of operation, the centre dealt with 64 packages from 47 correspondents in 14 countries and processed 4,300 Hymenoptera. In 1960 this rose to 10,100 Hymenoptera and 2,100 Diptera from roughly the same number of samples. Most of the identification work was done by a group of 20 or so entomologists scattered in various museums, universities and other institutes around Europe (and North Africa), including Mike Claridge in Cardiff and John Quinlan in London. Training was also offered, and Ferrière began accepting interns for six-month periods. The whole operation was transferred to the new, state of the art, MHNG buildings in the Malagnou Park in 1965.

Meanwhile, considerable overlap was becoming apparent between the francophone-inspired ICBC and the more anglophone International Advisory Committee for Biological Control (IACBC), and both were eager to avoid competition that might be detrimental to their shared cause. After discussions at the International Congress of Entomology in London (1964) and Moscow (1968), a joint meeting of the ICBC and IACBC was held in Amsterdam in 1969. The upshot was the creation of a single global body, the International Organization for Biological Control of Noxious Animals and Plants (IOBC), inaugurated in Rome on 30 March 1971 (Franz, 1988). This organisation comprised regional sections reflecting biogeographic regions and the political realities of the period. Fairly seamlessly, the ICBC became the Western Palaearctic Region of the IOBC. Ferrière was by then well into his 80s and the centre, having achieved its mission, was discontinued.

During his career Ferrière described 25 genera and 321 species new to science and became one of the leading experts on the chalcids (Besuchet, 1980). His 150 publications are listed by Blanc (1953: 345-351) and Delucchi (1978), and he was also series editor of the first 11 volumes of *Hymenopterorum Catalogus* with Jacobus van der Vecht (1906-1992). His publications include one of the Society's Handbooks (Ferrière & Kerrich, 1958). Ferrière's contribution was recognised by an Honorary Fellowship of the Royal Entomological Society (1949) and honorary membership of Entomological Societies of France (1950), Belgium (1950), the Netherlands (1951), Switzerland (1955), Bavaria (1964) and Geneva (1965). Thanks to his work, and that of the centre, the MHNG collection of parasitoids was one of the finest in Europe in the 1960s, but

Tormyidae, largely identified by Ferrière.

little has been added to the collection since Ferrière's time. The story of the Villereuse Annex and the role of the MHNG in advancing biological control also remained largely untold and forgotten in Geneva, but is a striking example of one man's dedication to this invaluable cause.

Acknowledgements

Thanks are due to Bernard Landry, current curator of Hymenoptera at the MHNG, and to Bernd Hauser and Jean Wuest, both retired, for discussions about and anecdotes of the history of the MHNG Arthropoda collections. We are grateful to Philippe Wagneur, Juliette Oulevey and Betty Oudomsouk of MHNG for their assistance. John Huber of Natural Resources Canada made useful comments about the MHNG collection. We thank Val McAtear of the Royal Entomological Society, Stephen Willis of the University of Edinburgh, Jacqueline Cox of Cambridge University, Russell Stebbings of the Cambridge University Museum of Zoology and Koen Smets of the Royal Belgian Entomological Society who all provided information from the records in their care.

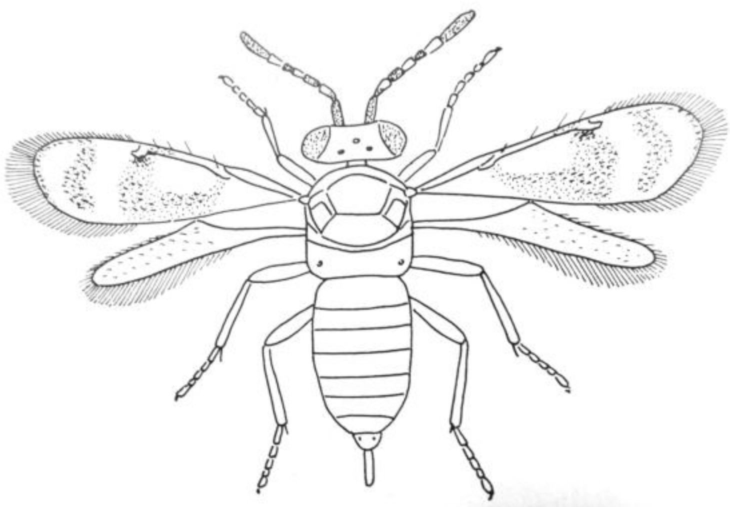


Fig. 40. — *Azolus atomon* Walk. ♀.

One of Ferrière's later illustrations, from Ferrière 1965.

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Society News

News from Council

Grand Challenges workshop

Luke Tilley

As outlined in previous issues of *Antenna*, the ‘Grand Challenges in Entomology’ initiative is a collaborative effort by entomological societies from around the world to develop a series of priority topics and questions on which we should focus our research efforts and activities as a scientific community. As part of the global initiative, the RES has conducted a multi-stage prioritisation exercise, in collaboration with Dr Sarah Luke, Dr Lynn Dicks and others from the University of Cambridge, UK, to gather together topic suggestions from our Members and Fellows, and to distil them into a shortlisted set of priorities. This was done through a multi-stage process comprising the following main steps: (1) an initial online survey of all members to gather topic suggestions; (2) processing of suggestions into themes with cross-checking of decisions across multiple scorers; (3) a second online survey of members to start prioritising suggestions; and (4) a two-day long online workshop to discuss longlisted suggestions and produce a shortlist.

Over 700 suggestions were submitted, by 189 RES Members and Fellows. One hundred and eighteen people then contributed at the online prioritisation stage, whilst 54 people were involved in the energetic workshop discussions. The final list of ‘Grand Challenge’ priorities comprises 61 suggestions, within 11 diverse themes, across which there is a range of cross-linking ideas. The prioritisation process has provided an opportunity for wide-ranging engagement and discussion across the Society, and a novel approach for gathering opinions from the RES membership about their views on the future of entomology. We hope that the final list of priority topics will provide a valuable resource to guide the agenda and activities of the RES over the coming years and decades. A detailed paper is currently being prepared to communicate the methods and results of the exercise; free-to-access editorials will also be appearing across the RES journals. For now, we are delighted to announce the following 11 themes into which each of the 61 suggestions have now been grouped:

Taxonomy

Blue Skies research

Ecosystem benefits

Insect technology and resources

Pest research

Anthropogenic impacts on insects

Conservation options

Methods and techniques

Knowledge access

Training and collaboration

Society engagement

We would like to thank the hundreds of individuals who contributed to the exercise overall, the facilitators and student representatives who allowed the process to take place so smoothly, colleagues at the University of Cambridge, and an extra thank you to all those Members and Fellows who worked so hard during the two-day workshop to progress the initiative towards the reports to come, here in *Antenna*, and in other RES publications.

Membership Consultation update

Luke Tilley

This year has been an exciting one for membership affairs at the RES. As part of a renewed focus putting our Members and Fellows at the heart of what the Society does, the Membership Committee was reinstated in April, chaired by trustee Dr John Baird. The Committee was given an exciting new remit, beginning with a survey and in-depth consultation of the membership to inform future recommendations and activities based on the findings. This will be the first update of many about the consultation and the recommendations and changes originating from it. Each recommendation will also be informed by the new RES strategy to be launched in 2022, which has had its own extensive consultation process.

