Antenna

Volume 46(3) | 2022

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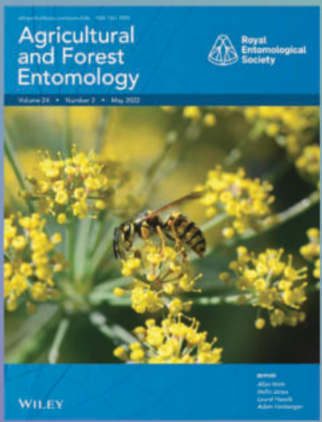

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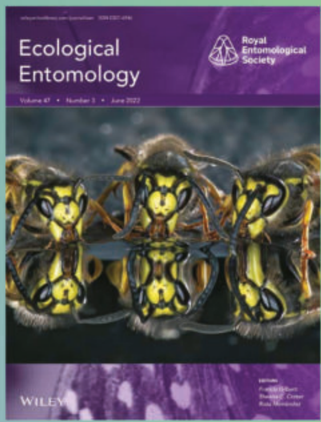

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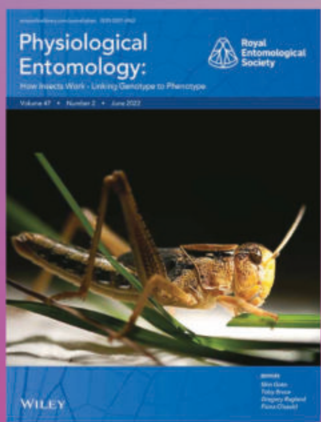

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Submissions are made by email to *antenna@royensoc.co.uk* and reviewed by *Antenna's* editorial team. There are no page charges for publication in *Antenna*, where we encourage use of full colour figures and photographs to accompany text. Standard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

Cover Picture: Carder Bee in Cornwall, UK by Jamie Spensley (age 17).

Editorial

We've been privileged to edit this issue of *Antenna* – under the watchful guidance of Richard Harrington, of course!

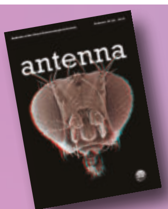
The first article, by Stuart Reynolds, left us buzzing – who knew that insects could accumulate electric charge, and that this is significant for pollination? Stuart continues to contribute a huge amount of time and experience to *Antenna* through the Research Spotlight series, and has further contributions planned. However, he will be looking out for new Spotlight contributors towards the end of this year, so do please get in touch if you have ideas for this series of articles.

This issue is not restricted to contemporary breakthrough research. Hisham El-Hennawy looks back some three and a half millennia to review what is known about the insect species found in the antechamber of the tomb of Tutankhamun. Slightly more recently (well, in the late 18th and early 19th century) Ian Hodkinson describes the contributions to experimental biology of the remarkable blind philosopher, polymath and experimental entomologist John Gough, and Peter Sutton explains how a hitchhiking bivalve on a Great Diving Beetle helped Charles Darwin to plug a gap in his theory of evolution by natural selection. In his continuing interview series, Peter Smithers talks to well-known leading entomologist and former RES President Jeremy Thomas. We also report on two RES meetings and on a wide range of RES awards, including the excellent winning essays for the ever-popular student competition.

The *Antenna* editorial team has been growing like Topsy. You will know from our previous issue that Tom Pope worked with Professor Simon Leather at Harper Adams University. Dafydd Lewis is an amateur entomologist who first picked up a net and breeding cage (or it may have been a jam jar) over 60 years ago. Since the last issue we have also been able to welcome Benjamin Chanda from Zambia, Sajidha Mohammed from Southern India and Josh Jenkins Shaw from Denmark as Associate Editors, which makes our potential global coverage extensive, as it now also includes other parts of Africa (Moses Musonda), Chile and South American countries (Patrick Vyvyan), Ireland (Louise McNamara), Malta (Kimberly Gauchi), Norway (Jes Bartlett) as well as the areas covered by the Associate Editors based in the British Isles. If you would like to represent another part of the world on the *Antenna* team, please let us know!

We hope you enjoy reading this issue as much as we enjoyed putting it together.

Dafydd Lewis and Tom Pope



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Index and online copies

Index

All articles, correspondence, obituaries and meeting reports published in *Antenna* from 1977-1983 and from 2002 onwards are indexed and can be searched within the Library Catalogue, Heritage Cirqa, which can be accessed at http://heritage.royensoc.co.uk. Issues from 1984–2002 are currently being added to the catalogue. We will shortly be removing the need to login to the catalogue, but currently to access the catalogue, you will need to contact the librarian for log-in details (library@royensoc.co.uk). Once logged in, select the 'Advanced' option and select 'Antenna' from the 'Media type' box to search the indexed articles. To expand your search to other sources, change the media box to 'All Media'.

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Antenna

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Letter from the President

It's a great honour to be writing as the RES President, and I am slightly nervous of the challenge of following in Helen's footsteps, to continue driving forward the great work she has been leading. It's also exciting and a privilege that, for the first time in the Society's history, a woman president is handing over to another woman president. As someone who has spent a lot of time helping to make science more welcoming to women, such as through the Athena SWAN Charter for gender equality, I am proud to be part of a Society that has the promotion of equality, diversity and inclusivity as a key part of its new strategy.

I have been a Fellow of the Society since I was a PhD student, studying migration in Silver Y moths, and the role of environmental and genetic factors. Since then, my research has mainly stayed focused on Lepidoptera, examining the causes and consequences of climate change and habitat fragmentation. Our research has revealed how many UK butterflies are spreading northwards as the climate heats up, with slower shifts where natural habitats are more fragmented, as well as declines and local extinctions where the climate has become unsuitable for cool-loving species. I'm based at the University of York, and Yorkshire has experienced many arrivals of new species from the south, as well as losses. I've also had the privilege of working with colleagues in SE Asia, following in the footsteps of a previous RES President, Alfred Russel Wallace, and revealing how tropical butterflies and moths are responding to climate change and rainforest fragmentation.

There are concerns about how human-caused changes to the natural environment are affecting insects, and we are thinking about ways to make our green spaces better for insects. Calls for 'No Mow May' have led to more dialogue about the management of the places we live in, and how quickly insect diversity can increase when landscapes are managed for nature. At times when news about biodiversity can seem very bleak, it's good to know that the Society is supporting Daneway Banks nature reserve in Gloucestershire, where the Large Blue butterfly is now flourishing thanks to the successful work of another previous RES President, Jeremy Thomas, and colleagues. I encourage you to visit Daneway Banks if you have the chance, it's a fabulous place.

There are exciting times ahead for the Society, with its recently launched 3-year strategy to 'enrich the world with insect science', and its fabulous new logo. I look forward to the next two years, welcoming new Members and Fellows, and making sure current Members and Fellows are supported so that our Society thrives. I look forward to meeting many of you at Ento22 at the University of Lincoln in September.

Jane Hill
President
Royal Entomological Society

Large Blue butterfly at Daneway Banks.

Static electricity and insect pollinators

Image of flower and honeybee: Nicolas Guérin

RESEARCH SPOTLIGHT

> It has been known for more than sixty years that flying insects carry a static electric charge

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Insects, flowers and static electricity

It has been known for more than 60 years that flying insects carry a static electric charge (England *et al.*, 2021). Buff-tailed Bumblebees, *Bombus terrestris,* are the current insect champions when it comes to static electricity. Clarke *et al.* (2013) trained bees to fly into an apparatus that measured their static charge; on average, each of them had a charge of 32 pC (*i.e.*, 3.2 x 10^{-11} coulomb) (Fig. 1a). That doesn't sound like a lot, but as we shall see it's important to the bee.

Where does this electricity come from? When they fly through the air, insects become electrostatically charged in the same way as when two different insulating materials (like human hair and a plastic comb) are rubbed together. This poorly understood process is called triboelectric charging – it's the consequence of electrons moving from one material to another during close contact. When the material surfaces are separated again, not all the transferred electrons return to their original positions, leaving a residual imbalance. When a bumblebee flies, it may generate a net positive charge through frictional interactions with particles in the air; alternatively, different parts of its body may rub together, generating equal and opposite static charges; if negative static charges are more easily lost, this would also leave a positive charge.

Bumblebees probably bear larger static charges than other insects because of the large surface area of their thoracic cuticle with its dense coating of hairs (Fig. 1d). This 'fur' undoubtedly provides the thermal insulation that allows the bee to fly at low ambient temperatures (Heinrich, 1976), but perhaps it also functions to generate static electricity during flight through triboelectric charging. Further, as we'll see later, some of the thoracic hairs also have the function of detecting external static electric fields, and they do this much more effectively when they are themselves electrically charged.

It isn't only insects that bear a static charge. Many non-conducting objects in the aerial environment are statically charged: typical plant surfaces exhibit electric fields in the order of 100 V m^{-1}, with field strength reaching much higher values (up to 3 kV m^{-1}) close to 'pointed' structures such as the petals and reproductive structures of flowers, similar to that at ground level underneath a high voltage power line (Bowker *et al.*, 2007). The further from the ground is the flower, the higher its static electric potential relative to the air around it (England *et al.*, 2021).

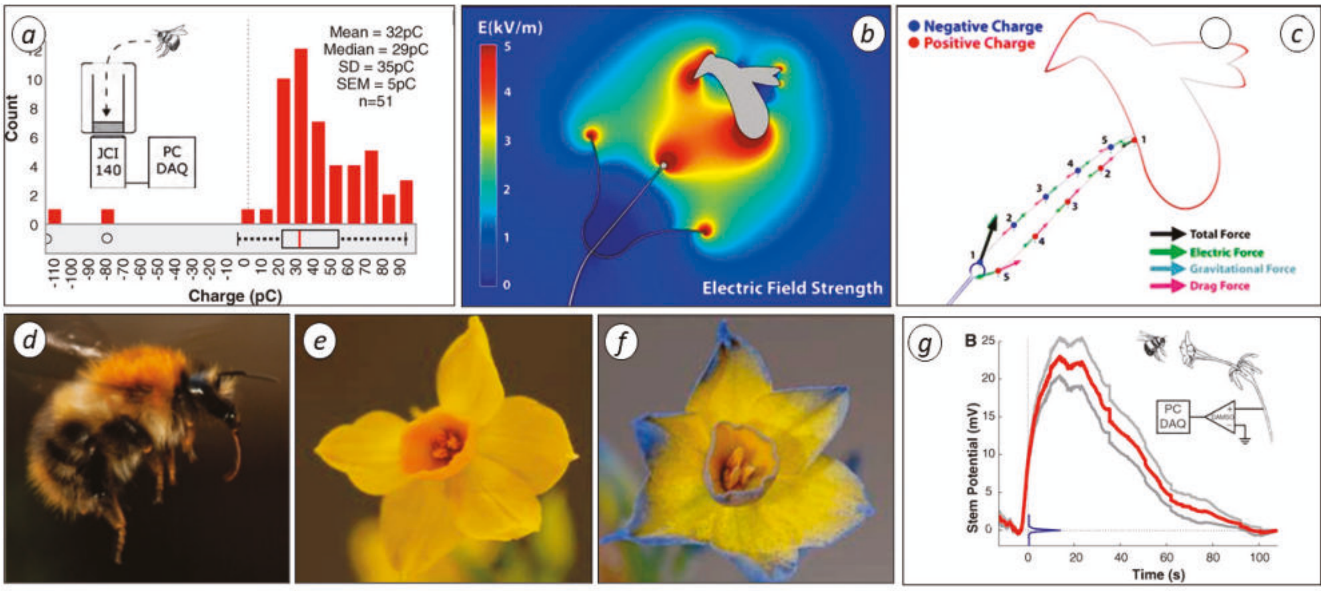

Fig. 1. ***a*** Determination of static electric charge on bumblebees. The insects were trained to fly into a cylinder with conducting walls (a Faraday pail) connected to an electrometer (JCI). Frequency of observations of different body charges is shown in the chart. ***b*** Finite-element modelled electrical field strength around a bumblebee as it approaches a flower similar to a *Petunia*. Morphologies of bee and flower are highly simplified. Colour scale at left indicates differing field strengths. ***c*** Visualisation of modelled trajectories followed by two pollen grains during transfer from bee to flower (*blue*) and flower to bee (*red*). Pollen grain colour indicates its charge (*red* positive, *blue* negative). *Green arrows* show electric force, cyan shows gravitational force, and magenta shows drag force. *Black arrows* show the total resultant force. Time is shown at 50 ms intervals from t = 0 (position 1) to t = 200 ms (position 5). Force arrows are drawn to scale. ***d*** A bumblebee (*Bombus pascuorum*) in flight. The dense covering of hairs on the bee's thorax may be responsible for the high density static electric charge borne by bumblebees. ***e*** Normal appearance a daffodil flower (*Narcissus pseudonarcissus*) and ***f*** with static electric field visualised by electrostatic dusting with a blue dye. Blue colour is localised at petal edges and also on reproductive structures within the flower. ***g*** Stereotyped 'flower marking' potential change recorded from *Petunia* flower stem resulting from bee landings (red, n = 51) ±1 SEM (grey). Natural variation in stem potential (n=35 samples of 30 s) in absence of bees, is shown in blue.
Image credits: ***a*** From Clarke *et al.* (2013), reproduced with permission. ***b***–***c***, ***e***–***f*** From Clarke *et al.* (2017), reproduced with permission; ***d*** photo by Sffubs: CC BY SA 3.0. ***c***–***g*** From Clarke *et al.* (2017), reproduced with permission.

Pollination systems

It turns out that static electric charges on bees and flowers are important in pollination. Most flowering plants are pollinated by insects, which mediate transfer of pollen (containing male gametes) from one flower to another in return for nutritional rewards provided by the plant, in the form of nectar and pollen. This mutualistic relationship has been central to the co-evolution of insects and plants ever since the origin of flowering plants about 275 Mya (Salomo *et al.,* 2017).

We now know that static electric charges on both flowers and insect pollinators play at least two different important roles in pollination. Firstly, the electrostatic field within a flower contributes directly to the movement of charged pollen grains from the flower's anthers to the insect, and *vice versa*. Secondly, pollinating insects appear to monitor the static electric charge on individual flowers as an indicator of the rewards they offer.

Static electricity and pollen transfer

The traditional view of pollen transfer is that it takes place simply through mechanical contact; in this view, a bungling bee visiting a flower to steal its nectar barges into the anthers and physically dislodges pollen grains located there. The released pollen then adheres to the bee simply because the grains are covered in sticky stuff, or because they have spikes; bee hairs also have complex branching shapes that retain pollen. Undoubtedly all these things happen. But once it was discovered that both flowers and flying pollinators bear a static charge, an obvious question was whether pollen might simply 'jump' across the air gap between anthers and insect under static electric attractive forces, without any physical contact. This might be advantageous to the insect by making the collection of nutritious pollen easy, and to the plant by enhancing transfer of dislodged pollen to the stigma of another plant's flower.

Experimental evidence supporting this electrostatic hypothesis of pollen transfer came from Corbet *et al.* (1982), who showed that a difference in electrical potential can indeed propel pollen grains across an air space of several mm between a flower of oilseed rape and an immobilised bumblebee, the distance being proportional to the square of the voltage difference. Realistic mathematical models (*e.g.,* Vaknin *et al.*, 2000; Clarke *et al.*, 2017) of the static electric field within and around a flower show that at key locations on both the bee and the flower, field strength reaches surprisingly high densities (up to 5 kV m^{-1}) (Fig. 1b). These models confirm that pollen grains can indeed be transferred from flower to bee and *vice versa* by the predicted electrostatic field, overcoming both gravity and viscous drag (Fig. 1c).

On this basis, it has been argued that the evolution of flower shapes has been constrained by the requirement for the flower to promote electrostatically-mediated pollen transfer (Armbruster, 2001; Vaknin *et al.,* 2001). It is a plausible claim that flower shape matters, because simple experiments show that the static electric charges borne on flowers of different shapes are localised in idiosyncratic ways. Clarke *et al.* (2017) dusted flowers with electrostatically-charged coloured powders; it can easily be seen in Fig. 1e–f that the dye is localised at petal edges and also on reproductive structures within the flower, indicating that these are

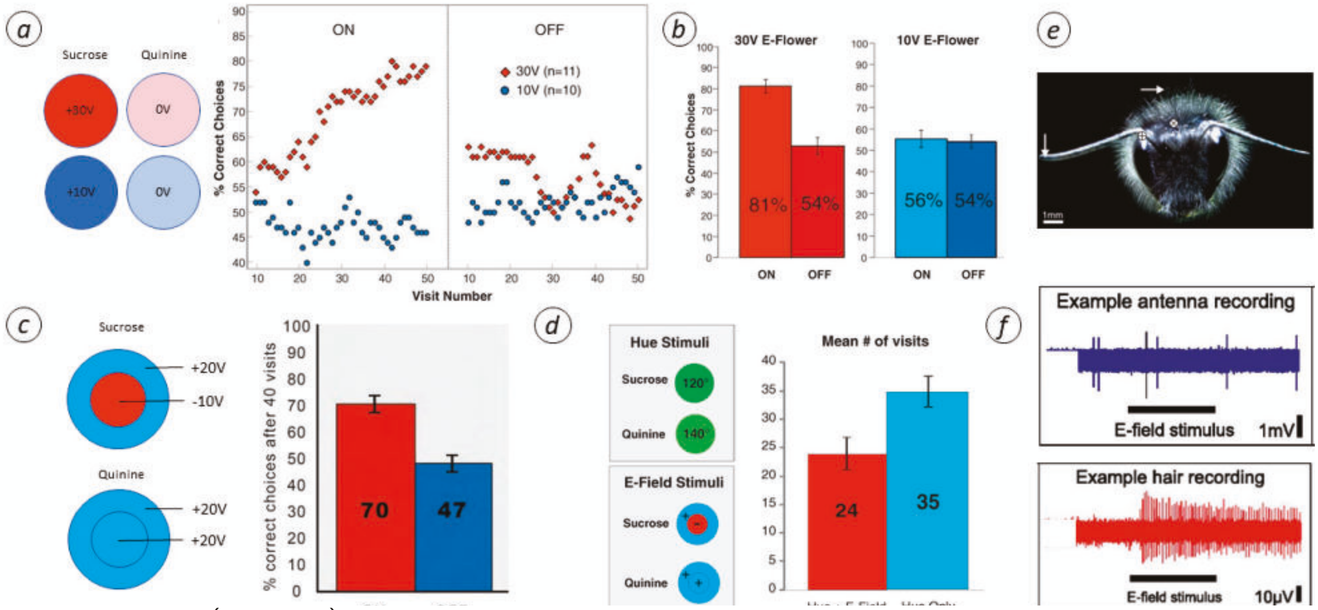

Fig. 2. ***a*** Bumblebees (*B. terrestris*) can be trained to distinguish artificial flowers bearing a static charge from those with no static charge by providing a sucrose reward in charged flowers and an aversive chemical (quinine) in uncharged flowers. Symbols at left indicate experimental design. Graph on right shows increase in correct choices with successive trials. Red symbols show successful learning when static charge was +30V; Blue symbols show failure to learn when static charge was +10V. (NB 50% correct choices indicates random choosing). Note that bees could no longer choose rewarding flowers when the electric potential was switched off. ***b*** bar chart shows percent correct choices in last 10 trials for +30V and +10V. ***c*** Bees can be trained to distinguish artificial flowers with different electric filed patterns. Diagrams show experimental design; artificial flowers were constructed to bear a uniform charge (+20V) over the whole flower, or a bullseye pattern with +20V in the surround and -10V in the centre. Bar chart at right shows % correct choices in trials 40–50. ***d*** Bees learn a colour distinction (2 different shades of green) quicker when paired with a static electric charge. Symbols on the left show hue (colour) and charge configurations of artificial flowers. Bar charts at right show number of trials needed for bees to reach criterion of 80% correct choices. ***e*** Frontal view of bumblebee (*B. terrestris*) head, to show locations of antennae and dorsal thoracic mechanosensory hairs. Circles indicate recording sites for (x) hairs and (+) antennae. Arrows show where laser Doppler vibrometry was used to measure antennal and thoracic hair displacement. ***f*** Examples of neurophysiological recordings from antennae and thoracic hairs during the presentation of an experimental static electric field. **Image credits: *a*–*d*** Data are taken and graphs rearranged from Clarke *et al.* (2013), reproduced with permission; ***e*–*f*** From Sutton *et al.* (2016), reproduced with permission.

locations of highest static charge. The significance of electrical charging patterns within the flower has not yet, however, been integrated into evolutionary or developmental models of complex flower shape.

An electrostatic flower-marking system

The other way in which static electricity may be used in pollination is as a marker of a pollinator's recent visit to the flower. Clarke *et al.* (2013) showed that a single visit to a *Petunia* flower by a *B. terrestris* bumblebee causes a positive polarisation of the flower relative to its normal potential. The change in potential is due to an exchange of electrical charge between the flower and the bee. The potential change caused by a visit does not persist long; the flower's electrical potential rises in seconds and then declines, lasting approximately 100 s, peaking at about 20 s (Fig. 1g).

It appears that this potential change is a signal. The electrical wave outlasts the original visit of a bee by many seconds. The return of the flower's potential to the original value (0 V) is presumably due to leakage of transferred electric charge away from the flower via the plant's vascular system. Potentially, the rate of leakage (and therefore the duration of the signal) could be controlled by the plant; this point is explored later.

It isn't only bumblebees that leave electrostatic signals on flowers. Khan *et al.* (2022) have shown that when visiting Sweet Alyssum (*Lobularia maritima*), two species of syrphid (*Cheilosia albipila* and *Eristalis tenax*) cause flowers to become positively charged (by about + 15 mV) relative to their normal state. It is reasonable to suppose that these hoverflies are using static electricity to mark recently-visited flowers.

Insect pollinators can detect and react to floral electric fields

If visiting insect pollinators routinely inspect the electrical charge on a flower as an indicator of its reward potential, choosing on this basis whether to visit them or not, then these insects must be able to detect and react to external static electric fields. It has been known for many years that insects from diverse orders are sensitive to static electricity. Early evidence (from 1960 onward) for this mostly relied on the observation of altered behaviour of insects exposed in the laboratory to experimentally-imposed static fields (reviewed by England *et al.*, 2021). Unfortunately, however, merely observing that an insect changes its behaviour (usually by altering its speed or direction of movement) when exposed to an electric field doesn't prove that this is because the insect has perceived and attributed significance to the electric charge. The electrostatic field may instead have interfered directly with normal locomotory function or orientation. Moreover, it is desirable that the examined response to electric fields should bear at least some relevance to the insect's normal real-life behaviour.

These problems of interpretation were addressed in a very impressive paper by Clarke *et al.* (2013), who cleverly asked the experimental insects to tell the experimenters whether or not they could detect an electric field as they went about their normal behaviour. The study involved *Bombus terrestris* bumblebees feeding freely at artificial flowers that differed only in whether they contained a reward, and their electrical charge (Fig. 2a).

When offered the choice between sugar-containing flowers that bore a +30 V DC voltage and bitter-tasting (quinine) sugarless flowers that were not charged (*i.e.*, zero potential), the bees were initially unable to tell them apart; half of their visits were to the +30 V flowers, half to the 0 V flowers. But they quickly learned to visit the sugar-containing electrically charged flowers in preference to those without charge; after 50 trials, 80% of their visits were to flowers bearing the +30 V electric potential. That the bees were using their perception of the flowers' electrical status to make this distinction is shown by the fact that when the charge was removed, the bees were immediately unable to tell the difference between the reward and non-reward flowers, once again visiting them with roughly equal frequency. Moreover, when the voltage difference was reduced to only +10 V, the bees were unable to learn the difference between the flowers (Fig. 2b). This voltage dependence shows that detection of floral charge requires that the electric field exceeds a threshold strength, and that the result isn't an experimental artifact.

Artificial flowers made of epoxy resin bearing a uniform electric potential are poor mimics of real ones, which bear spatially structured electric fields. Naturally occurring electrostatic flower patterns might be analogous to the visual nectar guides of flowers, which don't need to be learned but provide immediate benefits to bees in terms of success in accessing floral rewards (Leonard et al., 2011a). To show that bees can distinguish such patterns in floral electric fields, Clarke et al. constructed artificial flowers that carried either a uniform +20 V voltage and contained an aversive quinine 'reward', or which were given a bullseye electrical pattern (a ring at +20 V surrounding a centre at -10 V) and which offered a desirable sucrose reward. The bees quickly learned the difference between the two electrical flower patterns; again, once the electrical signal was turned off, the bees were unable to distinguish rewarding and aversive flowers (Fig. 2c).

Finally, it was shown that bumblebees could learn to prefer reward to non-reward artificial flowers when they differed in colour intensity (shade of green), but that they did so significantly quicker when the two kinds of flower also differed in their electric charge (Fig. 2d). This shows that bees can integrate sensory information derived from floral electric fields with visual information about flower colour. Moreover, it suggests that electroreception is a normal part of the bees' pollination behavioural repertoire.

Together, these experiments conclusively show that bumblebees can use static electrical cues, either alone or along with other characteristics, to inform decisions about which flowers to visit. The adaptive significance of this is presumably that real flowers normally differ in their electric fields in ways that reflect the value of the reward that they offer, and that their static electric charge can be used by bumblebees as a signal to identify the most rewarding flowers.

> **These experiments conclusively show that bumblebees can use static electrical cues to inform decisions about which flowers to visit**

How do insects detect the presence of static electric fields?

It has now been shown (Fig. 2e–f) that electrostatic signals are detected and encoded in bumblebees by thoracic mechanosensory hairs (Sutton *et al.*, 2016). An externally-imposed static electric field causes the lateral displacement of the hair, causing the neurone at the hair's base to send action potentials to the central nervous system. If the cuticular hair also bears its own static electric charge, then movement of the hair and the extent of sensory stimulation is much greater than if it does not. This dual-purpose role for sensory hairs had in fact been suggested almost 90 years earlier by Heuschmann (1929), but Sutton *et al.* were the first to show this using modern techniques. Koh *et al.* (2020) have used a combined theoretical and modelling approach to confirm that bumblebee thoracic hairs act as bimodal mechanical and electrostatic sensors. The mechanosensory hairs of *B. terrestris* do not appear to have any qualitatively-special mechanical properties not also present in the sensory hairs of other insect species, so that ability to detect static electric fields might be quite general (Palmer *et al.*, 2021).

The fact that insect electroreceptors also have other functions suggests that it might be relatively easy for electrostatic flower-marking systems to arise during the evolution of pollinators. As noted above, the syrphid flies *C. albipila* and *E. tenax* deposit an electrostatic mark on flowers. Both species are able not only to detect static charges but also to use electrostatic cues from charged artificial flowers to learn how to access a sugar reward. They could no longer distinguish rewarding and unrewarding artificial flowers once the static charge was removed. Electrophysiological recording showed that, just like bumblebees, hoverflies of both species possess thoracic sensory hairs that respond to an electric field by increasing the rate of firing action potentials (Khan *et al.* 2022).

On the other hand, it is evident that honeybees do not use thoracic hairs to detect static electricity, and indeed may not monitor electrical fields in flowers at all (Clarke *et al.*, 2017). Intriguingly, however, they use static electricity for a different pollination-related purpose. Honeybees share information with nestmates about the rewards available from flowers as part of their 'waggle-dance' communication system. Returning foragers vibrate their wings and orient their movements so as to convey the distance and compass point of the floral resource to be exploited, while the intensity of the performance indicates the value of the rewards to be obtained there (Seeley *et al.*, 2000). Since the dance takes place inside the hive, in the dark, its characteristic vibratory movements are conveyed to other bees largely by observing workers closely following the returning forager's movements in space. The antennae of an observing bee vibrate in resonance with the dancing bee, and the neural response encodes this signal (Tsujiuchi *et al*., 2007). It now appears that the way this information is transferred is not solely through mechanical displacement. Greggers *et al.* (2013) showed not only that waggle-dancing honeybees both emit and can detect modulated electrostatic fields, but also that these signals cause exaggerated movements of the antennal flagellum. In operant conditioning experiments the bees learned to associate similar electrostatic signals with rewards. It is thus now evident that the dance language signal, previously supposed to be purely auditory, includes a modulated electrostatic component.

Benefits and costs of flower-marking by pollinators

Unfortunately, we don't yet have the key piece of evidence that would allow a more positive assertion that electrostatic marks on flowers are actually used by pollinators to guide their choice of flower when foraging. To be sure, we need experimental demonstrations that preventing the deposition of such marks, 'wiping' them from recently visited flowers, or imposing artificial static electrical marks on real flowers, influences the behaviour of bees during spontaneous natural foraging. I hope that someone will try experiments like this quite soon.

But meanwhile, we can still ask some useful questions about how and why such an electrical flower-marking system might evolve. First, what benefits would a bumblebee or a hoverfly derive from leaving an electrostatic calling card? The fact that we already know that chemical marks of previous visits are used by insect pollinators tells us that such marking systems can evolve. Honeybees (Giurfa *et al*., 1992), bumblebees (Stout *et al.,* 1998) and at least some solitary bees (Yokoi *et al.,* 2009) are all known to leave repellent chemical signals on flowers that they have visited. Why do they do it?

Flower-marking, whether olfactory or electrostatic in nature, might be envisaged to provide benefits to pollinators at two levels. First, flower-marking would enable avoidance by the bee of flowers that have been previously visited by another pollinator. Because these flowers are likely to yield lesser rewards, such avoidance would enhance the profitability of the pollinator's foraging activity. If on arriving at a new patch of flowers there is too large a proportion of recently visited flowers, a visiting bee can decide to abandon it and fly to a different patch. If a newly encountered plant is acceptable, individual recently-visited flowers can still be avoided. Alternatively, an electrostatic marking system might be used simply to ensure that an individual bee does not waste time by revisiting flowers as it collects rewards from blooms present on a single plant, or patch of flowers. As mentioned above, previously-visited flowers can be labelled with a chemical mark, but an electrical signal would probably be more rapidly detectable. Such marks would presumably be honest (*i.e.*, convey accurate information), because dishonest ones would be confusing to the foraging insect itself. To be most useful, the marking system should be available to all pollinators. But this isn't essential – as long as a sizeable fraction of pollinators were able to 'see' the marks, such a system could provide adaptive benefits. In practice, some but not all olfactory marks can be detected by multiple pollinator species (Yokoi *et al.,* 2007).

Electrostatic marks of a previous visit would represent another flower-marking system, in addition to the chemical one. Why would it be beneficial to have two systems? Of course, we don't know which came first, but the electrostatic system for flower-marking looks simpler than the olfactory one. Depolarisation of floral static charge during a visit would presumably happen anyway, even if it was not recognised by pollinators as signalling a previous visit. It does not require production of new chemicals; pre-existing sensory and neural mechanisms could have been repurposed to allow the detection and interpretation of floral signals. For this reason, I suggest that electrostatic marking of flowers predates any olfactory marking system.

Why two sets of marks? One possibility is that well-informed pollinators may benefit by learning the characteristics of particular plant species more quickly. It is well known that learning in bees proceeds more rapidly when multiple sensory modalities are used in training protocols (Leonard *et al*., 2011b), so that using multiple markers of previous visits may enable more effective learning. Additionally, I suggest that the signalling dynamics of electrostatic and olfactory flower-marking systems are probably different. The deposition of a static electrical charge on the flower by the insect can take place immediately on contact and ought to be quicker than chemical marking. Similarly, the rate at which an electrical signal decays will almost certainly be quicker than an olfactory one. These differences mean that the time scale of the information conveyed by the two reward monitoring systems will be different. But confirmation of these points is needed.

Finally, while chemical marks on flowers are already known to be diverse, there is every reason to suppose that electrostatic flower marks will be similar among different pollinating species (although there may be differences between large and small individuals). This means that the reliability of the information contained within an electrostatic flower marking signal may be greater than that in an olfactory signal.

What about the plant? It may not be in the plant's interest always to communicate honestly (or even allow such communication by others) about floral rewards. Flowers need to attract as many pollinator visits as possible. The point of giving a nectar reward to a pollinator is to encourage a visit in the first place; whether or not the pollinator is rewarded may make little difference to the probability that the visit will result in fertilisation. But because the provision of the reward is energetically expensive, it is in the plant's interest to reduce its costs by cheating. This is presumably why many plants produce both rewarding and rewardless ('empty') flowers (Gilbert *et al.,* 1991). The latter look and smell like rewarding flowers, but don't produce nectar. In other words, these flowers *dishonestly* advertise their reward status. 'Empty' flowers have both costs and benefits to the plant. As a benefit, as long as the number of fertilisations acquired from uninformed pollinators (*i.e.*, those that can't tell the difference between rewarding and unrewarding flowers before visiting them) is not reduced, the plant has the opportunity to gain fitness by substituting less costly no-reward flowers for nectar-producing ones. Alternatively, the plant might gain from producing extra rewardless flowers, in addition to the original rewarding ones, because this would enhance the long-distance attractiveness to pollinators of the whole population of flowers borne on the plant. On the negative side, well-informed pollinators (those that rapidly learn the benefits to be gained from a patch of flowers, as well as the costs of accessing them) are discouraged if they discover that a foraging patch has too large a proportion of rewardless flowers, emigrating to a new patch. Dishonesty only pays if it is practised infrequently.

Some flowering plants do indeed provide honest signals to indicate to pollinators when floral rewards are depleted. This happens, for example, when a flower ceases to produce nectar when fertilised. To indicate this developmental change, the flower changes its colour and odour; this is an honest indicator of its non-rewarding status. Ito *et al.* (2021) considered how honest signals of this type might evolve. A mathematical model showed that this kind of honest signal about floral reward status is only evolutionarily stable when plants produce both rewarding and rewardless flowers and are visited by a heterogeneous population of both well-informed and uninformed pollinators. In their model, the plant and the well-informed pollinators both gained, while uninformed pollinators were unaffected because they did not perceive the signal anyway. Ito *et al.*'s paper did not consider electrostatic signalling of reward status. I think it would be very interesting to examine the nature of electrostatic responses to visitation by pollinators of normally rewarding and 'empty' flowers in those plants that produce both.

Evolution of electrostatic flower-marking systems

An insect pollinator would almost certainly bear little or no direct cost of participating in an electrostatic reward-signalling system. All that is necessary on its part is to discharge the negative potential on the flower, by donating some of its own positive charge. As noted in the opening section of this article, the amount of electrical energy involved is tiny, and it would soon be regenerated by further flight on the insect's journey to the next flower.

If an electrostatic signalling system has any cost at all, it would probably be incurred by the plant. Again, the acquisition of the static electric charge is probably not costly in itself, and the deposited electricity will be dissipated rapidly, flowing to Earth through the plant's vascular system. But there will be a fitness cost; because the transient change in the flower's static charge makes it temporarily less attractive to visiting pollinators, its chances of being fertilised will briefly be reduced. For this reason, we can expect that plants will probably seek to make the duration of the electrostatic mark as short as possible. The plant has the opportunity to influence the duration of the mark by adjusting the conductance of the vascular system's connection to the flower.

On the other hand, and perhaps surprisingly, it may actually be beneficial to the plant to bear an electrostatic mark. The specific requirement that to achieve fertilisation the pollinator must transfer the pollen to another flower of the same species means that plants should evolve traits that encourage pollinators to specialise, at least for a period of time, in visiting flowers of only one kind. Flying insect pollinators do indeed specialise in this way, although a recent study suggests that the true extent of flower constancy is less than previously supposed (Martinez-Bauer *et al*., 2021). I suggest that because the use of an electrostatic flower-marking system should increase the pollinator's certainty that time spent foraging within a patch of a single flower species is profitably used, those flower species that are so constructed as to permit an effective electrostatic marking system (*e.g.*, one that accurately reflects the reward status of flowers) will be rewarded by the increased constancy of pollinators to its species. Complex architecture and long handling times are attributes of such flowers. It should be straightforward to test the hypothesis that flowers of this type display pollinator-induced electrical marks more often and/or more prominently than others of simpler construction.