Emma Pegram, evaluation consultant, was engaged to assist the Committee, first with a survey open to the whole membership, then with a series of targeted interviews to construct a fuller picture of the needs and opinions of our Members and Fellows. A total of 385 people responded, which provided a lot of valuable feedback and allowed individuals to elect whether they would be open to be interviewed by Emma for more in-depth comment. The survey also helped to develop some key questions for the interviews. The following twelve questions were identified as priorities to understand the needs of the RES membership:

1. **How do people find out about the RES?**
2. **What do students and early career entomologists value about RES membership?**
3. **What do students and early career entomologists want from membership of the RES?**
4. **What is the value of membership to others? – Members, Fellows, non-members, those not working as entomologists.**
5. **What do students and early career entomologists think of the cost of membership?**
6. **Why are some people not Members or do not renew their membership?**
7. **How else could membership be improved?**
8. **What do people think about *Antenna*?**
9. **What do interviewees think about HQ and investment in Mansion House?**
10. **What reputation does the RES have?**
11. **To which other societies do interviewees belong?**
12. **What is the value of the RES to people not based in the United Kingdom?**

The interviews included 25 people in total. Specific details are not included to protect the anonymity of responses, though great effort was taken to draw from a diversity of backgrounds and circumstances. Fellows, Members and non-members were included from those who elected to take part in the interview stage. The 25 individuals can be broken down, as follows:

- **UK Student Members x5**
- **Non-UK Student Members x3**
- **Members and Fellows not working in entomology x3 (amateur and unpaid)**
- **Non-student early career Members (UK and international) x3**
- **Fellows working in entomology (mid-late career, UK and international) x3**
- **Non-members (mid-late career, UK and international) x5**
- **Non-members (student or early career, UK and international) x3**

Detail on the outputs of this consultation activity will follow in the first *Antenna* issue of 2022, but as a first step, we wanted to introduce the process in issue 45(4). Membership Committee members are working on the findings to make recommendations to Council in December 2021 and we will be communicating more results and any changes next year. Finally, an enormous thank you to all those who completed the survey and took part in the interviews. Your contributions will help to guide the RES towards a successful and exciting future.

Meet your new trustees

Thank you to everyone who voted in trustee elections in August. We are delighted to introduce your new trustees, serving four-year terms on Council 2011-2015. Many thanks to all the candidates who stood for election. Eight trustees were elected:

PRESIDENT-ELECT

Serving one year, then two years as President and a final year as Past President.

Professor Jane K. Hill *Hon. FRES*

Jane is a Professor of Ecology in the Department of Biology at the University of York, and currently the University's Research Champion in 'Environmental Sustainability & Resilience'. Her research examines the impacts of climate change and habitat degradation on biodiversity, quantifying the extent to which species, especially butterflies, are shifting their ranges as the climate warms.

Jane has been a Fellow of the RES since she was a PhD student exploring migration in Silver Y moths (*Autographa gamma*). She was awarded Honorary Fellowship in 2016, after many years serving as Editor-in-Chief of *Ecological Entomology*.

Jane's experience of gender equality and diversity will help the Society in its commitment to making entomology more inclusive. She led her Department's successful application for an Athena SWAN Gold Award, and has been involved with supporting equality, diversity and inclusion initiatives through her trustee role at the British Ecological Society. Jane brings her extensive experience in publishing to support the Society's journals in an era of more open science.

TREASURER (Chair of Finance Committee)

Dr Guðbjörg Inga (Gia) Aradóttir *FRES*

Gia served as interim Treasurer from September 2020 until successfully elected. She is a Fellow of the RES with a PhD from Imperial College, an MBA from Warwick Business School, and a wide skill set, including an experience of finance, investment management, compliance, strategy, and project management.

Gia is passionate about entomological science and has worked in the field for 20 years in various roles, both in the public and private sector – at Rothamsted Research, Inscentinel Ltd., Natural History Museum, the Icelandic Institute of Natural History and, most recently, as Programme Leader of Entomology at NIAB. She is currently an entomological consultant.

Gia looks forward to balancing the vision for the long-term financial success of the Society with supporting the Senior Leadership Team in their day-to-day financial management, oversight, risk management and compliance.

CHAIR OF MEETINGS COMMITTEE

Dr Richard Harrington *Hon. FRES*

Richard's whole career was with the Rothamsted Insect Survey, working on aphids. The Society was very important to him throughout, and he has returned the favour in a range of capacities. In retirement, he has more time to help with RES development as a modern, vibrant and inclusive organisation. He served as interim Chair of the Meetings Committee from September 2020 until election and as Coordinator of the Special Interest Groups since 2014, the same year he was awarded Honorary Fellowship.

Richard is passionate about meetings as a key component of the Society's role in disseminating entomological science. He's committed to ensuring that they are of the highest quality, meet the wishes of all members, attract new members, are open to non-members, and comply with the Society's policy on equality, diversity and inclusion.

Richard is also editor of *Antenna*, which complements the meetings trustee role very well, as reports of meetings are important in informing members and attracting them to future meetings, and the topics covered provide inspiration for articles in *Antenna*. He has previously been a trustee of the Society and also been a Trustee of Hertfordshire Scouts (as County Commissioner), an organisation with 17,000 members and an annual turnover of approximately £2,000,000.

CHAIR OF PUBLICATIONS COMMITTEE

Dr Shaun Winterton *FRES*

Shaun was born and educated in Brisbane, Australia, with degrees from the University Southern Queensland and Central Queensland University, and a PhD from the University of Queensland. He moved to the USA shortly after completing his PhD for a post-doctoral fellowship at North Carolina State University. He has lived in the USA ever since, except for a short stint back in Australia to head up the collections at both the University of Queensland and the Department of Primary Industries (Brisbane).

For most of his time in the USA, Shaun has worked for the California Department of Food & Agriculture in Sacramento. His research programme is broad, reflecting his varied professional experiences, including biological control, taxonomy, phylogenetics, phylogenomics and even aquatic botany. He has over 130 papers published in peer-reviewed journals, including RES journals, and received Best Paper awards for papers published in *Systematic Entomology* (2011) and *Journal of Australian Entomology* (2000).

Shaun has been a fellow of RES for several years and currently serves as senior Editor-in-Chief for Systematic Entomology. He served as interim Chair of the Publications Committee until election.

EARLY CAREER TRUSTEE

(An exciting new trustee role representing early career entomologists)

Dr Joe Roberts Mem.RES

Although always interested in natural history, Joe actually came to entomology later in life as his passion for insects was sparked during his undergraduate research project. As it turned out, this was a pivotal point in his life and he went on to study for a PhD in the chemical ecology of predatory mites before becoming a lecturer in entomology at Harper Adams University (HAU), UK. He recently became course manager for postgraduate entomology at HAU.

Joe recognises the importance of the RES in promoting excellence in entomology and demonstrating the importance of studying insects to everyone. As a trustee, he will ensure that outreach and engaging the next generation of entomologists is a core activity of Council. As an early career scientist, he is acutely aware of the stereotypes surrounding entomology and entomologists. He will therefore use his new position to make sure that the Society is forward looking, inclusive and challenging stereotypes.

TRUSTEE

Moses Mosunda Mem. RES

Moses recently graduated from the Copperbelt University with a Masters of Philosophy in Biology with a focus on entomology; he also has a BSc in Biology from the University of Zambia.

Moses developed a passion for entomology at a young age and would keep bees in a beehive near a cornfield at home. Despite not knowing then that bees were important in agriculture as pollinators, this entomological endeavour led to high yields in the crops that were cultivated near his beehives. Coming from Zambia, a malaria-endemic country, Moses has long been fascinated with the major malaria vectors such as *Anopheles gambiae*, *Anopheles funestus*, and *Anopheles arabiensis*. He believes that entomologists play a critical role in ensuring that vector-borne diseases can be eradicated, and this has led him towards training in mosquito gene drive technologies.

Currently, Moses works as a teacher in the Zambian Ministry of Education and as a committee member of the Zambia Association of Science Educators at regional level, where his responsibilities include developing strategies for annual meetings.

TRUSTEE

Professor Seirian Sumner FRES

Seirian is a Professor of Behavioural Ecology at UCL, with over 20 years of research experience in entomology, specifically on social insects, but with a particular fondness for wasps of all kinds. She has admired the work of the RES since her PhD days and was thrilled to become a Fellow in 2019. As a trustee of the RES Seirian will help to develop areas of impact, including outreach, with a special focus on promoting equality and diversity within the Society. The work that the RES does in widening participation of the public's engagement with entomology aligns with her own interests and expertise. She is committed to bringing entomology to a wider audience; examples include the citizen science project 'Big Wasp Survey' which she co-founded in 2017 with Prof. Adam Hart. This now runs as an annual event with the support of RES and is engaging and training over 1,500 citizens in entomology across the UK every year.