How long should the static electric signal last? Clarke *et al.*'s experiments show that in *Petunia* flowers the bumblebee's electrical mark lasts for around 100 s (slightly less than 2 min); for the bee that originally makes the mark, this may be only just long enough to be useful in preventing a return to the same flower as the insect moves on. But when many bees are working the same plant, an electrical mark should be useful to other bees as well. A longer-lasting mark might then be helpful, although data from pollinators (*Anthophora* spp.) working the flowers of the Bugloss (*Anchusa strigose*) show that the 100 s interval is not totally inappropriate; the mean interval between successive visits by pollinators was 3.25 min (Kadmon, 1992).

Another way of looking at this is that, from the point of view of the pollinator, a flower-mark will be most useful when it lasts about the same length of time as it takes to refill the flower's nectaries. This latter parameter is very variable among flower species (Luo *et al.,* 2014), and also varies in a circadian fashion in some (Bloch *et al*., 2017). Moreover, while some flowers with simple, open structures provide relatively small rewards that are quickly replaced after removal, others with complex structures (*e g., Impatiens biflora*) provide large nectar rewards that are associated with long pollinator handling times. It is hypothesised that flowers of the latter type (often called 'bee flowers') have evolved specifically to discourage visits from most pollinators while encouraging flower constancy in insects that are able to handle them (Heinrich, 1979). It is a reasonable hypothesis that structurally complex flowers like this should be able to hold a static electric visit-marker signal for a longer time than simpler flowers. At present we have no indication of how long electrostatic flower-marks endure on flowers of species other than *Petunia*. It appears from limited available data that electrostatic flower-marks may endure less long than olfactory marks (Frankie *et al.,* 1977), but this is just one many aspects of the topic that require further investigation.

Other aspects of insect life and static electricity

It's frequently the case that a notable theoretical or observational advance in one field of science is contagious, quickly leading to new discoveries of a related kind in other

It's frequently the case that a notable theoretical or observational advance in one field of science is contagious, quickly leading to new discoveries of a related kind in other areas of research

areas of research. Now that pollination biology researchers have found that insects can detect static electricity, entomologists with different interests have begun to be interested too. I confidently predict that this will lead to new, perhaps surprising, findings.

One example of this is the realisation that static electric charges may play an important role in the 'ballooning' dispersal behaviour of linyphiid spiders, tetranychid mites and some larval Lepidoptera (Gorham, 2013; Morley *et al.*, 2018; Cho, 2021; Habchi *et al.*, 2022 – but see Narimanov *et al.*, 2021). Another burgeoning interest concerns the role that electrostatic charges might play in the capture of insect prey by orb-weaver spiders (Ortega-Jimenez *et al.*, 2013; Vollrath *et al.*, 2013). There is already a significant body of research activity examining the possibility of using static electric fields to control crop pests and insects (Toyoda, 2020), and also to enhance the pollination of crops (Khatawkar *et al.*, 2021).

A potentially important question is whether oscillatory electric fields associated with high-voltage electric transmission cables (low frequency) or mobile telephony (high frequency) might adversely affect the fitness of insects, especially pollinators. This conjecture has received attention in the literature (*e.g.*, Vanbergen *et al.*, 2019; Balmori, 2021), and there is plenty of public concern expressed on the internet and social media. As yet, there is no conclusive evidence either for or against the idea (Schmiedchen *et al.*, 2018). I should point out, though, that in this article I have considered the entomological significance only of static electric fields that are modulated, if at all, only at extremely low frequencies. Most public concern is directed toward the possible effects on humans of the radiofrequency-modulated electrical signals used in mobile phones ('electrosmog'), and that is quite a different matter. Nevertheless, I don't think that the question of whether stray electrostatic fields are among the many factors contributing to insect declines, especially those of pollinators (see Wagner, 2019), is going to go away soon. But I am sure that improved knowledge about the role played by static electricity in the 'normal' lives of insects will lead to better-quality investigations of the possible harms done by anthropogenic electric fields.

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On the note of Anastase Alfieri *Les insectes de la tombe de Toutankhamon* (1931)

Fig. 1. Anastase Alfieri, 1926 © Senckenberg DEI. (http://sdei.senckenberg.de/biographies/information.php?id=341&sprache=_englisch)

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In 1923 Mr E.W. Adair asked Mr Anastase Alfieri (Fig. 1) to identify the insects that had been collected in the antechamber of the tomb of Tutankhamun (Fig. 2) and which had been entrusted to him for that purpose by Mr A. Lucas.

Alfieri wrote his note in English and expected that it would be published in the second volume of Howard Carter's *The Tomb of Tut Ankh-Amen* (Carter, 1927). After the publication in 1927, he was disappointed to see that his note was aggrievedly summarised in a few lines, neglecting the scientific names of the insects identified by himself. Therefore, Alfieri decided to publish his entire note in French, as was usual for his publications (Alfieri, 1931).

Here is the paragraph on insects included in Appendix II of 'The chemistry of the tomb' by A. Lucas in Carter (1927, p. 166):

"Insects also occur, but these too are dead. As a matter of scientific interest, specimens were collected and were submitted to Mr E.W. Adair, entomologist to the Ministry of Agriculture, Cairo, who passed them to Mr A. Alfieri, entomologist of the Royal Agricultural Society, Cairo, by whom they were identified. They proved to be chiefly small beetles such as feed upon and destroy dead organic matter, and they are all of kinds common in Egypt at the present day, and 3,000 years have not brought any change or modification in their size or structure."

Alfieri (1931) published the result of his identification of insects found in the tomb as follows:

1. Insects obtained from alabaster vase No. 16: *Lasioderma serricorne* Fabr. (Anobiidae), very numerous, and some *Sitodrepa panicea* L. (Anobiidae), all embedded in a dark hard substance, probably resin.
2. Insects obtained from alabaster vase No. 58: *Lasioderma serricorne* Fabr., stuck in a fatty substance of dark colour.
3. Insects obtained from alabaster vase No. 60: *Lasioderma serricorne* Fabr., very numerous, and three specimens of *Gibbium psylloides* Czemp. (Ptinidae). This vase contained a very dry eroded matter which facilitated the recovery of the insects that were enshrined.
4. Insects obtained from alabaster vase No. 61: Only a few specimens of *Lasioderma serricorne* Fabr., stuck in a fatty substance of dark colour and slightly aromatic.
5. Insects obtained from wooden box No. 115: A dozen of specimens of *Lasioderma serricorne* Fabr., a few specimens of *Sitodrepa panicea* L., hundreds of *Gibbium psylloides* Czemp., and a pair of elytra impossible to identify. The box was almost empty, containing only a few tiny red fragments of pottery.

At the end of his note, he added: "The presence of these insects in Egypt from antiquity to our days indicates that they are native to the country. They all belong to the family of Coleoptera and are those which feed on food substances, animal or vegetable organic

Fig. 2. Mask of Tutankhamun.
By Roland Unger, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=48168958

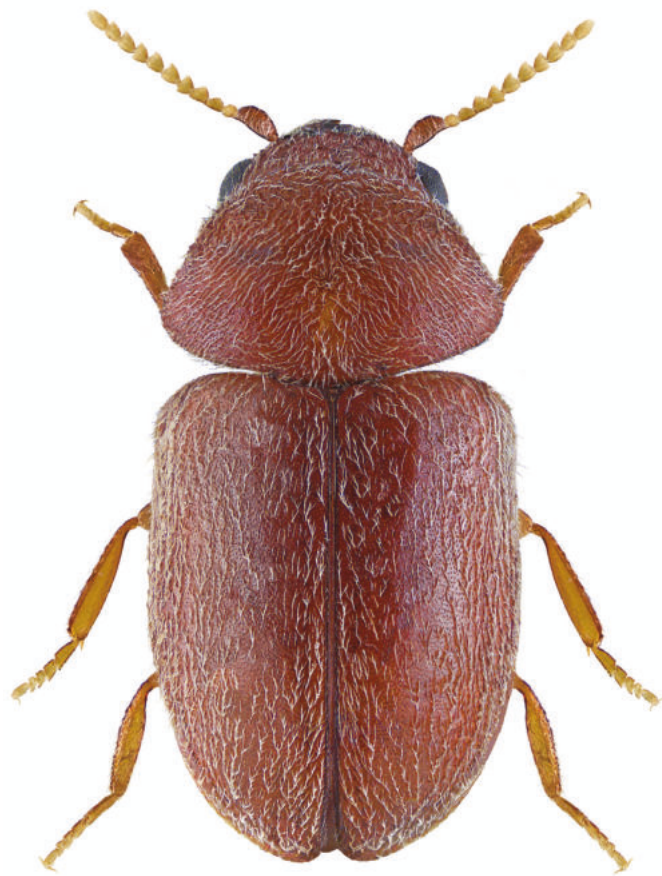

Fig. 3. *Lasioderma serricorne* (Fabricius, 1792) – Cigarette Beetle. By Udo Schmidt, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=56726059

matter. It is also very remarkable to note (excluding the difference in colour in some specimens of the tomb of Tutankhamun, difference doubtless due to dilapidation, or more probably still to the action of with whom they were in contact) that 3,500 years of existence little changed the morphological characters or dimensions of the current species".

After two years, Carter's third volume of *The Tomb of Tut Ankh-Amen* (Carter, 1933) included in Appendix II 'The chemistry of the tomb' by A. Lucas, pp. 172–173, the following correction of what was published in volume 2: 'Insects.' As stated in the previous volume, specimens of the various dead insects found in the tomb were submitted for identification to Mr A. Alfieri (then entomologist at the Royal Agricultural Society, Cairo, and now in the Ministry of Agriculture). It was stated that these insects were small beetles, such as feed upon dead organic matter and that they were all of kinds common in Egypt at the present day, 3,280 years not having made any modification in their size or structure, but the names of the beetles were not given and this may now be done.

1. From the Alabaster Vase No. 16:
   Lasioderma serricorne, Fabr., *Sitodrepa panicea,* L.
2. From Alabaster Vase No. 58:
   Lasioderma serricorne, Fabr.
3. From Alabaster Vase No. 60:
   Lasioderma serricorne, Fabr., *Gibbium psyllioides*, Czemp.
4. From Alabaster Vase No. 61:
   Lasioderma serricorne, Fabr.
5. From Box No. 115:
   Lasioderma serricorne, Fabr., *Sitodrepa panicea*, L., *Gibbium psyllioides*, Czemp.

All the above-named insects are beetles, *L. serricorne* and *S. panicea*, belonging to the family of the *Anobiiae,* and *G. psyllioides* to that of the *Ptinidae."*

Unfortunately, the correction published by Carter (1933) included a few misprints in the scientific names of beetle species and families. Also, it is clear that the "Spider-webs, and the remains of small spiders" mentioned in volume 2, p.166 (Carter, 1927) were not sent for identification by anyone.

Alfieri's identification of the insects found in the tomb of Tutankhamun (Alfieri, 1931) can be listed according to the current valid names as:

Order Coleoptera [Beetles]
- Family Ptinidae Latreille, 1802
  - Subfamily Anobiinae Fleming, 1821 [formerly family Anobiidae]
    - *Lasioderma serricorne* (Fabricius, 1792)
    - *Stegobium paniceum* (Linnaeus, 1758) [formerly *Sitodrepa panicea*]
  - Subfamily Ptininae Latreille, 1802
    - *Gibbium psyllioides* Czenpiński, 1778

Fig. 4. *Stegobium paniceum* (Linnaeus, 1758) – Drugstore Beetle. By Siga, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=6155431

Fig. 5. *Gibbium psylloides* Czenpiński, 1778 – Hump Beetle or Smooth Spider Beetle. By Udo Schmidt, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=56726204

The vernacular names of these species are:

L. serricorne – Cigarette Beetle (Fig. 3);

S. paniceum – Drugstore Beetle (Fig. 4);

G. psylloides – Hump Beetle or Smooth Spider Beetle (Fig. 5).

Anastase Alfieri was a Greek-Egyptian, who was born, lived and died in Egypt (23rd March 1892, Alexandria – 4th March 1971, Cairo). No doubt he was proud because of the discovery of the tomb and treasure of Tutankhamun, about three years after the Egyptian revolution of 1919; the discovery that made all Egyptians proud. This was recorded in poems and songs too. Therefore, his identification of the tomb's insects with Carter and his collaborators was important to him as an Egyptian. He admired his role and remembered it after forty years when he prepared in May 1963 a sketch of his professional career published in the preface written by Karl V. Krombein & Mostafa Hafez for his masterpiece *The Coleoptera of Egypt* (Alfieri, 1976). He said: "*Alfieri a publié une quarantaine de notes et d'études relatives à la taxonomie, l'écologie et la biologie des insectes. Par ailleurs, il n'existe pratiquement pas des publications sur l'entomologie égyptienne où il n'est fait mention de sa collaboration. On retrouve également son nom dans l'ouvrage de Howard Carter (The Tomb of Tut-Ankh-Amon, vol. II) pour lequel il a identifié les insectes, vieux de 3500 ans, contenus dans les jarres d'albâtre trouvées dans l'hypogée du pharaon*".

The publication of his note in 1931 made this work famous and an available reference to entomologists more than being a page in a book (*e.g.*, Solomon, 1965; Chaddick *et al.*, 1972; Panagiotakopulu, 1999; Buckland *et al.*, 2001).

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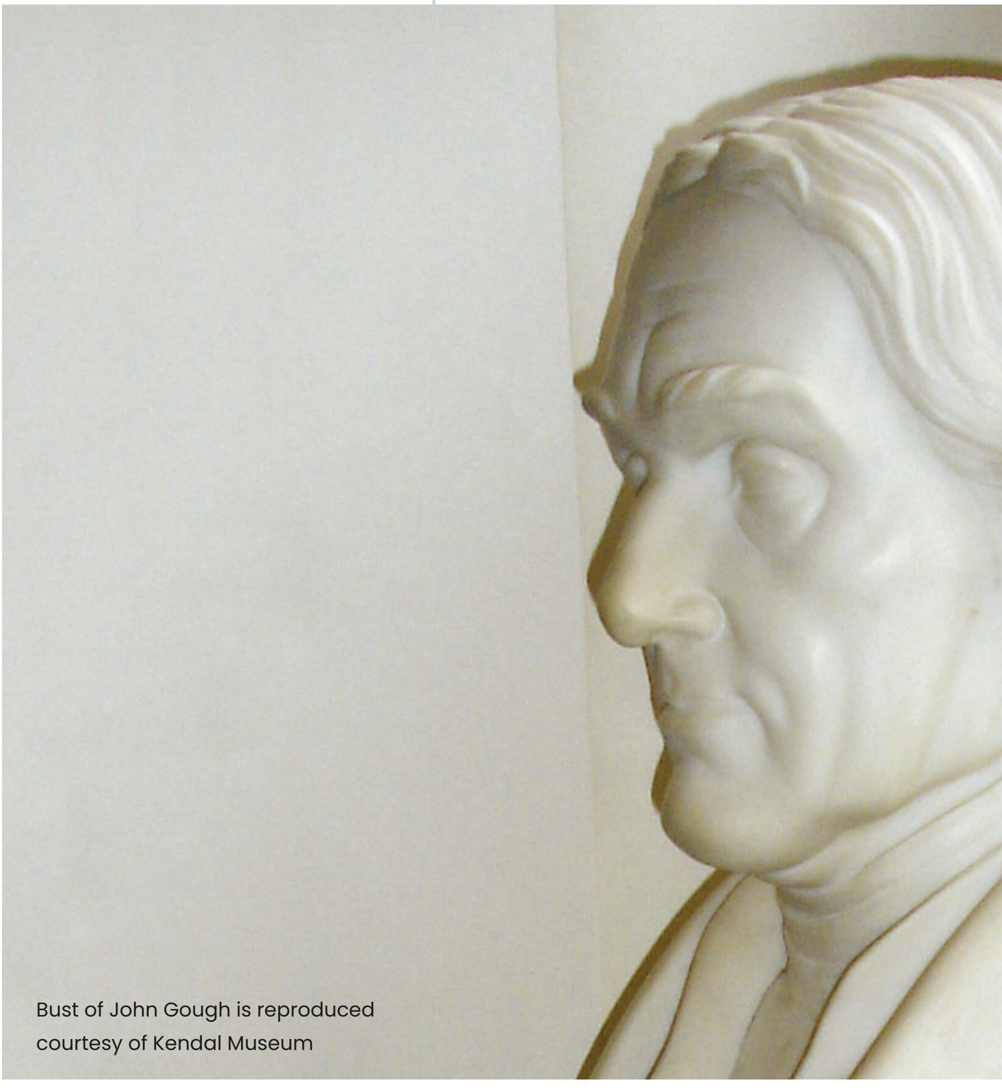
John Gough of Kendal (1757–1825), the ‘blind philosopher’ – a pioneer of experimental entomology?

The epithet ‘father’ of entomology, across its various branches, has been liberally applied to an assortment of practitioners ranging from Aristotle (384–322 BC) (father of entomology), through the Revd William Kirby (1759–1850) (father of modern British entomology) to Sir Vincent Wigglesworth (1899–1904) (father of insect physiology) (Locke, 1997; Leather, 2015; Melbourne, 2018). Spare a thought, however, for one remarkable historical figure who has received scant recognition until recently – John Gough, the blind philosopher and polymath who spent his entire life away from the scientific spotlight in his native Westmorland. He was a man later described by his star pupil, the eminent physical chemist John Dalton, himself an avid insect collector and botanist in his early days, as one of the most astonishing instances of genius he had encountered (Hodkinson, 2019; Pearson *et al*., 2021). It is only now that his contributions, across a range of scientific disciplines, are becoming more widely appreciated.

It was Gough who described the process of ecological succession in lakes and bogs 100 years before the concept, unattributed to him, found its way into later ecological thinking (Gough, 1793a; Barber, 2015). It was Gough who, during the 18th century, collected detailed daily meteorological records that he linked to the phenology of plants, the seasonal migration of birds and the activity patterns of insects on which the migratory birds feed (Gough, 1793b; Gough, 1813; Hilton, 2018). It was Gough’s later ideas on synoptic meteorology that became widely accepted in relation to the occurrence of cold north-easterly winds in England and their effects on vegetation growth (Gough, 1839; Wilson, 2011; Walker, 2016). He also made significant contributions to physics, mathematics and folklore (Pearson *et al*., 2021). For example, the counter-intuitive contraction response he observed in stretched India-rubber, when subjected to increasing temperature, later became known as the Gough-Joule effect (King, 1953). Gough had a sharp analytical mind and his experiments, conducted to his instructions, were highly innovative for his time and those on insects may be of interest to readers of *Antenna*.

During Gough’s lifetime, British entomology was based almost exclusively on the observation, description and cataloguing of species, predominantly their comparative morphology, classification, behaviour and distribution. What set Gough apart from most other scientists of his time was that he employed an experimental approach to the study of living animals and plants in which



Bust of John Gough is reproduced courtesy of Kendal Museum

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studies were conducted to test stated hypotheses relating to their physiological attributes, growth and survival (Hodkinson, 2019). They demonstrate the early logical application of the scientific method to understanding the physiology of living organisms. Long before statistics were invented, Gough designed simple experiments with various treatment levels applied across a range of organisms, and, where sufficient individuals were available, appropriate replication. His childhood inspiration, the Revd William Derham, in his book *Physico-Theology* (Derham, 1713), had paved the way by demonstrating that a continuing supply of 'air' was required for the survival of insects – around 60 years before Priestley discovered oxygen.

Unconvinced by a report from Dr Benjamin Franklin that live flies had emerged from a decanter into which he had poured a bottle of Madeira wine imported to London from Maryland, USA, Gough carried out four linked experiments to test the survival of insects and other arthropods in alcoholic drinks of increasing strength – beer, wine and brandy (Gough, 1799). The insects tested included scarab beetles, nut weevils, domestic crickets, wasps, bees, scorpion flies, craneflies, horseflies, robber flies, three species of muscid fly and 'erucae' (caterpillars), as well as house spiders, woodlice and centipedes. Exposure times varied from two or three hours to three or four days. On removal from the liquid, the insects were placed in a warm environment to allow recovery. A few flies survived the shortest exposure but almost all the species tested died at the longer exposure. Larvae of *Curculio nucum* (Hazelnut Weevil) proved an exception, and, in a follow-up experiment, he found that larvae survived up to 17 hours when immersed in brandy. He thus dismissed Franklin's general proposition and concluded that alcohol was "highly pernicious to the living principle in insects". It is ironic that comparable studies of survival in terrestrial arthropods submersed in seawater, including our own, came almost 200 years after Gough! (Coulson *et al.*, 2002).

Gough was also interested in the nature and cause of torpidity in animals (and plants) and was intrigued by the explanations proffered in an essay by Monsieur du Pont of Nemours (Du Pont, 1807), to which he raised several objections. He conducted studies on *Acheta domesticus* (House Cricket), dormouse and two species of snail. His study on crickets tested his proposition that "animals do not submit to torpidity upon choice, but from necessity; and when cold happens to be the immediate cause, they fly from it if possible" (Gough, 1808). He set up a simple experiment in which he established a colony in an indoor kitchen environment where he manipulated the temperature throughout the year. Within the kitchen, a fire was maintained continuously throughout the summer but was discontinued from November to June. During this 'cold' period this fire was lit for one day every 6–8 weeks. He observed that the crickets thrived and reproduced indoors during summer but then apparently disappeared during the cold period, only to become active again for short periods during winter when the fire was lit. He compared this result with parallel events outdoors in which crickets were active during summer but remained inactive through the winter. He concluded that activity occurred only when temperature conditions allowed and that Du Pont's ideas that animals somehow anticipated and enjoyed periods of torpidity were, at least for invertebrates, untenable.

While Gough's experiments are not earth shattering, they provide an early manifestation of a move away from mere observation to a more experimental approach to the study of insect biology. They represent a step beyond the descriptive approach then employed by his contemporaries such as Gilbert White in his much-feted book *The Natural History and Antiquities of Selborne* (White, 1789).

Acknowledgement
The image of the bust of John Gough is reproduced courtesy of Kendal Museum.

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Beetles as taxis – a solution to Darwin's conundrum

Reading Dr Martin Willing's column about molluscs in the Wildlife Reports section of *British Wildlife* magazine (Willing, 2020) reminded me of a meeting that I had with an artist in a London coffee shop in 2014 to discuss an illustration for a book about water beetles. This column highlighted the ability of certain molluscs to hitch a ride on large aquatic beetles and Dr Willing provided examples of this activity from previous literature, *e.g.,* Californian Limpets *Ferrissia californica* attaching themselves to a specimen of the water beetle *Colymbetes fuscus*, taken from a seasonal pond in the New Forest (Long, 2020), and a photograph of River Limpets, *Ancylus fluviatilis,* and a single Lake Limpet, *Acroloxus lacustris,* being transported by a large *Dytiscus* species that flew into a moth trap in Norfolk (Driscoll, 2011). It also referred to historical observations of this activity going as far back as the account of Kew (1893) who wrote, "freshwater limpets... sometimes ride on the backs of large flying water beetles."

However, this story, which provides part of an explanation for the global distribution of both land and water molluscs, goes back further still, and was welcomed by none other than Charles Darwin. In his letter to Alfred Russel Wallace dated 1st May 1857, Darwin wrote, "Land molluscs are a great perplexity to me", alluding to the fact that their widespread occurrence, and notably their presence on oceanic islands, was at odds with his theory of evolution. The central pillar of this theory required the evolutionary pathways of organisms to follow a traceable pattern of divergence from common ancestors, and the global appearance of what he considered to be largely sedentary organisms, in the absence of a plausible mechanism for their effective dispersal, was not consistent with his ideas.

Thankfully for Darwin, evidence was forthcoming and by the time his book *On The Origin of Species* was published (Darwin, 1859), he was able to propose that certain molluscs, in addition to having some degree of resilience to short-term immersion in seawater, were able to attach themselves to other organisms, including waterfowl and large aquatic beetles, that could then transport them from one place to another. Further examples consolidated the view that molluscs could be successfully translocated by this method, even over considerable distances, and of particular interest was an example provided by shoemaker and amateur naturalist, Walter Drawbridge Crick. Crick sent Darwin a female Great Diving Beetle, *Dytiscus marginalis*, that had inadvertently become a vehicle for a hitchhiking bivalve, and this provided the subject for the final paper that Darwin produced. It was in this paper, published two weeks before he died, that Darwin wrote: "I am now able to add, through the kindness of Mr W. D. Crick, of Northampton, another and different case. On February 18 of the present year, he caught a female *Dytiscus marginalis,* with a shell of *Cyclas cornea* clinging to the tarsus of its middle leg" (Darwin, 1882).

In a fascinating conclusion to this story, Walter Drawbridge Crick became the grandfather of Francis Crick, who, together with James

> "Freshwater limpets... sometimes ride on the backs of large flying water beetles."

Figure 1. The upper half of the illustration shows: Darwin in his later years; the ship, HMS Beagle, that took Darwin on the five-year voyage which would shape the future of biology; and the finches of the Galapagos Islands, that helped Darwin to crystallise his thoughts regarding evolutionary processes. Across the stylised depiction of a double helical strand of DNA, and a backdrop of genetic base code, lays the female Great Diving Beetle, *Dytiscus marginalis*, supplied by 25-year-old Walter Drawbridge Crick with its 'passenger', the bivalve clam *Cyclas cornea* attached to its mid tarsus. The lower part of the illustration shows the familiar image of James Watson (left) and Francis Crick (right) standing next to their three-dimensional model of deoxyribonucleic acid. (Illustration: Carim Nahaboo).

Peter Sutton
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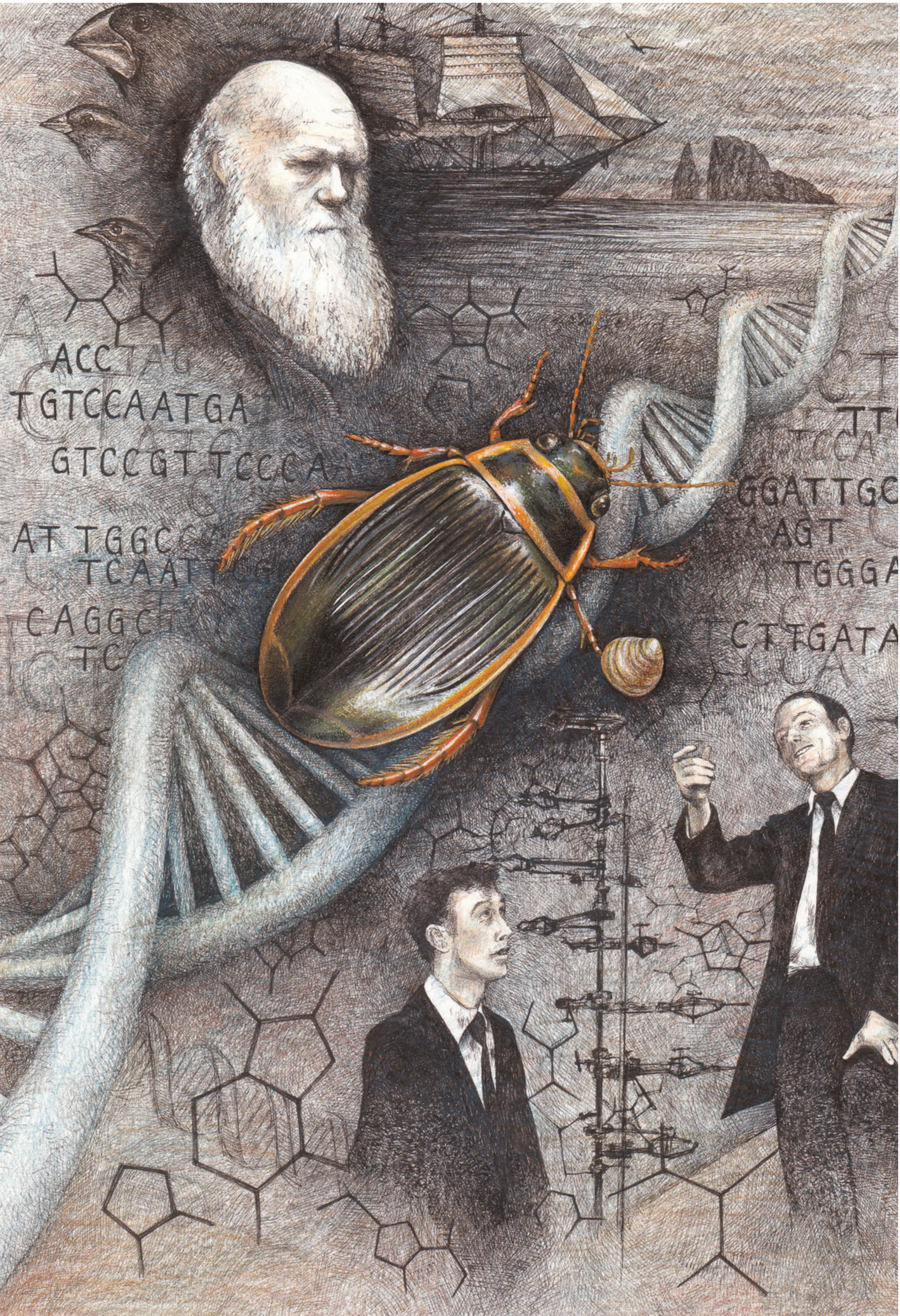
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One of the great stories of modern science can be linked together by a humble water beetle

Female Great Diving Beetle *Dytiscus marginalis* - Flitwick Moor, Bedfordshire. Photo: Peter Sutton.

Watson and Maurice Wilkins, received the 1962 Nobel Prize in Physiology or Medicine for successfully discovering the three-dimensional structure of deoxyribonucleic acid (DNA). This molecule carries the 'code of life' and is responsible for the transmission of inherited information from one generation to another. The elucidation of its structure, in the words of Matthew Ridley, "...led inexorably to the vindication of almost everything Darwin deduced about evolution" (Ridley, 2009).

Returning to the meeting at a coffee shop in London in December 2014, the artist I was meeting was Carim Nahaboo, a talented natural history artist specialising in entomological subjects. Together we discussed a possible illustration that would encapsulate this story and after a number of sketches, we settled on the image shown in Figure 1.

The illustration could reasonably have included a number of other scientists who were instrumental in the progressive accumulation of the *sine qua non* that led to Watson and Crick's successful discovery: Oswald Avery, described by Swedish Nobel laureate, Arne Tiselius, as the most deserving scientist not to receive a Nobel Prize for his work, began the journey with an inspired piece of microbiology that categorically identified DNA as the material from which genes (Gregor Mendel's 'packets of inheritance') were constructed; June Lindsey, for discovering the structures of adenine and guanine, two of the nucleotide bases to be found in DNA, from which Watson and Crick were able to deduce base-pairing patterns; William Astbury (who described Avery's work as "One of the most remarkable discoveries of our time"), for calculating the vital 3.4 Angstrom distance between the nitrogenous bases of DNA using X-ray diffraction studies; and Rosalind Franklin, for the production of Photograph 51, which has been described as the most important photograph of the 20th century, that confirmed the double-helix structure of DNA. When this image was shown, without Franklin's permission, to Watson by Maurice Wilkins, Watson reputedly said, "my mouth fell open and my pulse began to race". It is now widely recognised that Franklin's contribution, alongside that of Avery's, was worthy of a Nobel Prize.

However, it was decided to focus on the link between Darwin, the 'gift' from Walter Drawbridge Crick that helped to resolve the source of Darwin's perplexity, the role of Crick's grandson, Francis Crick, whose joint discovery provided a mechanism for inheritance and natural selection, and the fact that one of the great stories of modern science can be linked together by a humble water beetle.

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Royal Entomological Society

Society News

Soldier beetle on sentry duty. Credit Greg Hitchcock

News from Council

Meetings of Council

Council met on 18th May 2022. This meeting had an initial focus on decisions around the winners of RES awards and editorial board appointments. Discussion items at this meeting were around staff pay progression measured through performance, and the future potential use of the Mansion House estate. Several committees had met since the last Council meeting and reported updates to trustees. The following is a summary of the main points.

CEO Report

A summary of the newly published strategy and vision was given, including the launch. An update was given on the committee review that was a continuation from the earlier governance review, as well as an update on the work that was taking place around equality, diversity and inclusivity.

Trustees were informed of progress with workforce changes that were taking place and what impact that was having. A summary of upcoming and past events was given. Finally, there was an update on RES publishing and membership news.

RES Awards

Recommendations were received for winners of the Westwood Medal, which recognises the best comprehensive taxonomic work on a group of insects or related arthropods. There were also nominations for the conservation award and early career award.

RES roles

Robert Wilson was approved as a new Editor-in-Chief for Ecological Entomology and Gael Kergoat for Systematic Entomology. Postgraduate representatives for the next year were approved. These are Ayman Asiri (University of Cardiff), Ava Searles (University of Lincoln) and Vera Kaunath (University of Potsdam, Germany).

Staff Pay Progression

Staff have historically been on a set salary and received cost of living increases when awarded by trustees. However, there was no way of recognising outstanding performance. Therefore, it was agreed to put staff salaries into a new banding system with the opportunity for pay progression. The system agreed is used by many charitable organisations and increases would be authorised by the Finance Committee each year.

Mansion House Estate

Discussions were started on issues around the Mansion House estate and potential solutions to some compliance issues. There was discussion on how the estate could be of maximum benefit to the global membership and what the various options may be.

Committee Reports

Minutes of the Finance Committee, Membership Committee, Outreach Committee and Meetings Committee were reported.

Simon Ward
Chief Executive Officer

Broad-bodied chaser (*Libellula depressa*).

Aquatic Insects Special Interest Group and Scotland Regional Meeting

10th and 11th May 2022, Online

Convenors: Craig Macadam (Buglife), Arron Watson (Environment Agency) and Katrina Dainton (Forest Research)

Report by Richard Harrington and Arron Watson

Scotland's delightful lochs and rivers host a wonderful array of aquatic insects. Thus, combining a Scotland Region meeting with an Aquatic Insects Special Interest Group seemed like a great idea. The mayfly, stonefly and caddisfly recording schemes would come together with lectures and a field trip. Covid considerations, however, led to the meeting being run only online, but it was still hugely informative, productive and enjoyable. The first day comprised nine lectures, the second a recorders' workshop.

Richard Chadd

Richard Chadd (1964–2021) was an ecologist and stalwart supporter of recording schemes. Bill Brierley started the meeting with an appreciation of this kind, funny and incredibly knowledgeable pioneer. He graduated with a BSc in Applied Zoology from the University of Reading and an MSc in Water Resources Management from (then) Napier College, Edinburgh, his research project being done with the National Rivers Authority (NRA) at Spalding in Lincolnshire on assemblages in ponds. Bill was his supervisor. Richard went on to become NRA Area Ecologist, monitoring not only the freshwater biota, but also moths and other groups. He was President of the Lincolnshire Naturalists' Union and held committee posts in many organisations. He was a hugely enthusiastic and popular teacher of the public and professionals, and developed an online course on freshwater invertebrates. He regularly appeared on *Countryfile*, championing the reintroduction of *Austropotamobius pallipes*, our native White-clawed Crayfish. Richard was a true inspiration and is greatly missed.

Rare Invertebrates in the Cairngorms:

Delving into stoneflies!

Northern February Red Stonefly (*Brachyptera putata*) © Gus Jones

The *Rare Invertebrates in the Cairngorms* project is led by RSPB Scotland and the Cairngorms National Park Authority and is a partnership of six different organisations. Project Officer, Genevieve Tompkins, explained that its aim is to study the distribution, ecology and biology of several rare Cairngorms invertebrates in order to inform habitat management. Engagement with the public, landowners and authorities is key to success. The nationally scarce and endemic *Brachyptera putata* (Northern February Red Stonefly) is an attractive subject, as it is easy to identify and occurs early in the year when volunteers are keen to emerge from the winter's lull. It often perches on fence posts alongside rivers. The male drums its abdomen at around 90 beats per second to signal to a female, and the female drums back. Many of the Rare Invertebrates in the Cairngorms volunteers have enthusiastically taken on surveys and studies of this charismatic species over the past two years.