Seirian's research has also directly addressed public perceptions of insects; e.g. her 2018 paper on 'Why we love bees and hate wasps' published in *Ecological Entomology*. More broadly, her outreach work has also focused on gender equality in science, as co-founder of the multi-award-winning science communication event 'Soapbox Science', which recently celebrated its 10th birthday and now runs in over 30 countries across the globe. Women are under-represented in entomology; working with the RES to change this will be one of Seirian's top priorities.

TRUSTEE

Dr Allan Watt Hon. FRES

Allan has been a Fellow of the RES for many years and his experience includes being an Editor-in-Chief of *Agricultural and Forest Entomology*, *Antenna* editor, conference organiser and two previous terms as a RES trustee. He was awarded Honorary Fellowship in 2015. He has seen the Society grow enormously since first becoming involved with the RES, but recognises it needs to grow further, both in terms of becoming the natural home for all entomologists and also in promoting insect science more effectively. He knows that the current President, trustees and staff are determined to implement the change required, and will contribute his experience through the current period of transition.

Allan is especially keen on promoting better links between the various Society activities, particularly the promotion of insect science through the journals, the Special Interest Groups and outreach activities. He would also like to assist with further development of online Society events, one of the notable successes of the last 18 months, bringing more entomologists into contact with each other, and to consider other new ways of supporting insect science.

Finally, Allan believes it is the role of the trustees to ensure that the RES becomes a more membership-focused Society and he is keen to help implement the many good ideas that will, for example, come out of the current Grand Challenges in Entomology project and the membership consultation.

Journals and Library

Editorial Board opportunities

The Editors-in-Chief of *Physiological Entomology*, a Royal Entomological Society journal, would like to recruit Associate Editors to help with the handling of submitted manuscripts. The primary role of an Associate Editor is to work with the Editors-in-Chief to oversee the review process of manuscripts that fit your areas of expertise. This is an exciting opportunity to gain experience in the publication process and to give back to the academic community by supporting a society journal.

We have vacancies in the areas of neurophysiology, thermal physiology, nutritional physiology, immunity and host–pathogen interactions, physiological pharmacology, endocrinology, homeostasis, and excretion but encourage anyone with the appropriate expertise in insect environmental adaptation to apply. Appointments are made for an initial one-year term, with the possibility to extend for further years. Experience in editing is not essential but applicants must have experience of publishing and reviewing academic papers. We particularly encourage early career researchers to consider this opportunity and are keen to attract a diverse range of candidates.

For further information please contact: Shin Goto, Editor. To apply please send a 2-page CV and statement of motivation to: shingoto@osaka-cu.ac.jp.

Meetings

ENTO'21

23rd – 27th August 2021 Online

Richard Harrington

Chair, Meetings Committee

To be, or not to be, that was the question

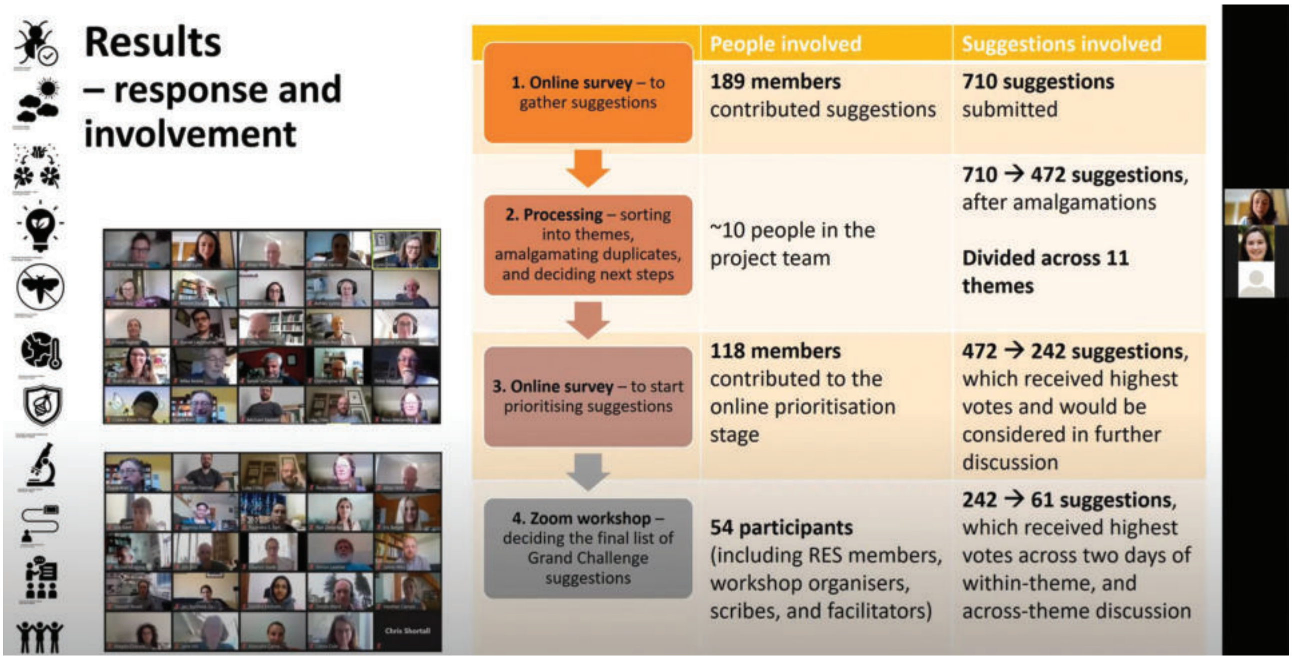
A decision on ENTO'21 had to be made at the Meetings Committee meeting in October 2020. Then, the Covid situation was dire and there was no sign of an end to the crisis. Having cancelled ENTO'20, we decided to go all-out to produce an excellent online ENTO'21. It was the right decision.

The plan

You can't please all of the people all of the time and, with the committee split down the middle, the decision was made to hold ENTO'21 towards the end of the school summer holidays rather than during the new term. The meeting would be held for a week, with a morning and afternoon session each day, each lasting about two hours. Ten session organisers would be sought, each finding a keynote speaker and four other invitees. Posters could be offered on any entomological topic. With nearly forty talks and fifty posters resulting, there isn't scope here to describe the science in any detail. For that, visit the website (https://www.royensoc.co.uk/event/ento22). Suffice it to say that the presentations were, without exception, excellent and described brand-new science and first-class syntheses. Instead, this article gives an overview and feel for what, we hope, was a one-off online-only ENTO.

A grand challenge

Putting together this meeting was clearly going to be a grand challenge and thus it seemed appropriate to base sessions around the emerging "grand challenges in entomology" initiative. Members had already been invited to fill in a questionnaire on this, and an initial analysis had been done, resulting in main themes being determined in time to inform



Determining the entomological grand challenges.

selection of session topics. The ten sessions and their organisers were as follows:

Session 1
Introduction to the posters and President's invited lecture
Dr Richard Harrington (RES)

Session 2
Grand challenges in entomology
Dr Luke Tilley (RES)

Session 3
Insect declines – the evidence and causes
Prof. Bill Kunin (U. Leeds)

Session 4
Insect declines – impacts and responses
Prof. Nick Isaac (UKCEH)

Session 5
Genomics in taxonomy and biodiversity
Amy Withers and Dr Phillip Donkersley (U. Lancaster)

Session 6
"Blue skies" entomology
Prof. Stuart Reynolds (U. Bath)

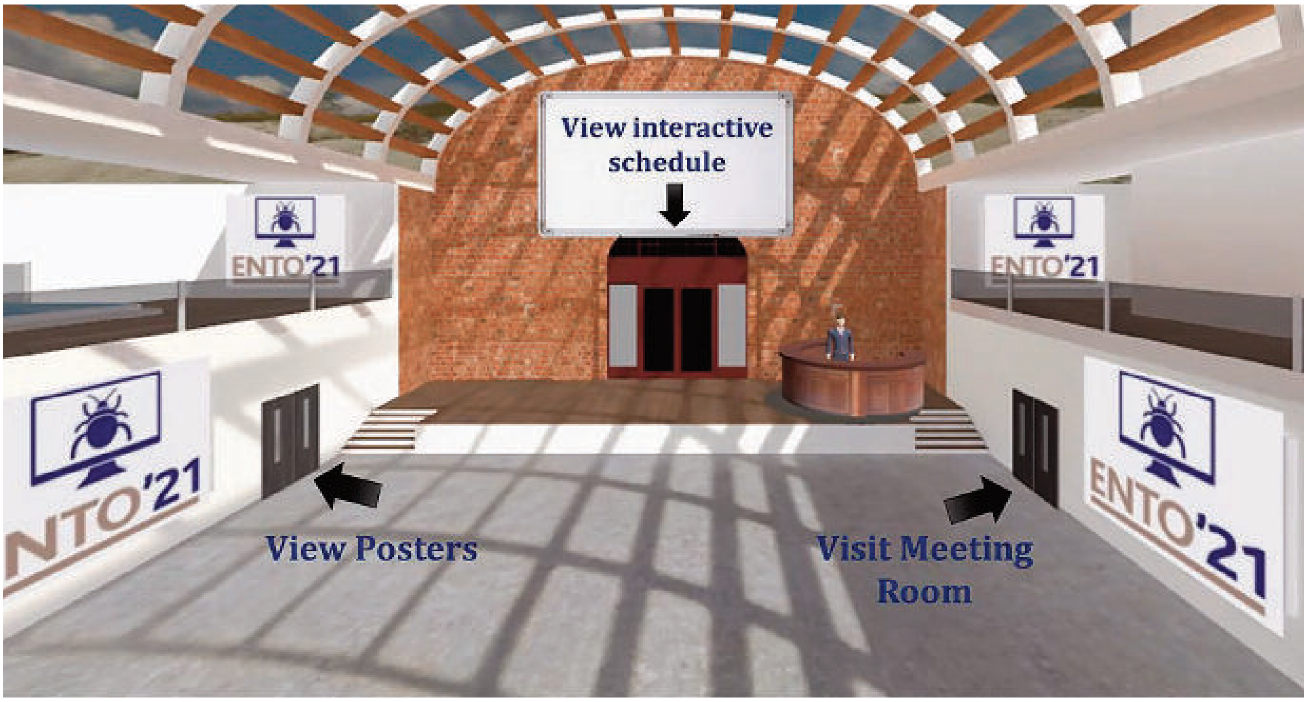
Session 7
Vectors of human and animal pathogens
Dr Marion England (The Pirbright Institute)

Session 8
Insects as inspiration for technology
Prof. Andreas Vilcinskas (JLU Giessen)

Session 9
Engaging diversely
Fran Sconce
and RES Outreach Committee

Session 10
Insecticide issues
Dr Ralf Nauen (Bayer)

Alex Ball NHM 3D Printed Models.



ENTO'21 virtual conference centre.

The ENTO platform

A bespoke platform was commissioned. This comprised a virtual conference centre with a smart foyer bedecked with the ENTO'21 logo, five poster rooms and break-out meeting rooms, together with access to the programme, abstracts and contact details of consenting presenters. Zoom links to each session were accessed via the platform.

The President's invited lecture

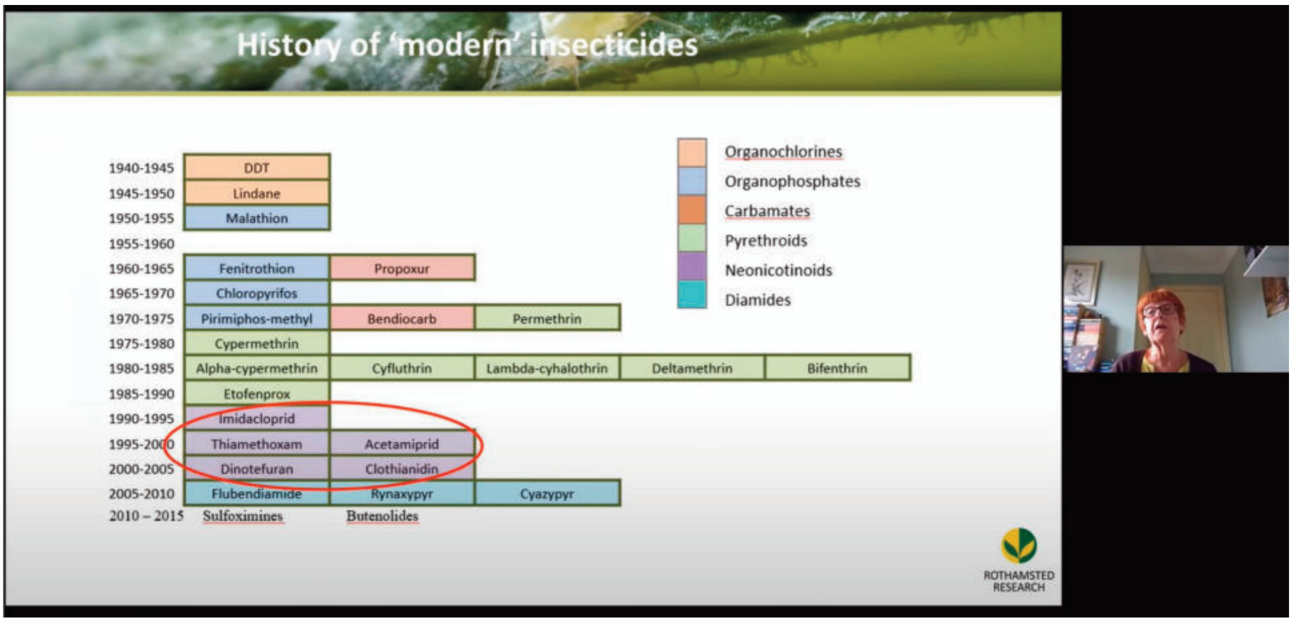
For the first time at ENTO, there was a President's invited lecture. The speaker was Professor Claire Kremen from the University of British Columbia, Canada. Claire is an Honorary Fellow of the Society and this year's winner of the RES Conservation Award for lifetime achievement for her highly influential work on the selection and design of protected areas, especially in high-diversity tropical ecosystems, and for transforming global perceptions on the crucial role of insects, particularly pollinators, in agriculture. Her lecture was titled "Mainstreaming insect conservation: are we nearly there yet?".

LGBTQ+ mixer

Another ENTO first was an LGBTQ+ mixer, attended by 18 delegates after Session 4 on the Tuesday.

Annual General Meeting

The AGM was held after Session 6 on the Wednesday afternoon and attended by 56 members, far more than have attended in the past at The Mansion House.



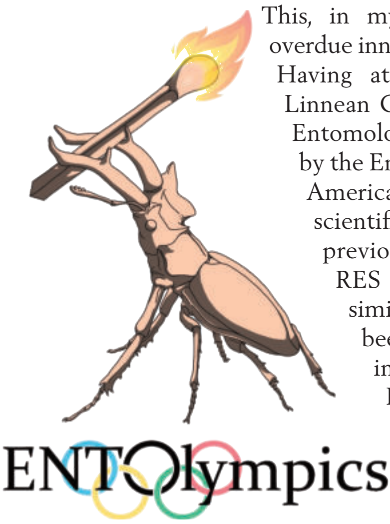
Lin Field History of 'modern' insecticides.


Faiz.


Ito.


Roro.