Help us find the Northern February Red

The Northern February Red stonefly (*Brachyptera putata*) is found only in Scottish rivers. We need your help to map which rivers it lives in. It's easy to get involved by following the three steps below:

Step 1

Look at fenceposts alongside the river in February and March to see if they have stoneflies on them.

Step 2

Take a picture of the stoneflies on the post.

Step 3

Send your photographs to:

scotland@buglife.org.uk

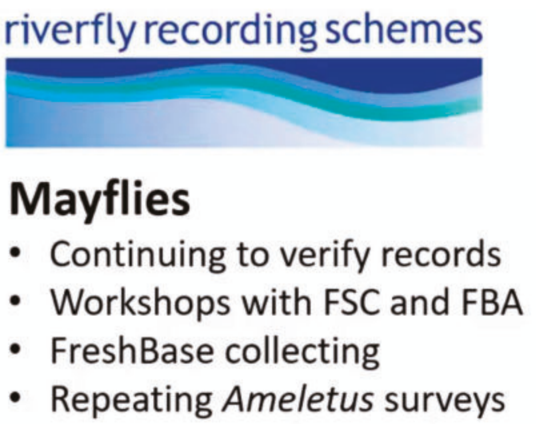
Please use the subject 'STONEFLY' and include the following information:

- **Your name**
- **Photograph date**
- **River name**
- **Location (grid reference if possible)**

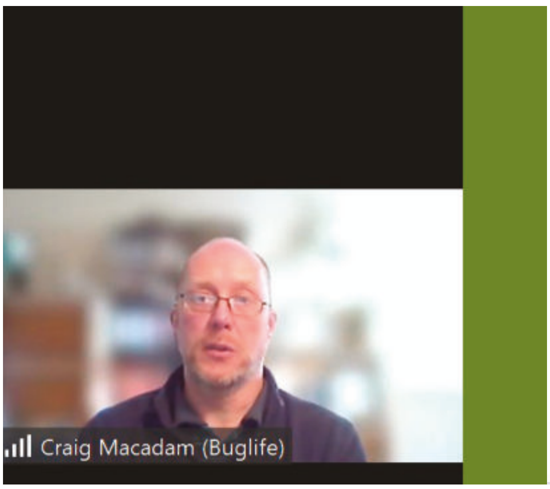
You can also tweet your photo and information to @BuglifeScotland

Photo credits: Gus Jones and Stewart Taylor

Natali Nikolova studied the mating calls of *Perlodes mortoni* (British Orange-striped Stonefly) for her undergraduate thesis at Edinburgh Napier University. Sixteen individuals were collected and analysed for duration, frequency, number of knocks and inter-knock duration. Nine hundred and thirty two male calls, 274 diphasic duets (male call, female reply) and 20 triphasic duets (male then female then male) were recorded and compared to data on sexual dimorphism, length of body, abdomen width and head width. Higher temperatures were associated with increased frequency and decreased inter-knock duration. Larger body weight led to higher frequencies. Females were more responsive to higher frequencies and shorter inter-knock durations. Surprisingly, no significant differences were detected between the calls of *P. mortoni* and *P. microcephalus*, but *P. mortoni* females did not respond to male *P. microcephalus* calls.



Co-organiser, Craig Macadam, introduced the *Siphlonurus* genus of mayflies, of which there were thought to be three species in the UK. The commonest is *S. lacustris*, which is found throughout the UK but more in the north and west. The endangered *S. alternatus* inhabits lochs and slow-flowing rivers of Perthshire, Dumfries & Galloway, East Ayrshire and Derbyshire, while *S. armatus* lives in streams that dry up in summer and, it was thought, is found in parts of southern England. Records from the Darwell Reservoir, Sussex, however, raised Craig's suspicions. They appeared to match the UK key, but something didn't feel quite right. European keys suggested that they are *S. aestivalis*, on the basis of gill structure and features of the 9th and 10th abdominal segments. Other specimens identified as *S. armatus* have since been confirmed as *S. aestivalis*, supported by DNA evidence. *Siphlonurus armatus* is now only known in the UK from three locations, two in Sussex, and one in Hertfordshire.



Drake Mackerel Mayfly (*Ephemera vulgata*) © Terry Matthews

On to caddisflies now. Ian Wallace is their national recorder and spoke about improving identification of larvae of the genus *Lype*. He is revising a 1998 key to caddis larvae and developing an online training manual, but there are issues over how to make it widely available. *Lype* larvae eat decaying wood and digest the microorganisms causing the decay. *Lype phaeopa* is common, *L. reducta* less so. They can use adjacent water bodies but have never been found together. What keeps the two species apart is unknown; perhaps temperature, oxygen levels, water chemistry or different digestive abilities. There are no obvious structural differences between them, but in *L. reducta* there tend to be two distinct colour zones on the frontoclypeus, whereas in *L. phaeopa* it is relatively uniform. Some specimens fail to fall clearly into one category or the other, but Ian is confident that a new feature, the 'Rinne Wiberg-Larsen character' will distinguish the two.


Leptocerus interruptus. First adult record in Gloucestershire for 10 years. © Steve French

Steve French came to caddisflies via moth trapping, when he inadvertently thought a caddisfly was a micromoth (caddisflies have hairs, not scales) and became interested in moth trap by-catches. He has set up a 'Moth trap intruders' Facebook group to collate records of non-moth appearances in light-traps. These include beetles, true flies, hemipterans, bees, wasps, ants, spiders and even birds, mammals and amphibians, which stake out light-traps hoping for a meal. The most surprising intruder recorded by a group member was a Puffin! The Facebook group now has 1,700 members and is growing fast. Caddisflies are very common in light-traps, the most abundant being *Limnephilus lunatus*. *Leptocerus interruptus* was a notable find in 2019 – the first adult record of the species in Gloucestershire for 100 years. Common mayflies include *Ephemera danica* (Green Drake Mayfly), *Cloeon dipterum* and *Serratella ignita*. Stoneflies are less common, but *Leuctra* species have occasionally been found in traps near rivers. Dragonflies and damselflies are commonly found. A shield bug, *Pinthaeus sanguinipes*, was the first record for the UK. In just over a year, there have been 3,334 records from 94 recorders covering 549 species.

Sophia Ratcliffe is data manager for the NBN Atlas. She described a new collaboration called 'iNaturalistUK' (https://uk.inaturalist.org), and an associated identification phone app called 'seek', which is engaging and easy to use. Wildlife observations can be shared on iNaturalist, which has a global network, and each participating country has a separate website. iNaturalistUK was launched in 2021 and is led by the NBN Trust, Biological Records Centre and Marine Biological Association (MBA). It includes over two million observations. The MBA uses iNaturalist for 'CrabWatch EU', teacher and school engagements, 'bioblitz' events *etc.* iRecord imports daily all UK 'research-grade' records from iNaturalist for verification, and over a million records have been automatically imported since September 2012. Thanks to Ian Wallace and Craig Macadam's reviewing, caddisflies, mayflies and stoneflies have the greatest verification rates. The NBN Atlas is the UK node of the Global Biodiversity and Information Facility (GBIF). It is clear that there is a rapidly-growing one-stop shop for global biodiversity records.

Jennifer Dodd (Edinburgh Napier University) is studying the impact of river channel restoration on macroinvertebrate communities and has been working on the Beltie Burn, a tributary of the River Dee, since 2017. According to the Roy Military Map of Scotland, the Beltie Burn showed a sinuous river channel. By the mid-19th Century the channel had been straightened to accommodate agriculture-associated drainage and a railway. Restoration funding was secured by the James Hutton Institute via NatureScot's Biodiversity Challenge Fund, and in September 2020 sinuosity was returned to sections of the river. Two control river sections (straightened, negative control and natural, positive control) are monitored in concert with the newly created meandering channel. In each section, a 1 km reach is surveyed for macroinvertebrates. Physical features of the river, such as depth, width, velocity, substrate and sediment characteristics are also measured. Variability in depth was greatest in the restored site and lowest in the negative control. Substrate was much finer in the restored site. Prior to restoration, the natural site supported a higher family richness than the straightened site. Monitoring of the physical and biological conditions of the newly-created river channel will continue for at least the next five years and the response to restoration will be compared with the controls. It is hoped that the newly-created habitats will improve niche space available and support a greater diversity of species. Jennifer is now investigating differences in species niche preferences to help explain the likely impact of restoration.

The first day concluded with updates from Ian Wallace and Craig Macadam on the recording schemes. Ian reported that there were 720,000 entries for the NBN caddisfly atlas, the main sources for adults being iRecord, iNaturalist and individuals and, for larvae, the Environment Agency. Species accounts have been written for the atlas, but the types of illustration are yet to be determined. Habitat photos will only be included if they add intriguing detail. Caddisflies showing the greatest rate of range expansion are *Leptocerus tineiformis*, *L. interruptus*, *Ceraclea senilis* and *Limnephilus decipiens*. Craig reported that some mayfly species are retreating uphill as a result of rising temperatures, and that a brand-new stonefly key, covering the morphology, ecology and life history of all UK species is nearly complete.

Skills Workshop: Extraction, Visualisation and Analysis of Aquatic Insect Data

It was great to see around 20 attendees learning about aquatic insect data. Arron gave a brief overview of what data are available in the public domain, what these data could look like and how they could be used. There was then an interactive session taking some aquatic invertebrate data from the Environment Agency public domain and converting the data into the Biological Monitoring Working Party (BMWP) indices to better understand the response to pollution upstream and downstream of a reservoir. Participants enjoyed this; they had to put their thinking caps on to work out what was going on while also attempting to extract some data. There was feedback that a digital skills session would be a good idea so Arron will be looking at organising an event in the latter part of 2022.

Ecdyonurus sp.
© Matt Eastham

Many thanks to all contributors and to their co-authors. Craig is standing down as Aquatic Insects SIG Convenor after 20 years and deserves huge thanks for making it such a success. Thanks, too, to Arron for taking the helm.

Jeremy Thomas

Living with the Blues

HONORARY FELLOW INTERVIEW

The rain lashed my windscreen from leaden skies as I meandered through the sinuous Dorset lanes. My satnav had decided I would benefit from a more scenic route to my destination. So, despite the weather I found myself enjoying some of the picturesque hamlets and villages that Dorset is famous for while on my way to visit Jeremy Thomas at his home deep in the rural heart of this county. Jeremy is an entomologist who needs no introduction; his name is synonymous with the conservation of butterflies, and in particular the Large Blue. He is the champion who unravelled the full complexities of the Large Blue life cycle and then vigorously campaigned for, and oversaw, its reintroduction to the UK. Arriving in his quiet hamlet, I walked through the garden to his house and knocked on the door, which was flung wide offering a warm welcome from my host. Jeremy made coffee and we settled into the armchairs in his lounge where he regaled me with stories from across his career.

Early Life

Jeremy began by explaining, "I spent the first three years of my life in Aden where my father was a diplomat. I don't remember much but I do recall having a pet gazelle. We then moved back to the UK to Dorking and then Coulsdon and finally Horsham, where I spent my teens.

I was fortunate that natural history was an integral part of my life. My mother was very keen on birds and flowers and taught us the names of all the common species. She would also take us out bird watching very early in the morning.

I was also very lucky with the various schools that I went to. At my pre-prep school we went on regular nature walks and at prep school I had two very good teachers, Mr Hands and Mr Holland, who would take us out into the countryside. We would also visit chalk quarries to hunt for fossils, and they often took us to visit Haslemere Museum to view their collections. It was Mr Hands who encouraged me to start a butterfly collection, as back then this was a natural thing to do. They were only common species such as Meadow Browns or Small Tortoiseshells but this kindled my lifelong interest in these insects.

Then at my secondary school I had Mr Potts and Mr Thompson who were both keen natural historians. Mr Thompson was a botanist who encouraged me to draw the wild flowers that we collected. As a result, I really came to understand their morphology. Once you dissect and draw a flower you really come to appreciate its beauty and complexity. At after-school clubs we collected worms at night and observed the native crayfish in the river Pang.

We also conducted a number of research projects, one of which was on locusts, during which I reared hoppers at low and high population densities to observe their development into either swarming or (green) solitary adults. To obtain the locusts I visited the Anti-Locust Research Centre in London. My mother drove my sister and me to London where they gave me a container full of locusts. On the way home in the car I could not resist taking a peek and cracked the lid just as we rounded Hyde Park Corner. They were faster than I anticipated and they flew out of the container, filling the car with a storm of whirring wings that swarmed around my mother, much to her annoyance and consternation. My sister was horrified and opened the window so we lost half of them, but I managed to reclaim the rest and we arrived home safely. Using the locusts I had managed to save, I was then able to obtain eggs and run the experiment.

At school, biology was actually my worst subject; the prizes I won were for maths, poetry and art. In fact, at one point I wanted to go to art school but having talked to artists later in my life (all of whom were much better than I would ever have been) I realised how hard it would have been to make a living as an artist, so I am now very glad I did not."

Me searching for overwintering Brown Hairstreak eggs on blackthorn during my PhD.

University

"At the University of Cambridge I attended one of the smallest colleges, Corpus Christi, where I had two outstanding tutors, one of whom was Oliver Rackham. There were only two of us taking biology that year and then the other student dropped out, so I had one to one tutorials with Oliver right through my Cambridge career. He had a formidable memory; I remember him commenting on one of my essays in the third year and referring back to comments he had made on a first-year essay, which he quoted word for word. Looking back on that time, to have had those personal tutorials with Oliver Rackham was just incredibly good fortune.

Cambridge had a natural sciences tripos system, so students had to choose three subjects from a wide range. I selected the biology of cells, the biology of organisms and geology. I studied these for the first two years and then specialised in zoology in the final year. The course was taxonomically based but it did contain some animal behaviour and a fair bit of insect physiology. This was because Vincent Wigglesworth had a chair in the department. He did not teach as he was a rather shy man who stayed in his labs, which were a series of sheds on the roof of the department. But many of his ex-students had gained lectureships and were then teaching in the department.

While I was an undergrad I had wanted to go into broadcasting or maybe even politics as I wanted to promote nature conservation, but I eventually realised that I could be most effective conducting conservation research. In my final year Norman Moore gave us a series of lectures that were truly inspirational. He was a dragonfly expert who was head of the Wildlife

Releasing a Large Blue from an emergence trap placed over a *Myrmica* nest that had adopted caterpillars the year before in the last UK colony.

and Toxic Chemical Department at Monks Wood. After his last lecture, I asked him if there was any chance of a job in his group at Monks Wood Experimental Station, then a Nature Conservancy research lab, rather than move to Oxford where I had been offered a DPhil studying weasels. He thought about it for a moment and said "Maybe. Come over and we can talk about it". So, after finals I arranged to visit Monks Wood. I had a friend and fellow student, Richard Tedder, who offered to drive me over as he too wanted to see Monks Wood. Richard's father was Lord Tedder, Marshal of the Royal Airforce. He turned up with one of the family's cars, a 1920s Rolls Royce, so we drove to Monks Wood in great style. On arrival he parked it just outside the director's office. The director was Kenneth Mellanby who rushed out to inspect the car and was extremely impressed as it was a 'red Rolls Royce,' a rare early model with the RR in red. I introduced him to Tedder and there was an animated conversation between the two after which Mellanby turned to me and said "no problem at all we must have you here". So by the end of the day he had organised a funded PhD for me with Norman Moore and Bill Block as supervisors."

Monks Wood

"I was the first PhD student they ever had. Norman suggested a couple of ideas, one was hedgehogs and the other was to look at the two *Prunus*-feeding hairstreak butterflies and work out why they were so rare. I chose the hairstreaks and began studying Black Hairstreaks in a band of woodlands that ran across the midlands from Peterborough to Oxford, and Brown Hairstreaks in the woodlands of Surrey.

The research station had only been set up a few years before and there were about 100 people working there, fifty of them scientists with an average age of under thirty. It was a very exciting time. There were amazing conversations over lunch. I remember discussion as to why swans could be dying: it turned out that it was caused by the fishermen's lead shot that they were ingesting. This information was about to be released when the government suppressed it (as members of a quango, we were all bound by the Official Secrets Act). But a senior scientist then leaked it to the press as he felt it was in the public interest.

The year I arrived the RSPB had moved to Sandy, just down the road. They were also predominantly young people and we would socialise on a regular basis, but in-between darts matches and other events, we discussed conservation issues.

I received little direct supervision from Norman as he was extremely busy talking to politicians in the UK and the USA trying to ban the pesticides DDT and Dieldrin. However, as the only PhD student, the scientists at Monks Wood took me under their wing."

The Large Blue

"A joint committee for the conservation of the Large Blue had been set up in 1963. The RES were founder members; in fact, the Large Blue runs through the history of the Society like the lettering in a stick of rock. For example, all of the papers describing early investigations of its life history were published in the Society's journals, and the RES established the first nature reserves for it in the 1920s-30s. Other members of the committee were landowners such as the National Trust, the Wildlife Trusts and Natural England. At that time the Large Blue was on the brink of extinction, being found on only two sites in the UK, whereas ten years before it bred on at least thirty sites.

In the second year of my PhD, I was 'asked' to interrupt my studies and go to Devon to try to unravel the biology of this butterfly, since 120 years of previous attempted conservation initiatives had in every case failed. It's strange looking back as now there are thousands of people studying the ecology of butterflies, but then there were about six globally. I was the only person available in the UK.

I was given access to a site that had just six adults flying on it and spent my time hunting for eggs and mapping their distribution, but I achieved rather little. Then a committee member took me to one side and told me there was another site, the top secret site X, which had a larger population. The flight season was over by then, but I drove down and mapped the eggs which were far more abundant. I slept in my car in a layby and continued searching and identifying the ants the following day.

Jack Dempster then found me funding from the NERC, which employed me for the next six years to continue the study of the last Large Blue colony. Each April to October I took accommodation near the site and lived with the Large Blue day in day out, identifying and measuring every factor that killed each stage of the life-cycle or influenced oviposition and dispersal, and generally uncovering its life history.