ENTOlympics



This, in my view, was a long-overdue innovation for the Society. Having attended some of the Linnean Games, now called the Entomology Games, organised by the Entomological Society of America at their annual scientific meeting, I have previously pushed for the RES to organise something similar, but support has been lacking. We are now in a different place and Dr Liam Crowley (University of Oxford) and Dr Manuela Carnaghi (Natural Resources Institute), both former RES student reps, enthusiastically embraced the idea and came up with an excellent competition for students and early-career entomologists. Fifteen teams participated, including the winners of this year's Entomology Games, Auburn University. They came second equal. The winners were PhasmAcari from the University of Brawijaya, Indonesia, comprising Faiz, Ito and Roro (pictured) and the other team in joint second place was Ent12, from Universitas Ahmad Dahlan, also in Indonesia. Each member of these teams received a prize.

Attendance

Around 450 registered for ENTO'21 and 318 of these logged into the conference platform and hence actively engaged. Individual sessions were attended by between 44 and 112 delegates, but several more listened to recordings of parts of the meeting, which were available to delegates on the conference platform for a month. Forty countries were represented. The international flavour of the meeting was evident from the outset during the inspiring one-minute poster pitches in the first session. The speaker line-up was diverse in terms of gender and nationality. One session, though, comprised five German men, thus contributing significantly to increased beta-diversity. The meeting was free to members and to student non-members. Others were charged £50 but offered free membership for a year. Hopefully they will stay with us thereafter.

Thanks

My grateful thanks to: co-convenor, Stuart Reynolds; RES staff, especially Luke and the remarkable Fran who ran the technology without more than the tiniest of hitches (and those few were all related to poor internet connections around the world); Liam and the ENTOlympics team; and all session organisers, presenters and their co-authors, especially those who got up at an unearthly hour.

ENTO'22

ENTO'22 is being organised by Dr Sheena Cotter and colleagues from the University of Lincoln. It will be held there from 13th to 15th September, but it will also be possible to join online. Whilst online attendance has its advantages in terms of not having to travel, being able to dip in and out, and being able to fidget, check emails and eat lunch undetected, I for one yearn for an in-person gathering with the opportunity for discussion and new contacts at the bar. Can't wait!

Profile

Eleanor Anne Ormerod (1828 – 1901): A forgotten entomological pioneer

Richard Harrington

Barely two miles from RES HQ, there is a plaque on the outside wall of Torrington House, 42 Holywell Hill, St Albans, celebrating the fact that Eleanor Anne Ormerod lived there from 1887 until her death in 1901. The plaque gives no indication as to why she deserves such recognition. Just down the road, in Harpenden, is arguably the most famous home of agricultural entomology in the world, now called Rothamsted Research. I worked at Rothamsted for the whole of my career and only vaguely knew of this woman. Ask most entomologists there, and they've never even heard of her. And yet she pretty much founded their science. She's not the Rosalind Franklin of entomology, though, for she received many accolades in her lifetime, but does seem to be unjustifiably forgotten by her successors.

The Royal Entomological Society is aiming to do something about that. Eleanor was, after all, a Fellow of our Society, elected in 1878. A former Rothamsted Deputy Librarian, Maggie Johnston, alerted me to the poor condition of her gravestone in Hatfield Road Cemetery, St Albans. RES Council agreed that its restoration would be a worthy cause, and would highlight the role of women in entomology. Buried beside her, and commemorated on the same stone, is one of her elder sisters, Georgiana Elizabeth (1825–1896), who was a renowned scientific illustrator and also a Fellow of our Society, elected in 1880 (https://www.invaluable.com/artist/ormerod-georgiana-elizabeth-920m1pky6h/). After following prescribed procedures, the work was originally planned for completion at the end of 2020, but regrettably the stonemasons sourced to undertake the restoration of the memorial were unable to deliver due to the intricate nature of the work required. The RES is still looking for a replacement stonemason, and would warmly welcome any suggestions from the *Antenna* readership. These can be sent to me in the first instance (richard@royensoc.co.uk).

Eleanor was born at her wealthy parents' newly-acquired estate, Sedbury Park in Gloucestershire, their tenth and last child. Her father, George, was a Fellow of the Royal Society – not, it seems, for scientific endeavours but rather for his work on the history of Cheshire (and, perhaps, for his standing in society). Eleanor was home-taught by her mother, Sarah, and had an interest in insects from childhood. She later became an authority on the local agriculture and from 1868 combined the two through her contribution to a collection of insect pests being compiled by the Royal Horticultural Society, winning the Society's Flora Medal for her trouble. She can be credited with establishing what was probably the first entomological 'citizen science' project, following the publication of a pamphlet called *Notes for Observations on Injurious Insects*. This she distributed to several volunteers who sent in their observations, from which

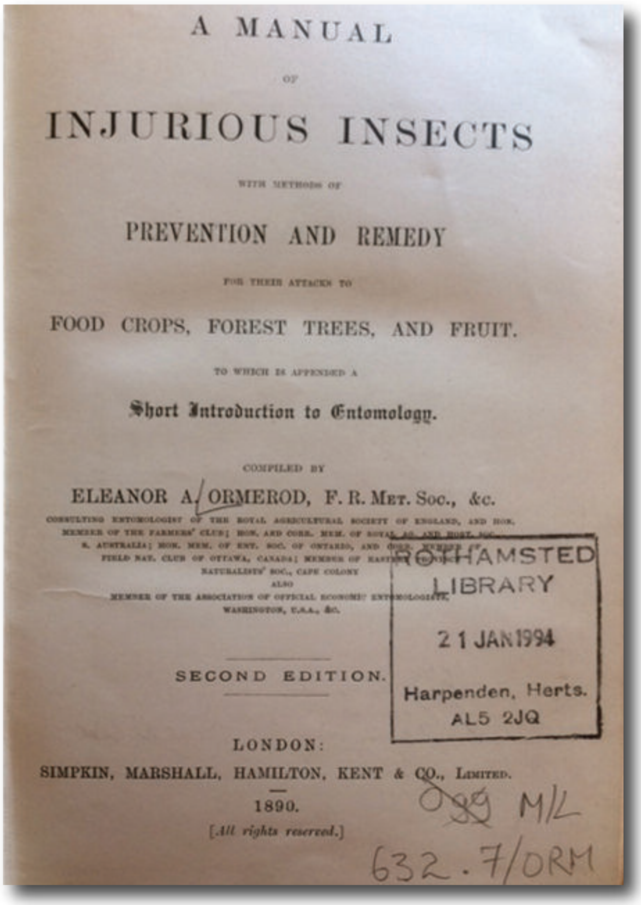
The plaque at Torrington House, St Albans.

Eleanor Ormerod's grave in need of restoration.

she compiled annual reports on agricultural pests. She became a consulting entomologist to the Royal Agricultural Society, and a lecturer at the Royal Agricultural College in Cirencester. Being of the landed gentry, she didn't need to earn a living and was never paid for her endeavours.

Her mentor was John Obadiah Westwood (1805–1893), a founder member of the Society and its President from 1852 to 1853, after whom our Westwood Medal for taxonomic work is named. He was made honorary Life President from 1883 until 1893. Eleanor described him as "the prince of entomologists" and he was somebody from whom she was happy to take constructive criticism. He was, though, staunchly anti-Darwinist and it seems that Eleanor also took this view. On recommending a book on injurious insects to a correspondent, she said "This is a grand book, but I would not put it in my students' hands without a strong observation that I consider Darwinianism (*sic*), &c., of this nature perfectly unproved and baseless". This was in 1889, a full thirty years after the publication of *On the Origin of Species*. It's easy to criticise her now, but can we truly be sure which side of the argument we'd have been on had we lived then?

Eleanor's own work was not without controversy. For example, she was an advocate of the use of Paris green (Copper (II) acetate triarsenite) as an insecticide, although it is highly toxic to most insects, including beneficials, and to mammals, including humans. However, she also advocated environmentally-friendly methods of control which laid the basis for integrated pest management. Controversially, she called for the extermination of house sparrows, which she termed "feathered robbers" and "avian rats" as they were pests of grains and fruits. She said in a letter to W. B. Tegetmeier (1816–1912), who was preparing a book on the house sparrow, "I quite reckon on being violently attacked, but it did me no harm before to be threatened to be shot at, also hanged in effigy, and other little attentions. Still, it was disagreeable!". I was rather amused by her dismissal of


A MANUAL

OF

INJURIOUS INSECTS

WITH METHODS OF

PREVENTION AND REMEDY

FOR THEIR ATTACKS TO

FOOD CROPS, FOREST TREES, AND FRUIT.