The PhD had taken a back seat as I was doing so much on the Large Blue. It was going extinct, so I had to concentrate all my efforts there. The PhD had been delayed by eighteen months initially, and my university supervisor Bill Block would often ask me how it was going. "Fine" I would say "I am getting there". Then one spring he called my bluff and told me the viva was in five weeks' time. There were no word processors back then so I wrote my thesis out longhand. I stayed in my room at Monks Wood and wrote through the night, taking the manuscript to a typist the next morning. I ate breakfast in the local transport café before returning to my room to continue writing. It took four weeks to complete the task but I made the deadline. The task was made more difficult as there were Nightingales in the scrub outside my office window and they would sing at fortissimo all night, which was really distracting. It would have been wonderful at any other time but at that moment!!!!!!!!!

As the Biological Records Centre was also based at Monks Wood, I simultaneously collaborated with John Heath and Ernie Pollard who were producing the first ever UK atlas of British butterflies. John provided the maps, I wrote all but four of the species accounts and Ernie wrote the introduction and analysis.

At this time it was assumed that most butterflies dispersed so widely that it was impractical to monitor changing population sizes in any meaningful way. I had been walking some of the woodland rides at Monks Wood recording the flowers that the various butterfly species were feeding on, and I realised that on successive days the counts of each species seen were uncannily constant. So Ernie and I sat down to discuss the possibility of transects to assess butterfly populations. Thanks to my interest in photography, I knew when butterflies were active and when they were not. Ernie and I worked

Releasing a Large Blue on a restored re-introduction site in the 1990s (photo: David Simcox).

out a method which would involve an imaginary box of a standard width and we agreed on the minimum temperatures and wind speed at which counts could be conducted. I wrote up the method for recording, and the next week Ernie and I conducted the first butterfly transect. Ernie then rolled the method out as the National Butterfly Monitoring Scheme, and with Ken Lakhani developed statistical analyses of the results.

In 1974 I moved to Furzebrook in Dorset where Mike Brian and Graham Elmes were studying the socio-biology of Red (*Myrmica*) ants, the hosts of Large Blue larvae. I brought ecology to the mix, identifying both the Large Blue's exclusive specificity to a single host, *Myrmica sabuleti*, as well as the narrow niche occupied by that ant under UK climates. Years later Graham Elmes, Toshiharu Akino (an excellent postdoc from Kyoto) and I analysed the hydrocarbon secretions of Large Blue larvae, confirming their mimicry of a single ant species' recognition profile. I also had a theory that the larvae were being treated as queen ants, and I suspected that they were sending acoustic signals, but we did not have the equipment to investigate it. Eventually, Karsten Schönrogge, Francesca Barbero (a talented PhD student from Turin) and I modified an MP3 player to record the sounds produced by the ants and Large Blue larvae. When we played these sounds made by the butterfly to *Myrmica sabuleti* workers they clustered around the speakers in a defensive group. It quickly became apparent the queen *Myrmica* ants did indeed make distinctive sounds to their workers, which Large Blue larvae and pupae mimicked and so were treated as royalty within the nest.

Unfortunately I discovered the host specificity of the Large Blue larvae too late to save the last UK colony. It took two years to determine host specificity, another two years to obtain statistically significant data, then another five years to describe the niche of the ant and to persuade landowners to change the management regimes to encourage the ant. These delays meant we were a year or so too late to save the UK populations but it was decided that we could restore the habitat and re-introduce the butterfly.

It took time to find a suitable source population until Graham Elmes found large numbers of Large Blue larvae in *M. sabuleti* nests in Oland, Sweden. So David Simcox and I visited Oland and found that the numbers were large enough to seek permission to collect some and take them to the UK.

Although we were commissioned to make the introduction by one UK government department, the department issuing the licence allowing us to import them never came up with the correct paperwork, but rather than miss the opportunity we went ahead anyway. This resulted in the then Ministry of Agriculture threatening to prosecute me, but in the end they backed down.

David and I introduced the butterflies as young larvae, and after about twelve generations they became adapted to the local Somerset conditions and eventually to the Cotswolds. I was the Large Blue project officer from 1972 until 1999 when David Simcox took over from me and has run the project with Sarah Meredith since then.

The Large Blue was a major strand of my ongoing career, and during the 1980s-2010 I had the pleasure of extending research to all five recognised (and Endangered) species of *Maculinea* on the continent. This culminated in two EU Framework awards that enabled roughly 100 younger scientists and conservationists from 15 universities and institutes across Europe to study aspects of their biology for seven years, with a very pleasing knock-on that a good many of them now hold tenured positions in their universities. A far cry from the 1970s when I worked alone on the *Maculinea*!

During this period, I also spent time analysing the data coming out of the butterfly monitoring and mapping schemes, and used the same methodologies for the Large Blue to look at other endangered butterflies. One of the insights I gained form this early work was that the Large Blue and the Black and Brown Hairstreaks were far less dispersive than anyone had previously thought, and that their larvae were far more specialised than anyone had appreciated. My team and I also studied the Silver Spotted Skipper, Adonis Blue and Heath Fritillary, again measuring their low dispersal and identifying the narrow niches exploited by their respective larvae. Four of these were on trajectories of decline that – by extrapolation - suggested national extinction by the current century. Happily, this knowledge was widely incorporated into agri-environment and other management schemes, and all are thriving today.

I was greatly helped, in the second half of my career in NERC's Centre for Ecology & Hydrology, by the UK Research Council's Special Merit Promotion scheme whereby a few research scientists are independently promoted to the equivalent of a university professorship, yet spared most responsibilities of management. However, all good things come to an end, and for my last four years I was 'persuaded' to be Director and Head of site of CEH's Dorset research laboratory, with about 75 tenured staff (plus c 50 postdocs *etc.*) formed from the merger of Furzebrook and the East Stoke Freshwater Laboratories. This was a difficult time as it was already listed for closure under government cutbacks, and many staff were understandably distressed. I, however, was fortunate again in being offered the Chair of Ecology at the University of Oxford plus a Professorial Fellowship at New College. Intellectually enlightening, it has been one of the happiest and most productive spells of my career, lasting seven years until retirement, though I remain active as Emeritus Professor in both research and its application to conservation, still with departmental and college facilities".

Miriam Rothschild

"Miriam was extremely kind and helpful. She wrote to me when I was doing my PhD, inviting me to study Black Hairstreaks at her home, Ashton Wold. She was very supportive; if I had a problem Miriam always knew someone who could advise. Early on she invited me to join the Entomological Club, the oldest entomology society in existence. It is really a dining club with just eight members that meet twice a year to discuss entomology and exchange ideas. We also run the Verrall Supper each year."

At this point Jeremy brought out a number of Frederick Frohawk's notebooks, which we browsed through.

"These were given to me by Malcolm Spooner who was then the chair of the Large Blue committee". Malcolm knew Miriam as he had worked with her at Bletchley Park.

"I took these notebooks to a meeting of the Entomological Club at Ashton Wold to show Miriam as there were postcards in the books from her father to Frohawk. She looked at them quizzically and said, "I remember these, I lent them to Spooner years ago". So I said "You had better have them back then" but she said, "No no no they are no good to me. They will be far better off with you". When Frohawk died Miriam had tried to sell his drawings to raise money for his widow but it was the beginning of the war and they failed to sell. The story had circulated that they remained in London and were all destroyed in

Frohawk's long-lost original drawing of a Large Blue caterpillar being adopted by a red ant, a generous present to Jeremy from Miriam Rothschild. Frohawk's initial field sketch (mounted below) was found years later among the notebooks used to prepare his classic *Natural History of British Butterflies.*

the blitz. To our surprise, Miriam said they were never in London and that they all came here to Ashton Wold. "I think I still have them here somewhere" and she dug out a pile of drawings which she deposited on my lap. In amongst them was a drawing of the Large Blue larva being carried by an ant. "Wow", I said, "This is the original of the drawing that is now in all the textbooks." To which she replied, "You had better have it then". At which point Jeremy took it off the wall in his study to show me.

"Miriam's father, Charles Rothschild, founded the Wildlife Trusts, and one of the things he did was to review the key wildlife sites across the UK. These were good examples of their habitat type and he hoped they could be preserved as nature reserves. The Royal Society asked me to go through these notes and reassess the sites to see how many were still viable and could they be restored. This was a massive report that took me six months to produce. Sadly by then some had been destroyed and many had become degraded.

Miriam had arranged for the national lottery to fund this restoration and once I had identified the viable sites restoration could begin. Peter Marren then went on to write a book with Miriam that detailed the viable sites. This was published as *Rothschild's Reserves: Time And Fragile Nature*."

RES

"I have served the Society regularly since the 80s, working under all three of the registrars. I was initially on Council for two spells and also Vice President twice under Cyril Clarke and Jack Dempster's Presidencies. I was particularly involved with the Society's role in conservation which has always been an important role for the RES; for example, the re-introduction of the Large Copper and early work on Large Blue were carried out by the RES. But when the government set up the Nature Conservancy in 1949 and the Wildlife Trusts and the National Trust became major players in nature conservation, the RES took a step back from practical conservation. Instead, the RES led in establishing a Joint Committee for the Conservation of British Insects in the late 70s to create new policy for insect conservation: I was appointed the survey officer. I have also been involved in many of the symposia, am the current chair of the conservation committee, and was President of RES from 2012 to 2014.

In 2015 the CEO of the Gloucestershire Wildlife Trust approached me with a proposal. The reserve at Daneway Banks – one of the richest limestone grasslands in the country - was coming up for sale and they wanted a complementary organisation bringing expertise and prestige to

The opening of Daneway Banks by HRH Prince of Wales. Left is Ellie Harrison, TV presenter and President of Gloucestershire Wildlife Trust; far right, Roger Mortlock, CEO of GWT. We are sitting on a bench that has a carving of the Large Blue's life-cycle!

With David Attenborough and John Pickett (my successor as President of RES) at a celebration of 25 years' successful re-introduction of the Large Blue to Britain, held at Montacute House (donated for the day by the National Trust) in Somerset (David has been a good friend to both the project and personally over many years).

be partners. He originally suggested Oxford University (where I held the Chair of Ecology) but I thought the RES might be more appropriate since Council had recently ruled that RES should once again seek to own and run nature reserves for insects. It was also a very cheap 'sweetheart deal' as the owners wanted us to have it. Daneway has

been a great source of pleasure for me and I hope the RES will do more of this in the future. As a near neighbour, the Prince of Wales has been involved in Daneway from the very start. He made a donation to the original purchase and then agreed to open the site. That was a busy day with many dignitaries to engage with, so the Prince then came back on a quieter unofficial day to see the Large Blues. More recently, the Prince of Wales's Charitable Trust provided a £209K award to RES to employ David Simcox and Sarah Meredith to restore further sites for insects and rare plants in the Cotswolds and Somerset."

We had paused briefly to snatch a bite to eat, but it was only when Jeremy's wife Sarah returned home that we realised we had been talking for almost four hours. So, in true English style we drew the conversation to a close over a cup of tea. Four hours with Jeremy had been revelatory - those conversations and stories had revealed a man whose dedication to the cause of insect conservation went way beyond the roles he had fulfilled. I was reminded of a colleague of mine who, responding to a question about being a biologist, said "Being a biologist is not what I do, it's who I am". This certainly applies to Jeremy. Insect conservation is his life, not his career. He has seen insect conservation evolve from a few isolated champions working in comparative isolation to a mainstream discipline that employs thousands of people around the world. But more importantly he has been one of the major drivers behind this evolution and continues to ensure that it moves forward. He has also been instrumental in ensuring that the RES continues to be a major player in the field of insect conservation. As he indicated in his colourful confectioners analogy, conservation is deeply embedded in the Society's history and it is a vital aspect of its future strategy. Jeremy's role as a champion of vanquished species has inspired generations of entomologists to follow in his footsteps. So it is reassuring, as we move into an uncertain future, that Jeremy's influence and his ongoing legacy will continue to strive for a more equitable relationship with the natural world.

Peter Smithers

Grant Reports

Insect Odyssey: Insects, Books and the Artistic Imagination

Dr Elisabeth Darby

Figure 1. Bridget Bailey: *Taxonomy of Making* (detail). Photo: Tas Kyprianou

Insects have long fascinated both fine and decorative artists. From Albrecht Dürer's *Stag Beetle* (1505) to Damien Hirst's multiple butterfly works, and from the porcelain *Goat and Bee* jug (Chelsea, c.1745) to the dragonflies adorning the *art nouveau* creations of Emile Gallé and L.C. Tiffany, artists and designers have employed insects in multiple ways: as form, as decoration, and to symbolise diverse concepts such as change, industry, disease, decay, and social harmony. Moreover, some contemporary designers have actively engaged insects to assist in the creation of objects, notably Tomáš Libertíny in his *Honeycomb* vase 'made by bees' of 2006. The Swedish group Front's series *Made by Animals* included a table with 'decoration' resulting from beetle infestation (2005). These artists will possibly have used entomological publications to assist them, together with first-hand observation, but the books themselves will probably not have constituted an integral part of the new work. This is how the exhibition *Insect Odyssey: Insects, Books and the Artistic Imagination*, at The Salisbury Museum, distinguishes itself.

Insect Odyssey is a multi-media exhibition which explores insects through the interpretations and visual responses of 27 contemporary artists and makers to the publications which, since the seventeenth century, have documented and illustrated these intriguing creatures. The concept arose in conversations between Entomologist Dr Michael Darby, Artist/Curator Prudence Maltby and Design Historian Dr Lis Darby about the aesthetic and scientific significance of entomological books and journals, and their future in our digital age. From this arose a discussion about how these specialist publications spawn more popular illustrated guides, and how all these served to highlight the work of the entomologist and the importance of invertebrates in our increasingly fragile ecosystem.

These wide-ranging conversations led to the idea of offering selected artists and makers an illustrated entomological publication to use freely in the creation of a new piece for the exhibition. While there have been other exhibitions which have explored the influence of insects on artists and craftspeople, none (as far as we are aware) have utilised original scientific publications as the starting point for the creative endeavour. This unique approach gives an historical dimension to the project and permits the role of the entomologist in identifying and classifying species to be highlighted.

The curators deliberately chose artists working in different disciplines and media from across the UK and further afield to mirror the rich diversity of the insect world. Through the varied scales, materials, colours, and textures employed in the new works, and through the narratives embedded in them, the aim is to draw attention not only to the myriad physical and behavioural characteristics of insect populations, but also to the historical, cultural, and social associations they provoke. A small number of existing art works have been included to support the exhibition.

The artists approached the publication and insect world in differing ways and one of the many exciting and rewarding aspects of this project for the curators has been to observe the varied and imaginative journeys of the participants. Indeed, Bridget Bailey, who has used her millinery skills to create her insects, was drawn to document the whole process of making – her own odyssey. Assembling books, actual insects, various materials, and pieces of equipment in her display, she records the trials and errors of making the insects,

Figure 2. Kate Kato: *Transactions of the Entomological Society of London, 1891*

noting "there are so many parallels in the evolution of making with the way nature evolves" (Fig. 1).

For several of the artists, the exhibition concept determined the presence of the entomological book itself in the final work. Thus, Kate Kato "wanted the pages of the book I was sent to come to life" and used some of these, together with wire and thread, to create life-size insects crawling out of the publication. Painted with watercolour, the pages of the book are visible on close inspection (Fig. 2). Su Blackwell cuts and shapes paper to create book sculptures and in her piece for *Insect Odyssey*, she explores the interdependence of insects and plants, specifically how bees, flies, butterflies and moths are attracted to particular flowers. Kate Holland bound a copy of Jenny Whittle's miniature book *A Beetle Assembly* (1985). Executed in goatskin and gold leaf, with articulated green enamel-effect elytra and vellum articulated wings, this tiny creation (just 34x28x12 mm in size) thus appears as both book and beetle (Fig. 3). Tess Chodan encrusted the pages and cover of her volume on bees with sustainably sourced insects which are partially gilded, while in *Flight of Imagination* by Susan Horth, various insects in wire, mesh, beads, pearls and paper emerge from the book, ready to take flight (Fig. 4).

Some of the represented artists and makers were drawn specifically to the physical characteristics of insects as they are detailed in entomological publications and displayed in collections. Thus, Peter Randall-Page's multiple images of the scarab beetle evoke the layout of scientific journals. Tracey Bush's interest in insects was triggered by a visit to the Entomology Department of the Natural History Museum in London. Prompted by an awareness of the vulnerability of collections, her work has focused on making cut paper insects which are pinned into entomological boxes in the manner of natural history specimens. For *Insect Odyssey*, Tracey responded to an article on collecting lepidoptera in the Amazons in the publication she was sent, recreating these species "by hand cutting maps of where they were found in the Amazon from vintage maps and atlases" and interspersing these with "butterflies hand cut from the text describing where they were 'taken'" (Fig. 5).

The ceramic artist Patricia Low's passion for insects was also first instilled by a visit to the Natural History Museum in London. She makes intricate preparatory drawings before transferring the image onto her coiled clay vessels. Her *Elephant Hawk Moth* vase shows the insect in foliage, the naturalism of the creature reminiscent of entomological publications and contrasting with the intricate linear pattern in gold lustre inside the vessel (Fig. 6). Julie Ayton's ceramic bowl for *Insect Odyssey* juxtaposes a plain dark exterior with an interior inspired by the pages of *The Observer's Book of Common Insects* (1953). Meticulous mark-making records details of anatomy and structure, reflecting the entomologists' quest "to drill down, record and explain the alien, inexplicable magic of form and function that insect morphology illustrates" (Fig. 7).

For some artists the accuracy of physical representation is linked to their concern for species depletion. Sarah Gillespie's mezzotint diptych of the White-spot Moth and the Nottingham Catchfly flower mimics the double page spread of an open book, the softness of the technique beguilingly capturing the texture of the insect (Fig. 8). Inspired by Henry Noel Humphrey's *British Moths and their Transformations* (2 vols., first edition 1843-45), which also show abundant moths in relation to plants, her pairing acknowledges the dependence of the White-spot Moth on the Nottingham Catchfly flower, its larvae feeding exclusively on the seed heads of this vespertine wildflower. The artist is increasingly concerned about the declining number of native British moths, commenting that "the piece was born of grief". The darkness of the mezzotint, and the gradual drawing forth of the image, hint "literally and poetically of the moth and its flower being neither present, nor absent but always both" and of the dialogue between artist and the natural world: "we are relatives and share each other's fate". Louisa Crispin focuses on cabbage white butterflies, some of the most common Lepidoptera in Britain but ones which are now under threat. Using graphite, her meticulously drawn insects encourage us to look again and value these delicate creatures.