TO WHICH IS APPENDED A

Short Introduction to Entomology.

COMPILED BY

ELEANOR A. ORMEROD, F. R. MET. SOC., &c.

CONSULTING ENTOMOLOGIST OF THE ROYAL AGRICULTURAL SOCIETY OF ENGLAND, AND HON. MEMBER OF THE FARMERS' CLUB; HON. AND CORR. MEM. OF ROYAL AG. AND HORT. SOC. S. AUSTRALIA; HON. MEM. OF ENT. SOC. OF ONTARIO, AND CORR. MEMBER OF FIELD NAT. CLUB OF OTTAWA, CANADA; MEMBER OF EASTERN PROVINCE NATURALISTS' SOC., CAPE COLONY

ALSO

MEMBER OF THE ASSOCIATION OF OFFICIAL ECONOMIC ENTOMOLOGISTS, WASHINGTON, U.S.A., &c.

SECOND EDITION.

LONDON:

SIMPKIN, MARSHALL, HAMILTON, KENT & CO., LIMITED.

1890.

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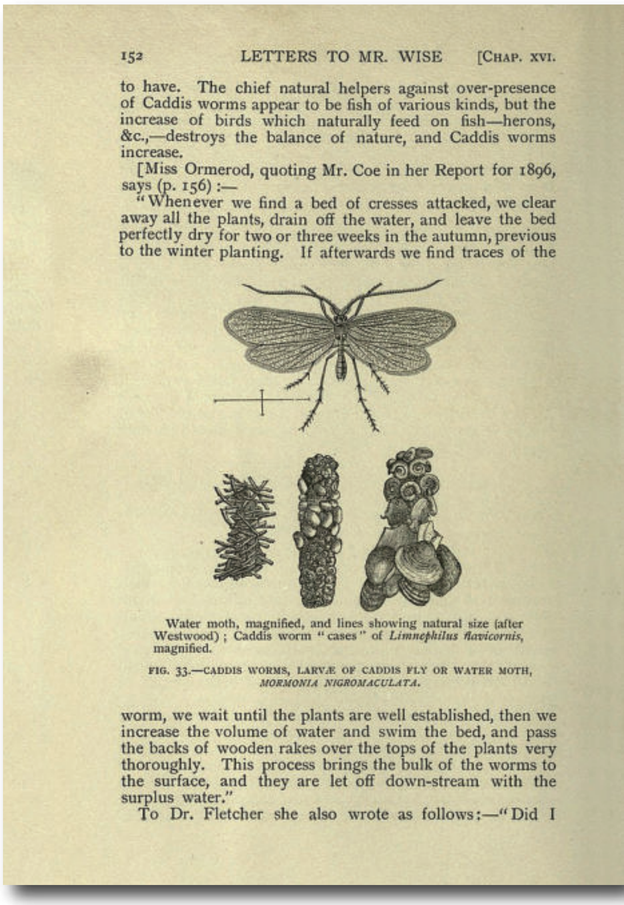

152 LETTERS TO MR. WISE [CHAP. XVI.

to have. The chief natural helpers against over-presence of Caddis worms appear to be fish of various kinds, but the increase of birds which naturally feed on fish—herons, &c.,—destroys the balance of nature, and Caddis worms increase.

[Miss Ormerod, quoting Mr. Coe in her Report for 1896, says (p. 156):—

"Whenever we find a bed of cresses attacked, we clear away all the plants, drain off the water, and leave the bed perfectly dry for two or three weeks in the autumn, previous to the winter planting. If afterwards we find traces of the

Water moth, magnified, and lines showing natural size (after Westwood); Caddis worm "cases" of *Limnephilus flavicornis*, magnified.

FIG. 33.—CADDIS WORMS, LARVÆ OF CADDIS FLY OR WATER MOTH, *MORMONIA NIGROMACULATA.*

worm, we wait until the plants are well established, then we increase the volume of water and swim the bed, and pass the backs of wooden rakes over the tops of the plants very thoroughly. This process brings the bulk of the worms to the surface, and they are let off down-stream with the surplus water."

To Dr. Fletcher she also wrote as follows:—"Did I

concerns that the tree sparrow might accidentally be targeted: "The tree sparrow……is readily distinguished by its smaller size, being only 5½ instead of 6 inches in length….". She was eventually persuaded that extermination of sparrows could have unforeseen ecological implications and relented.

She was feted all over the world for her contributions to agricultural entomology and other areas of natural history, winning prestigious awards in France, Russia and South Africa. One of her final honours was unique – she was the first woman to be awarded an honorary doctorate (LL.D) at The University of Edinburgh, where her portrait still hangs, and where their cloud computer service is named "Eleanor" after her (https://www.digitalresearchservices.ed.ac.uk/resources/eleanor). She was also the first woman to be made a Fellow of the Royal Meteorological Society, having collated a journal of weather records and notes on the relationships between weather and plant life.

Eleanor never married. Her death, 120 years ago on 19th July, was reported in many national and local papers. I particularly like the account in the *Pall Mall Gazette*, which states that "In her, the Entomological Society has lost one of its leading lights, the agriculturalist his standing counsel, and the criminous grub its most uncompromising and scientific exterminatrix". In spite of her achievements and her fame, her funeral was apparently "plain and unpretentious", characteristics which matched her own. The *Herts Advertiser* of 27th July 1901 said that she "never allowed the honours which were freely showered upon her to spoil the gentleness and unselfishness of her disposition".

Eleanor's autobiography was published by Elibron Classics in 2005 as an unabridged facsimile of the edition published in 1904 by John Murray, London, called "Eleanor Ormerod LL.D. Economic Entomologist. Autobiography and Correspondence". The correspondence reinforces the newspaper obituaries in showing her to be a truly generous and modest person. It also reveals the very wide range of insect and other invertebrate pests about which she was knowledgeable and able to advise on.

Some of Eleanor Ormerod's publications

The Cobham Journals. Abstracts and summaries of meteorological and phenological observations made by Miss Caroline Molesworth, at Cobham, Surrey, in the years 1825 to 1850.

Report of observations of attack of turnip fly in 1881 (1882)

Manual of injurious insects with methods of prevention and remedy for their attacks to food crops, forest trees and fruit: to which is appended a short introduction to entomology (1890)

Paris-green (or Emerald-green): its uses, and methods for its application, as a means of destruction of orchard moth caterpillars (1891)

A textbook of agricultural entomology (1892) (This book has been replicated in paperback in 2015)

Handbook of insects injurious to orchards and bush fruits with means of prevention and remedy (1898)

Flies injurious to stock: being life-histories and means of prevention of a few kinds commonly injurious, with special observations on ox warble or bot fly (1900)

SCHEDULE OF NEW FELLOWS AND MEMBERS

as at 6th October 2021

New Fellows (1st Announcement)
Prof. Shashi Bhushan Vemuri
Dr Radhika Venkatesan
Dr Catherine Matilda (Tilly) Collins
Dr Vootla Shyam Kumar

New Fellows (2nd Announcement and Election)
Dr Trevor John Hawkeswood
Dr Arran James Folly

Upgrade to Fellowship (1st Announcement)
Dr Ramasamy Srinivasan

New Members Admitted
Mr Andrew Tillson-Willis
Dr Jason Sumner-Kalkun
Miss Jennifer Newton
Dr Deepa Senapathi
Dr Kieran Khamis
Mr Kaide Andrew Macaulay
Mrs Anna Sobieraj-Betlińska
Dr Maria Martinez Castillero
Dr Lucyna Twerd
Mr Moses Musonda
Dr Matthew William Bulbert
Dr Sarah Helen Luke
Dr Wilson John Wall
Dr Maurizio Francesco Brivio
Dr Judy England
Dr Daniel Schlaepi
Dr Coline Jaworski
Dr Matt Tinsley
Dr Rosie Mangan
Dr Gary Powney

New Student Members Admitted
Mr Gaurav Singh
Mr Sunny Maanju
Mr Luis Miguel Quinzo-Ortega
Miss Louise-Ellen Sinnock
Mr Dawid Martyniuk
Mr Robin Hutchinson
Mr Adam James Roberts
Ms Aisling Moffat
Miss Alixandra Nicole Prybyla
Ms Jasmine Mae Morgan
Mrs Zoë Langlands
Mr Sachin Bhardwaj Lock
Mr Ross Peter George

Re-Instatements to Membership
Dr Andres Arce

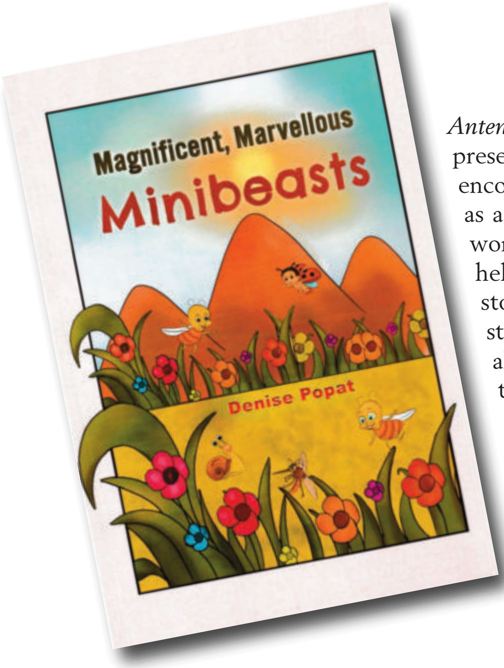
Deaths
Prof. Simon Robert Leather Hon. FRES, 1978, UK
Dr Clive Arthur Edwards, 1955, USA
Dr Frederic Christian Thompson, 1978, USA
Dr Robert Barrass, 1957, UK
Mr Colin Johnson, 1962, UK
Prof. Frederick Douglas Bennett, 1999, UK
Prof. Rolf Garms, 1987, Germany (notified 11.10.2021)
Mr Douglas Boyes, 2018, UK (notified 12.10.2021)
Mr Jeremy Jones, 1987, Isle of Man (notified 22.10.2021)

Reviews

Magnificent, Marvellous Minibeasts

Denise Popat

Published by Austin Macauley Publishers
ISBN 978-1-398-40164-8
£9.99



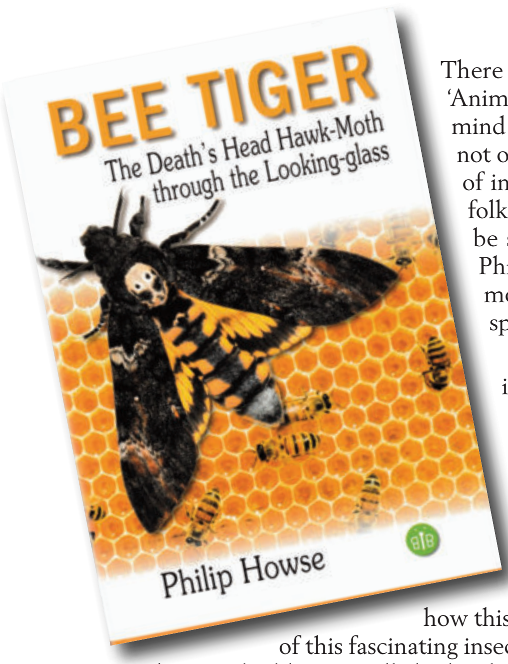
Antenna has reviewed a number of insect-based stories for children, all of which have presented a narrative that informed the reader of the important role that insects play and encouraged an appreciation of them. This book is slightly different, as it uses minibeasts as a vehicle to introduce children to a broader appreciation and understanding of the world around them. Designed to stimulate the senses, the stories have been written to help teachers of children with special needs, but while this was their initial focus these stories will stimulate any child that hears them. Each offers opportunities for the storyteller to involve the children in experiencing various elements of the story and also to physically take part in the action. The stories have threads of compassion and the importance of helping others running through them. The biology within these stories is sometimes a little hazy, but the overall effect is to encourage an appreciation of the natural world in general, and minibeasts in particular. For anyone with a theatrical leaning these stories offer a platform to vamp them up and generate real excitement. At a time when changing public attitudes to the natural world are vital, this book has a serious part to play.

Peter Smithers

Bee Tiger. The Death's Head Hawk-moth through the Looking-glass

Philip Howse

Published by Brambleby Books
ISBN 978-1-908-24162-7
£13.99



There are many books which take a detailed look at a particular group of insects; the 'Animal' series from Reaktion Books, with titles such as '*Beetle*', '*Wasp*' and '*Fly*', spring to mind as examples. Such titles give the opportunity for an author to examine that group not only from the ecological or taxonomic standpoint, but also to consider how that group of insects has become integrated into human society, perhaps through art, literature or folklore. However, there are probably few instances when a single species of insect can be said to be so iconic that it can form the basis for such an in-depth investigation. Philip Howse's *Bee Tiger* does just that by focussing upon the Death's Head Hawk-moth *Acherontia atropos* (although he does also reference the other two closely related species found in Asia).

To British entomologists the Death's Head Hawk-moth holds a special place given its size (often given the accolade of our largest moth), its striking yellow banding, its ability to squeak, its propensity to raid bee hives for honey and its rarity as a migrant (although, as its larva eats potato it tantalisingly could potentially turn up on your allotment at any time). What makes it doubly special is the marking on its thorax which gives it that haunting name, the apparent image of a human skull and cross-bones, and it is this which has tipped it over into an insect with a place in human culture.

In this comprehensive discourse on the moth, Howse sets about examining how this species has come to be associated with the macabre, but also looks at the life history of this fascinating insect. The Death's Head larva has specialised on feeding on members of the Solanaceae, tolerating highly toxic alkaloids which it can then use for its own defence and that toxicity advertised through yellow colouration in both larva and adult. He reveals that the short stout proboscis of the adult moth is just the right length to reach the bottom of a comb cell in a bee-hive, enabling it to gorge on honey. Did you know that the adult moth is coated in a fatty acid mixture enabling it to absorb the chemical signature of the bees from the hive it attacks and hence avoiding detection? Howse discusses how the evolutionary pressures from bird and bat predators have combined to influence the appearance and behaviour of the species we see today. Have you ever spotted a resemblance to a bird when the wings of the moth are closed?

Perhaps the biggest revelation though, is about that skull marking. We are so used to looking at insect specimens, photographed or illustrated as though pinned for a collection that we may forget to look more closely at the living insect. From a bird's-eye view, looking head-on to a moth as it might be encountered at rest, that 'skull' image combines with the half exposed yellow hind wings and abdomen to transform the moth into a giant hornet, not something any predator wishes to mess with.

If you thought you knew this moth before, I am sure you will find something surprising to you in this book. For example, one of the iconic references to the Death's Head is that of its appearance in the book and subsequent film *Silence of the Lambs*. The action in that book takes place in North America (where none of the three species are established) and where the species actually referred to in the book is *Acherontia styx*. To complicate matters further, the iconic poster image for the film version is of *A. atropos*, but with the skull markings replaced by a miniature version of Salvador Dali's image of a skull made up, when you look closely, from seven nudes – his work entitled *In Voluptas Mors*.

Quirky facts like this add to the appeal of this wide-ranging book. In summary, this is a splendid if fairly light read, well worth the modest cost. If I have one criticism it is that sometimes the digressions to provide appropriate context to a point are a little too long and are aimed at the reader with very little prior biological knowledge. The latter, however, is a minor personal gripe which does not deter me in the least from advising you to read this book for your pleasure, enjoyment and interest.