Fly Lace by Arlette Ess juxtaposes a familiar material (lace) with unexpected images of flies, each provoking different associations and emotions and representative of our two conflicting identities: "we're a product of nature on the one hand (in our original environment

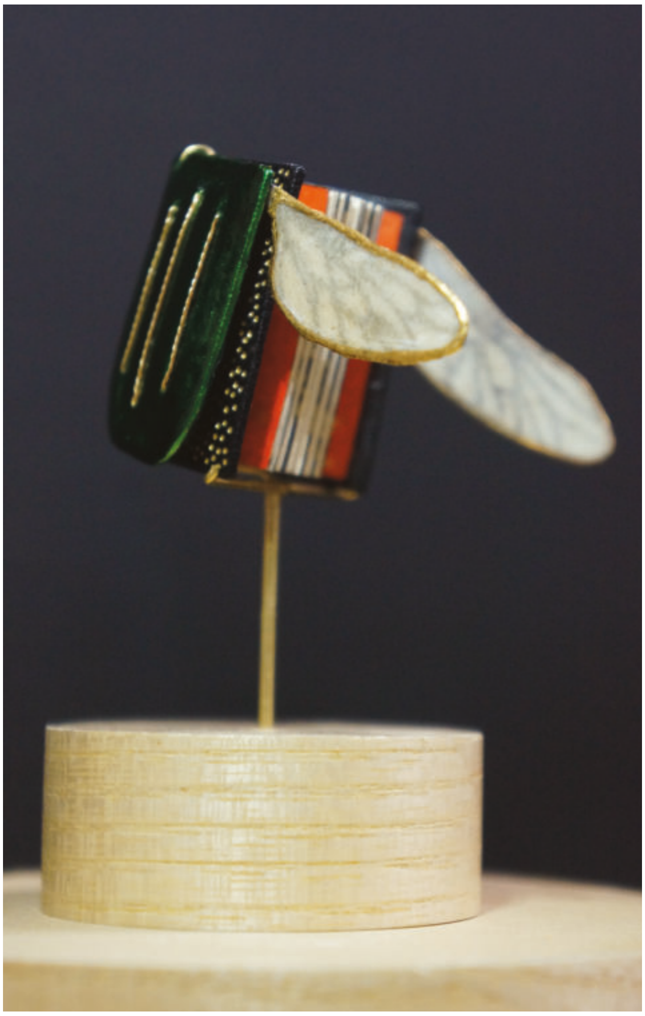


Figure 3. Kate Holland: bound copy of Jenny Whittle *A Beetle Assembly* (1985)

likely to be visited by flies), and members of an industrialised civilisation on the other (suppressing our own smell, modifying our appearance, surrounded by pesticides and man-made materials)". The synthesis of incongruous elements in *Fly Lace* aims to encourage us "to work for nature and not against it" (Fig. 9).

The entomological publications prompted several artists and makers to consider the habits and behaviour of insects. Linn O'Carroll's desk, for example, explores their significant contribution to forensic science. By studying the insect populations at a crime scene (notably the beetles and flies which are attracted to a decomposing body), forensic scientists can estimate the time of death, changes in location or position of a body, and sometimes the cause of death. The chance discovery of a discarded desk while walking (a fundamental methodology in O'Carroll's artistic practice), remembrance of a BBC Radio 4 talk by Amoret Whitaker on the role of insects in forensic science, and the arrival of Edward Step's *The Marvels of Insect Life – A Popular Account of Structure and Habitat* (1915) for *Insect Odyssey*, coalesced in the decision to create a *Bureau of Investigation* devoted to the blow fly. A creature that is "very often maligned" and that people feel repulsed by, the artist describes her own discovery of the blow fly's "value to science" as "incredible"; it is an odyssey she seeks to share with visitors to the exhibition through her multi-sensory and interactive installation. In her *Fly and Spider*, Bridget Bailey documents an everyday scene: a dead fly being preyed upon by a spider. Placed under a glass funnel (the artist's version of a dome), the battle is given new status and recalls the taxidermy scenes so beloved by the Victorians which often pitted creature against creature (Fig. 10).

Rhea Thierstein focuses on the wasp, creating a swarm of enlarged insects, each individually sculpted in acetate, wire, gold paint and gold leaf with the wings capable of movement in a gentle breeze (Fig. 11). While we are often irritated by wasps (a reaction emphasised by the scale of these imitations and their fluttering wings), they can act as pollinators and their feeding habits are important in keeping ecosystems in balance. The swarm of wasps conveys the idea of protective behaviour (crucial for so many species) but also hints at the disruption caused when one species becomes over-abundant and threatens the survival of others.

The activities of insects take a more sinister turn in the contributions of Nicola Bealing and Tessa Farmer. The illustrations of dismembered insect parts in the *Transactions of the Entomological Society* prompted Bealing to imagine their disparate elements reassembling themselves into a hybrid creature in her oil on linen painting entitled *The Mutation* (Fig. 12). Tessa Farmer's *The Intruders* is an intricate and absorbing work incorporating a range of natural materials (Fig. 13). It presents a neglected and insect-damaged collection of books into the pages of which a wasp has built a nest. Farmer's "sinister skeletal fairies" have usurped the

Figure 4. Susan Horth: *Flight of Imagination*: work in progress

nest, enslaved the wasps, causing chaos and disrupting scientific knowledge. The work comments on the need for vigilance in the preservation of entomological collections and libraries.

Both Noémi Kiss and Lou Rota have utilised insects to revitalise and give new meaning to found objects in their exhibits. Kiss, who describes herself as a "material fetishist", draws attention to the history of carpets, traded and used over decades by different people, the wear and tear slowly revealing the layers of materials and the techniques used in their construction. The *Ant Tapestry* (Fig. 14) is painted over but the silhouettes of the creatures reveal the carpet patterning underneath. Lou Rota revels in not adding to the glut of "stuff" in the world. She sources discarded ceramics and items of furniture and uses cut-out insects and plants "to transform the unloved into the covetable". Fascinated by the "graphic beauty of invertebrates - their symmetrical forms, iridescent colours, and weird and wonderful physiologies", she often catches herself making up little stories about her creatures as she positions and applies them (Fig. 15). The scurrying insects in the work of both artists invite us to look more closely not only at the insects but also the underlying artefacts and reflect on *their* lifecycle in our throwaway culture.

It is evident from these contributions that the books and the insects illustrated and discussed in them have acted as a springboard for ideas and commentary, and the narrative potential of the insect world is a strong theme throughout the exhibition. Louise Richardson's *Slip* hauntingly encapsulates this, together with a sense of time and history, whilst also subtly referencing the work of entomologists (Fig. 16). Taking her cue from Pliny the Elder's *Historia Naturalis* (Book 11, 34) "*Folke use to hang Beetles about the neck of young babes, as present remedies against many maladies*", Richardson describes the making of *Slip* as "a journey, travelling through books, uncovering the stories, remedies, superstitions, and meanings of a variety of insects". This mixed media work centres on a vintage nightdress with insects taken from the book sent to the artist (and another), which have been stitched and mounted under glass microscope slides. The classification and labelling of the insects in the piece were, for Richardson, "a visual method of making sense of what I have discovered, inspired by the collector's scientific research methodology", while their positioning in the lining of the old nightdress "symbolises the nature of storytelling, and the passing down of the folk tales we hold inside us".

Henny Burnett's research into wasps, prompted by the entomological publication she was sent, uncovered the story of the Chinese eunuch at the Imperial Court, Cai Lun who, observing that wasps build their nests by chewing wood, was encouraged to make the first paper. Illustrations of Cai Lun, photographs of wasps' nests taken by her great uncle, J. M. E. Mellor, Senior Entomologist at the Ministry of Agriculture in Egypt, in

Figure 5. Tracey Bush: *Lepidoptera of the Amazons* (detail)

Figure 6. Patricia Low: *Elephant Hawk Moth* vase

Figure 7. Julie Ayton: *The Disappearing Beetle*

Figure 8. Sarah Gillespie:

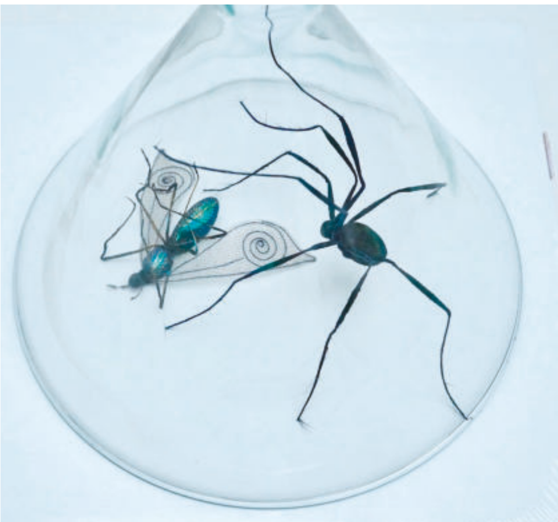


Figure 10. Bridget Bailey: *Fly and Spider.* Photo: Tas Kyprianou

Figure 11. Rhea Thierstein: *Equilibrium*: individual wasp

Figure 12.

Figure 14. Noémi Kiss: *The Ant Tapestry* (detail). Courtesy of Marion Friedmann Gallery

Figure 15. Lou Rota: Chair

The White-spot Moth and the Nottingham Catchfly flower

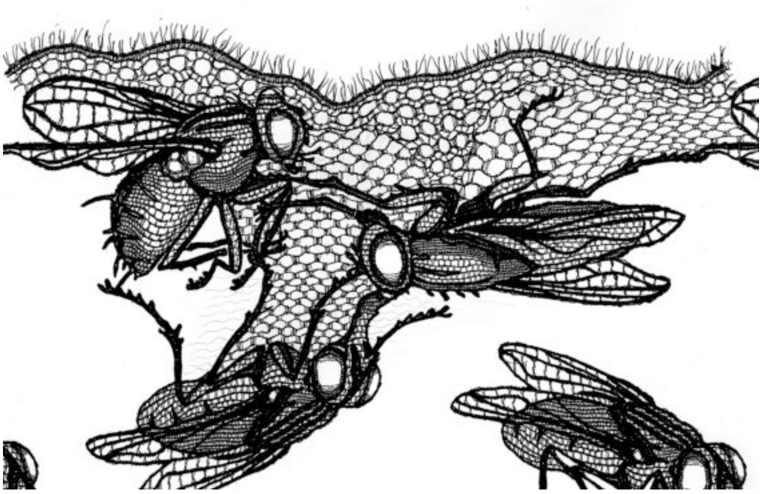


Figure 9. Arlette Ess: *Fly Lace* (detail)

Nicola Bealing: *The Mutation*.
Photo courtesy of the artist and Matt's Gallery, London

Figure 13. Tessa Farmer: *The Intruders* (detail)

Figure 16. Louise Richardson: *Slip* (detail)

Figure 17. Henny Burnett: *Vespiaries*. Photo: Martin Urmson

Figure 18. Julieann Worrall Hood: *Lost.* Photo: Matt Faber

1927, together with a film of nest-building, are combined with a sculpture based on the hexagonal structure of a wasp's nest (Fig. 17). This work contrasts ideas of nurture and protection with the contradictory feelings of wonder and fear we feel on encountering a wasp's nest.

Julieann Worrall Hood "was drawn to the shortness of life spans" and the "epic journeys" made by some butterflies described in the entomological publication she received (*Looking at Butterflies* by L. Hugh Newman, 1959). The perilous long-distance migrations of butterflies mirrored the hazards of human exile and the loss of security and home, both historical and contemporary. Her tiny butterfly wing house *Lost* was made in response to these associations, to the vulnerability and brief lives of so many species. The fragility of life is evoked by the tattered wings of the butterfly against a robust concrete base (Fig. 18).

Susan Francis's piece plays on the exhibition's themes of insects and books but re-directs us towards Franz Kafka's novella *Metamorphosis* (1915) in which the central character, the travelling salesman Gregor Samsa, wakes up one morning to find he has turned into a gigantic insect. Here, the metamorphosis is reversed and the insect that should emerge from the pupa, is the artist herself. With the film encased within a cutlery cabinet, whose open doors allow the visitor an intimate viewpoint, we follow the artist as she travels through the domestic landscape, her diminutive scale turning everything familiar into an alien world.

Manipulating scale (evident in many of the works for *Insect Odyssey*) also characterises James Morton-Evans's boxes which reference the natural history dioramas found in museums. Re-purposing objects and occasionally using reliably sourced dead insects, Morton-Evans enacts stories that are at once humorous and sinister within these boxes. It is in this vein that *Transactions of the Experimental Entomological Society* for the exhibition acts as a cautionary tale: "humans toy with nature at their peril" (Fig.19).

It has not been possible to consider the contribution of all the participants to *Insect Odyssey* in this article but the varied and multidisciplinary responses to the entomological publications, the personal stories and investigations of the artists, and the different emotions prompted by these invertebrates, collectively provide multiple perspectives on the physiology, behaviour and significance of insects. This is a timely project as COVID-19 has created an unprecedented engagement with the natural world, generating heightened awareness of pollution, climate change and species depletion. *Insect Odyssey* celebrates contemporary artistic practice but, in the extraordinary breadth of works displayed, it also draws attention to the fragility of insect populations, and the urgent need to protect the planet and redress the balance between man and nature.

Figure 19. James Morton Evans:
Transactions of the Experimental Entomological Society

Participating Artists:
JULIE AYTON / BRIDGET BAILEY / NICOLA BEALING / SU BLACKWELL / HENNY BURNETT / TRACEY BUSH / TESS CHODAN / LOUISA CRISPIN / RUTH DRESMAN / ARLETTE ESS / TESSA FARMER / SUSAN FRANCIS / SARAH GILLESPIE / KATY HARRALD / KATE HOLLAND / SUSAN HORTH / KATE KATO / NOÉMI KISS / PATRICIA LOW / JAMES MORTON-EVANS / LINN O'CARROLL / PETER RANDALL-PAGE / LOUISE RICHARDSON / LOU ROTA / KT ROTHE / RHEA THIERSTEIN / JULIEANN WORRALL-HOOD

Insect Odyssey: Insects, Books and the Artistic Imagination
25 June to 25 September 2022
The Salisbury Museum
The King's House, 65 The Close,
Salisbury SP1 2EN
Tel: 01722 332151
www.salisburymuseum.org.uk

The exhibition is supported by a Goodman Award from the Royal Entomological Society.

Royal Entomological Society

RES Student Award 2021

The Royal Entomological Society is excited to announce the winning, second and third place essay entries of the 2021 RES Student Award. To enter the annual entomology writing competition, students write an 800 word essay in English, on an insect-related topic of interest to the general public.

Prof. Adam Hart, RES Trustee and Chair of the RES Outreach Committee, and Dr Victoria Burton, Outreach Committee member, oversaw the judging of entries. Adam said, "As usual the standard was very high, giving us a real judging challenge. This year, lots of entries explored different ways to present 'essays', and there were some very imaginative approaches that were able to combine solid scientific material with inspired science communication. It is reassuring to see such up-and-coming talent for entomological communication!" Victoria commented, "I appreciated how many drew on their own experiences with insects in nature and related that to their personal wellbeing".

All winners can be viewed online: https://www.royensoc.co.uk/membership-and-community/awards-and-grants/res-student-award/

1st

Leah Fitzpatrick

Oxford Brookes University

ARANEAE & OPILIONES

Araneae & Opiliones LLP
One Cardinal Square
London E9 D25
United Kingdom

TO: Sir Andrew Hack
British Press Association
289 Murdoch Square
London W3 H87
United Kingdom

31st December 2021

RE: Defamation of Character and Libel by the British Press Association of the Noble False Widow spider

Dear Sir,
We represent the Noble False Widow spider (*Steatoda nobilis*, referred to as *S. nobilis* throughout) in the above matter. This letter has been sent in anticipation of our firm filing a lawsuit against you and your company, the British Press Association.

Our client has been relentlessly targeted for a decade by articles published in your papers – in 2013 there were 114 of these articles framing our client in an extremely negative light, with more misleading articles published since then[1]. Years of misinformation driven by your papers have led to our client being held responsible for causing severe public disruption including the closure of several schools after *S. nobilis* was found on the premises and 450 people admitted to A&E in 2018 fearing they had been bitten by the UK's purported 'most dangerous spider'[1,2]. The current level of targeted attack has led to eradication of our client indiscriminately despite the enormous benefit they offer humans in their pest control and small number of actual bites.

Present in the British Isles since the beginning of the 20th century, our client likely arrived accidentally on shipments from the Canary Islands and established themselves in the south of England[3]. Our client is a 'synanthrope' – meaning their preferred habitat is within proximity of humans, both urban and rural. Garden furniture or corners of outside walls are favourable habitats for *S. nobilis* due to the shelter it offers and amount of food present at these locations[1,4].

Despite the long-term presence of *S. nobilis* within the British Isles and overlapping range with humans, as of 2021 there have been only 24 confirmed bites worldwide involving our client, the first of which occurred in 1991[4,5]. We also have a number of character witnesses (formed of professional arachnologists who have worked with our client previously) that describe *S. nobilis* as a 'shy' species 'reluctant to bite'[6]. In response to perceived threats, our witnesses observed the most likely behaviour presented by our client has been to either retreat into a hiding place, run or 'play dead'[3]. We would refer you to *Latrodectus* vs. United States 692 U.S. 33 (2002) for further details on defence behaviour in a similar case. As well, medical professionals are notably poor at identifying spider bites and unless one was seen or caught a spider cannot be accurately confirmed[7].

We do concur that *S. nobilis* is capable of delivering an unpleasant bite. Our client has willingly worked with researchers to help better understand the risk they present and how to prevent conflict – to commit to this *S. nobilis* has been attending SPIDER counselling (*Speculating on Personal Intent, Decreasing Effects & Risks*) for the last 2 years. Symptoms caused by our client can be mild to moderate including radiating pain, nausea and temporary reduced mobility of an affected limb. A few cases have gone on to develop infection which has resulted in hospitalisation[4,8].