Ray Barnett

Having read this book, I could not help adding a short note of my own to Ray's review. This is Philip Howse at his best, an authoritative overview of the cultural references to this iconic moth. It is a journey through our myths and legends, music and literature, a cultural cocktail that is generously laced with some intriguing biology. *Bee Tiger* presents a cultural autecology that teases apart our anthropocentric perspective of this moth and juxtaposes it with detailed accounts of its entomology.

Peter Smithers

Rebugging the Planet

Vicki Hird

Published by Chelsea Green Publishing
ISBN 978-1-645-02018-9
£12.99

This is a heartfelt plea from Vicki Hird to change the way we interact with the natural world, but it is a plea with a difference, one that presents its arguments via the lens of globally declining invertebrate populations. It is a manifesto for a green revolution aimed at the layman, a tool kit to enable individuals to make changes to the way that they live, and offers advice on how to put pressure on various layers of society, from friends and neighbours to local politicians and national government, in order to bring about a greener, more diverse world.

The book begins by examining the global decline in invertebrate populations and discusses some of the causes. It also looks at human attitudes to invertebrates, asking why they are negative and how we can alter them. Subsequent chapters explain all the good things that invertebrates contribute to the biosphere, then offer an outline of the aims and practices of rewilding before examining the role that parks and other community open spaces can play in promoting local biodiversity. In chapter 5, Vicki addresses the big issues of our day: climate change; soil degradation; chemical, plastic, light, and noise pollution; and the impact of invasive species. The next chapter explores food production and consumption, examining the impacts of intensive farming, the pressures exerted by supermarkets and other elements of the food supply chain and the role that the consumer has via their choices in moving food production and supply towards sustainability. The following chapter delves into the world of politics, an arena that Vicki knows well from her work as a campaigner and lobbyist. Here she asks who it is that holds the power to make the changes that are required. Agrochemical companies promote their products, dominating the way food is produced while large multinationals monopolise the food markets. Can governments alter the balance of power to implement a greener agenda? Poverty and inequality are also identified as key drivers of biodiversity loss and the degradation of natural systems. The penultimate chapter offers a view of the world as it could be if many of the ideas in the book were implemented. The final chapter, "*You don't have to rebug alone*", offers advice on how to lobby and an extensive list of resources and organisations that can help and support individuals to initiate change.

Throughout the book, key ideas are referenced to a 'Notes' section at the rear of the volume. Following chapters 3 to 7 are boxes that offer suggested actions that can implement the ideas covered in the chapter. These range from simple changes in attitude to the organisation of more interventionist actions. Also scattered among the text are other boxes that offer an insight into the incredible world of insect biology. These fascinating glimpses of invertebrate behaviour and ingenuity provide a counterpoint that can alter attitudes and persuade readers that invertebrates have their own discreet charm.

Vicki is not alone in making this call for change, but she is unique in her down-to-earth approach, and in offering the wide range of suggested actions from simple changes in lifestyle and consumer choices to becoming an activist, all of which can be undertaken by anyone who wants to make a difference. '*Rebugging the Planet*' is an introduction to the complexities of the multiple crises that we currently face. It is an introduction that should spur a new generation into action to build a better world and will enable its readers to appreciate the invertebrates that surround them for what they are, not just what they do for us. It's an appreciation that will alter their life choices and move them towards a greener, more biodiverse, future. '*Rebugging the Planet*' is a book for everyone, a manual for change that will be driven by concerned citizens.

Peter Smithers

Butterfly Valley

Inger Christensen, translated from the original Danish by David Broadbridge

Privately published and available in a signed and numbered limited edition of 100 copies.

No ISBN

Copies can be purchased for £10.00 inc. P&P from davidbroadbridge@hotmail.co.uk

This series of poems was first published in 1991 by the late Inger Christensen (1935-2009), an eminent and accomplished Danish poet, novelist, playwright and essayist. I am rather in awe of translation; not a question of simple translation of words using Google, but the surely daunting task requiring intimate knowledge of two languages in addition to a sensitivity and feel for the work the translator undertakes. A translation can be crude or sophisticated – and there is no definitive answer. For example, Clive James's 2013 translation of Dante, where the beginning of canto 3, at the gates of Hell, the declaration widely known for many years as "Abandon all hope, you who enter here", is freshly translated as "Forget your hopes. They were what brought you here". Scholarly, but with a flash of Clive James!

David Broadbridge's work allows no such luxury of a generous interpretation, although he has the advantage of it being a good deal shorter than the Divine Comedy. It is the structure that makes it more confined. These verses are not limericks, or doggerel, but sonnets of exceptional quality requiring sensitivity in translation as well as linguistic competence. As Broadbridge himself declares in the short introduction, quoting Seamus Heaney: "… 'It is one thing to find lexical meanings for the words and to have some feel for how the metre might go, but it is quite another thing to find the tuning-fork that will give you the note and pitch for the overall music of the work'. With this in mind, my translation is an attempt at impersonation – to make Inger Christensen sound like herself in English.".

Each sonnet has a formal rhyming structure, slightly fluid in places, but the additional challenge for Christensen – and more so for her translator – is that the last line of each is the first line of the next, until the final sonnet which, astonishingly, comprises the first line of each of the previous 14 sonnets, in sequence. The whole is not a gimmick. It is a thoughtful, restful and inspiring series of beautifully constructed poems. Clever too. Certainly clever. The names of numerous butterflies and some moths do appear in these lines, but they are in some way peripheral, serving to introduce and to illustrate deeper issues … of summer, of beauty, of humanity.

There is an issue with the pages; printed on high grade card, they come away from the binding at the slightest excuse – actually, I didn't mind; it made looking at one page at a time very easy. Without any knowledge of the original, or of the Danish language, there is nothing for most readers (including me) to compare it with. But as a poetic work, with an inkling of how very difficult this must have been, I looked for flaws in the content, for weakness, and felt ashamed. Inger Christensen has the credit for her original work, but I suspect David Broadbridge's beautifully crafted translation has done her justice. Perfection is an elusive goal, but I have a curious feeling that this might come close. To a lover of poetry, and to a Lepidopterist, this is a treat.

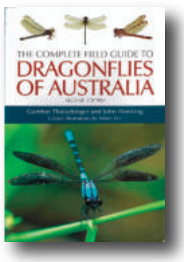
They are rising up, the earth's butterflies
pigments from the warm body of the ground,
cinnabar, ochre, phosphor, gold, they rise
a swarm of basic elements abound.

John Tennent

The following reviews and those above have been added to the *Antenna* website: *www.royensoc.co.uk/publications/reviews*

Britain's Insects: A field guide to the insects of Great Britain and Ireland

Paul Brock



The Complete Field Guide to Dragonflies of Australia – Second Edition

Günther Theischinger, John Hawking & Albert Orr

Diary

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

Offers to convene meetings on an entomological topic are very welcome and can be discussed with the Chair of the Meetings Committee.

MEETINGS OF THE ROYAL ENTOMOLOGICAL SOCIETY

Student Forum 2022 (hybrid)
17-19 February, 2022

2022 Verrall Lecture
2 March, 2022

Insects as Food & Feed (IAFF) Special Interest Group conference (hybrid)
26-27 April, 2022

Insect Week 2022
20-26 June, 2022

Pollinators in Agriculture meeting.
Pollination Special Interest Group in collaboration with the AAB & BES
6-8 September, 2022

ENTO'22
13-15 September, 2022

Orthoptera Special Interest Group
2 November, 2022

NON-SOCIETY MEETINGS

European Congress on Orthoptera Conservation (ECOC) III
1-2 April, 2022

XXVI International Congress of Entomology (ICE)
17-22 July, 2022

XII European Congress of Entomology (ECE)
16-20 October, 2023

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

RES STUDENT AWARD 2021

Write an entomological article and WIN!

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

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

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

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

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

ENTRIES
You can send electronically via e-mail to info@royensoc.co.uk

For further information telephone 01727 899387

Please include:

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

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

CLOSING DATE
The closing date for entries is 31 December 2021. The winner will be announced in the Spring 2022 edition of *Antenna* and on our website.

ROYAL ENTOMOLOGICAL SOCIETY - FOUNDED 1833 -

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