Our client is, as mentioned, very reluctant to bite – recent findings discovered that most confirmed bites have occurred during sleep (8 cases) or trapped in clothing (5 cases)[8]. The average size of *S. nobilis* is between 7-14mm, when compared to the average human who is approx. 1630-1765mm, the usage of biting by our client in response to these distressing situations (frequently resulting in death for our client) is justifiable [1,3,5]. The resulting infections, while regrettable, are often because induvials do not clean the bite site. While harmful bacteria have been identified on *S. nobilis* fangs, many animals (including domestic cats and dogs) also present this risk[8].

We do not intend to downplay any symptoms or emotional impact caused by our client in court but we will be focusing on the context of these cases. Our client has been very remorseful about these bites and is currently working with our PR team to work together with those bitten, ideally to offer compensation in the form of pest control.

The perceived risk of our client has been blown out of proportion by your papers, using aggressive language such as 'attack' to describe an unfortunate but understandable defence response by *S. nobilis*. The fuelling of fear perpetuated by your papers is disgraceful.

Finally, on behalf of our client, we must also inform you that we strongly advise against attempting to pay for damages. Our client has no need for financial compensation, although they have stated they are open to negotiating access to undisturbed corners within your office buildings.

Respectfully,
Leah Fitzpatrick, Charlotte Webb and Shelob Ungoliant

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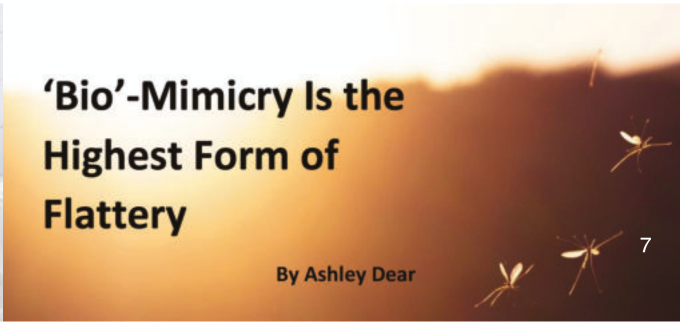
2nd

Ashley Dear
Harper Adams University



Opening a wardrobe to find a moth has indulged in feasting upon your favourite jumper, or opening a cupboard to find an ant raiding party amongst your sweet treats, or even trying to enjoy a traditional British cream tea in a beautiful English garden only to be bombarded with an ariel wasp attack is something we are all familiar with. I'm sure that at some point it has made everyone question the very existence of insects if their only role is to be a nuisance.

But these six-legged fiends should actually be considered as our six-legged friends. An incredible 480 million years of evolution, driven by changing environmental conditions and inter and intra species competition has created one of the largest taxonomic groups on the planet. Insects used these 480 million years to become specialists in their ecosystems, evolving physical and behavioural traits which we as humans have begun to recognise as potentially being beneficial to us.

The concept of biomimicry is the practice of mimicking strategies seen in nature to solve the problems of humans. These strategies can come from any field in nature but the 'annoying bugs' most people see as an inconvenience of everyday life has been a field which is providing the answer to many of our problems. What they have spent millions of years evolving to do, what makes them so specially adapted at doing what they do best, is now being studied to unlock the answers to our modern day problems.

The sharp sting of a medical needle is one that many of us have come to recognise, especially over the last two years as vaccines have become more important now than ever before. But what if painful injections could soon be a thing of the past? Sounds too good to be true? Well this is a classic problem to be solved through biomimicry.

We want to inject people in such a way that they don't feel anything. So which species has spent millions of years evolving ways in which to penetrate human skin without being detected.... much to our dismay.... the mosquito.

A team of scientists from Kansai University, Japan, have developed a needle that mimics a mosquito's proboscis and feeding behaviour to deliver a painless injection[1]. The needle is currently 1 mm long and only 0.1 mm wide but a team in the USA are already developing larger versions[2]. The Japanese team developed a silicone needle with two serrated shanks which penetrate the skin and allow a drug-administering tube to deliver a numbing agent. This along with tiny motors which vibrate the whole device to assist it easing, painlessly, into the skin, mimics the same method and apparatus used by mosquitos.

Another 'new norm' brought around by the ongoing pandemic is our increased reliance on home delivery. The delivery of goods to our front doors has been the saving grace for most of us over the last few months but the increase of door deliveries comes with more complications. More deliveries means more complicated delivery routes which also means soaring greenhouse gas emissions. So how do delivery services combat these problems?

Well, for this conundrum we turn to the beloved buzzing bumblebee. By likening our delivery stop locations to the bee's favourite flower locations, 'Routific' founder Marc Kuo created the Bee's algorithm[3]. This algorithm is based on the foraging behaviour of honeybees. Honeybees will visit many different flowers to gather nectar; not only do they learn the most optimal routes to save energy but they then communicate this to their hive sisters through the medium of dance. Although I hoped this story would be the tale of how delivery drivers are now optimising their routes through dance, it is actually a tale of how these bee dances influenced the algorithm which is now creating delivery routes which are more efficient, saving both time and greenhouse gas emissions.

These biomimicry examples are only two of the ways insects are solving the problems of modern-day humans. Nature has spent millions of years evolving solutions to the problems we now face as a modern society and it is becoming increasingly obvious that we should be searching here for further answers.

Even by only focusing on insects to help us become more sustainable, the black butterfly (*Pachliopta aristolochiae*) has micro and nanostructures on its wings which are influencing more advanced and efficient solar panels[4], the firefly (*Photuris* sp.) has already inspired the creation of a vastly more efficient LED bulb[5] and termites are reducing energy costs by influencing building designs that mimic the natural air conditioning possessed by their nests[6].

Anthropogenic causes are increasing global temperatures which threatens much of the Earth's biodiversity, yet it is this biodiversity which often holds the key to solving our problems.

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3rd

Amy Farrow
Harper Adams University

'Choose your own evolutionary pathway' – a brief exploration of the evolution and diversity of four major insect orders!

Imagine you are one of the very first insects to roam the Earth. There are many habitats to explore and ecological niches to fill, but how will they be filled and why are the insect orders all so different?

1. You are an insect, roaming the Earth millions of years ago. One day you return to your habitat and notice a lack of food for your offspring, do you:

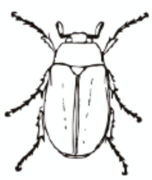
a. Develop parasitic behaviour and lay your eggs inside other insects so your young will be born safely within the insect and have instant access to food? (Go to **section 2**).
b. Hope that there is enough food to go around. (Go to **section 3**).

2. Over the past c.350-309 million years you have developed into the order Hymenoptera – the sawflies, wasps, bees and ants! Hymenoptera has c.157,388

described species, however the true number of species may be between 883,810 and 1.1 million! The success and large amount of diversity within Hymenoptera is partly down to their parasitism – many species lay their eggs inside other organisms (including inside other insects), meaning guaranteed food when they hatch! However, there were other behaviours which enabled even more diversification, for example the pollen feeding behaviours and herbivory of a broad range of plants by bees.

3. So far you have managed to find enough food for you and your offspring to eat, however a new problem arises. You notice other dangers: other animals keep stepping on you and your offspring. Do you:

a. Develop a sclerotised (hardened) forewing which serves to protect you under pressure and increase the number of habitats you can hide in? (Go to **section 4**).
b. Evade predation through flying (Go to **section 5**).



4. Over the past c.253 million years you have developed into the order Coleoptera – the beetles! The beetles have c.386,500 described species, however the true number of species may be between 1.7 and 2.1 million! Beetles are characterised by a sclerotised (hardened) forewing which can protect them from many different environmental stresses. This has allowed them to become a highly diverse order and to adapt and thrive in many different habitats such as in leaf litter, under bark and many other habitats that would damage the delicate wings of other insects.

5. Predation is still a big issue for you! You can either disguise yourself and hide, or you can find a way to escape quickly! Do you:
a. Develop camouflaging and predator-alarming patterns on your wings? (Go to **section 6**).
b. Develop nimble flight and large compound eyes to evade predation quickly? (Go to **section 7**).

6. Over the past c.245 million years you have developed into the order Lepidoptera – the butterflies and moths! Lepidoptera have c.157,424 described species, however the true number of species may be between 255,000 and 500,000! Lepidopteran wings serve as camouflage in many different environments, but some lepidopterans have brightly coloured wing patterns which can also alarm predators and scare them off. The patterning on the wings of different butterflies and moths can adapt quickly to new environments in some species (such as the peppered moth) and the different patterns are a key feature of the order.

7. Over the past c.267 million years you have developed into the order Diptera – the true flies! The flies have c.156,774 described species, however the true number of species may be between 400,000 and 800,000! The halteres - small club-shaped organs behind the forewings - are gyroscopic and are what make the flies such nimble fliers. Their flight, coupled with their compound eyes, allows for their effective escape from predators. The flies are an incredibly diverse order, with many species filling many different roles such as pollinators, decomposers/nutrient cyclers, parasites, pests and vectors of disease.

A note on evolution

This 'pick your own' evolution is a very simplified version of the factors influencing and directing evolutionary pathways. In reality, the selective pressures acting on the evolution of species is not controlled by any one factor but can be the result of multiple traits and behaviours which lead to the survival of the individual and thus the trait. As these traits accumulate over time, different species develop which are adapted to specific environments or niches and leads to highly diverse groups of insects such as the orders described above. Hopefully this exercise has inspired you to consider some of the ways in which different species have adapted and the reasons why certain traits – whether behavioural or physical – have come to be.

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Complete winning entries can be viewed online

1st Prize – Leah Fitzpatrick, Oxford Brookes University. "British Press Association vs the Noble False Widow spider." *www.royensoc.co.uk/wp-content/uploads/2022/04/RES-Student-Award-article-Leah-Fitzpatrick-updated-images.pdf*

2nd Prize – Ashley Dear, Harper Adams University. "'Bio'-Mimicry Is the Highest Form of Flattery." *www.royensoc.co.uk/wp-content/uploads/2022/04/ashley-dear-article-submission.pdf*

3rd Prize – Amy Farrow, Harper Adams University. "Choose your own evolutionary pathway' – a brief exploration of the evolution and diversity of four major insect orders." *www.royensoc.co.uk/wp-content/uploads/2022/04/Amy-Farrow-Anetnna-article.pdf*

Royal Entomological Society

RES Award for Insect Conservation

The Royal Entomological Society's Award for Conservation was established in 2002 in order to recognise a lifetime's achievement, or equivalent accomplishments, in the conservation of insects. Nominations are assessed annually by the RES Conservation Committee and recommendations submitted to Council for its final decision – no easy task due to the invariably high quality of nominees. Indeed, such has been the excellence and diversity of candidates that Council decided to award two separate Conservation Awards in two of the previous four years. And so it has been in 2022, when we are delighted to recognise the achievements of two very different entomologists, each with a reach and amazing influence for good both within and well beyond their native countries: Dr Robert M. Pyle of the USA, famous for his work on conserving Lepidoptera, especially butterflies; and Dr Úna FitzPatrick for her pioneering work on conserving bees and other pollinators in Ireland and continental Europe.

Prof. Jeremy Thomas

Dr Robert M. Pyle, Hon. FRES

From the 1970s onwards, Bob Pyle pioneered and popularised insect conservation in the USA at a time when fish, large mammals and certain birds and trees were more-or-less the only taxa considered worthy of conserving. He focused mainly on butterflies, and was elected as both an Hon. FRES and a Fellow of the Entomological Society of America for his contributions to insect conservation – one of the few entomologists to receive this latter honour who are not connected to economic entomology or pest control.

In 1971-72, Pyle spent a pre-doc year as a Fulbright Scholar in the UK under the tutelage of John Heath at Monks Wood Experimental Station, where he rapidly absorbed - and contributed to - the then emerging, world-leading ideas for monitoring, understanding the ecology of, and conserving insects. This inspired Pyle to found the *Xerces Society* (1971), the first conservation organisation devoted to insects in either of the Americas. Xerces has been a great success and still flourishes as a major driver of policy and conservation practice in the States.

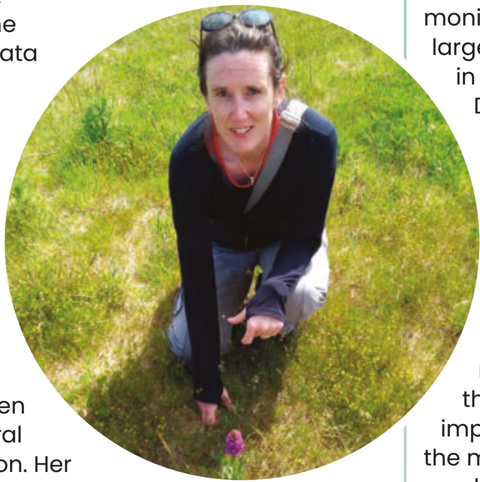
After a doctorate under Charles Remington at Yale, Pyle, Sally Hughes and Remington instituted the annual *4th of July Butterfly Counts*, which remain a hugely popular vehicle for lay involvement with insects and which increasingly yield rigorous data on changing abundances across North America. Xerces and the *4JBCs* were the models for similar activities soon to be established across Europe. In 1976, with Lincoln Brower, Pyle initiated conservation efforts for the threatened phenomenon of the migratory Monarch butterfly. He then spent two years establishing butterfly conservation in Papua New Guinea - where it was pretty much unknown - including the sustainable breeding of common species for village-supportive butterfly farms and the conservation of the rare giant birdwings. In Australia, Bob Pyle is revered as one of the 'big three' pioneers of global butterfly conservation.

Since then he has used his exceptional gifts as an entomologist, scientist, author, poet, teacher and communicator to advance the popularity, knowledge and conservation of insects – particularly butterflies - across the world. For example, during three years in 1979-82 at the IUCN/WWF's Conservation Monitoring Centre at Cambridge, he co-compiled (with Sue Wells and Mark Collins) the first *IUCN Invertebrate Red Data Book*, which laid the blueprint for all subsequent global assessments. He has also taught, lectured and inspired others repeatedly across Europe, as various nations 'discovered' and grew concerned about declining butterfly populations.

In America, Bob Pyle has popularised butterflies as author of *The Audubon Society Field Guide to North American Butterflies; Mariposa Road*: *The First Butterfly Big Year; The Butterflies of Cascadia*: *A Field Guide to All the Species of Washington, Oregon, and Surrounding Territories*; *Peterson Field Guide Coloring Books for Insects* and *Butterflies* [both for children]; *Handbook for Butterfly Watchers;* and *Butterflies of the Pacific Northwest*.

Bob Pyle is also a poet and general author of note, winner of various literary prizes including a Guggenheim Fellowship. Among the books where he brings art and literature to insect natural history are *The Art of the Butterfly; Nabokov's Butterflies*; and *Chasing Monarchs*: *A Migration with the Butterflies of Passage* (1999), the last an unusual combination of original research presented as a popular book, in which he tracked the southerly migration of western Monarchs over many weeks, thereby demonstrating for the first time that some Monarchs cross into Mexico west of the Rockies and proving that the eastern and western populations, hitherto considered separate and more vulnerable, are integrally connected.

Dr Úna FitzPatrick



Dr Úna FitzPatrick, of the National Biodiversity Data Centre (NBDC) in Ireland, receives the 2022 RES Award for Insect Conservation for her considerable and exemplary contribution to insect conservation both in Ireland and globally, where she bridges the gap between ecology, citizen science and the general public and conservation. Her work has played a huge and transformative role in recording, promoting and conserving insects.

In her early career, Dr FitzPatrick produced some of the seminal work on bee diversity in Ireland, including the first Irish National Red List of bees as well as some of the first published literature on Irish bee declines. Working at the NBDC since 2007, she has been an inspiration to biodiversity recorders and citizen scientists around Ireland, and a driving force in fostering a national interest in biodiversity, biodiversity monitoring and conservation. In addition to managing the national database of records for bees and hoverflies, Dr FitzPatrick has had a leading role in training and capacity building of biological recorders in Ireland, including running numerous ID-training workshops, a bumblebee swatch and a wealth of other pollinator ID resources. She set up the first Irish bumblebee monitoring scheme in 2011, and trained and inspired a large number of citizen science recorders to participate in this very successful scheme.

Dr FitzPatrick has recently won funding to pilot a moth monitoring scheme with Irish farmers. She also cofounded the All-Ireland Pollinator Plan (2015-2020), in collaboration with Dr Jane Stout. This initiative has been hugely successful, and mobilised 68 governmental and non-governmental organisations from the North and South of Ireland to enact pollinator conservation in over 2,400 sites nationally, eliciting special mentions from both the President of Ireland and the Taoiseach. As chair of the Plan, she leads its implementation nationally: it is now considered one of the most successful pollinator initiatives in the EU and is used as a template by many other countries. Dr FitzPatrick also secured funding for a large scale European Innovation Partnership funded project 'Protecting Farmland Pollinators' (2019-2023) to develop and test scoring for pollinator conservation measures on Irish farmland. Although much of Dr FitzPatrick's work is in Ireland, she is also involved in the development of the EU Pollinator Monitoring Scheme. She is also passionate about ensuring North-South collaboration across the island of Ireland in all her work.

In summary, Dr FitzPatrick has gone above and beyond the normal confines of her job to be a leading figure in insect conservation, both in Ireland and across Europe. She has single-handedly been responsible for a dynamic change in biodiversity recording and insect conservation in Ireland, and is an inspiring role model for many working in biodiversity and entomology.

Royal Entomological Society

RES Award for Early Career Entomologist

RES Council received a strong set of nominations for the Early Career Entomologist Award this year and the trustees are delighted to announce this year's winner, Dr Franz Löffler.

The RES Early Career Entomologist Award is for any person who is within ten years of completing their undergraduate degree or with less than ten years working in entomology whose work, or contribution, is judged to be outstanding with single or ongoing impact on the science.

Dr. Franz Löffler

Osnabrück University, Germany

Franz is a landscape ecologist who is interested in the effects of global change on biodiversity. His research covers various indicator groups with a particular focus on insects and birds. He started his career at the University of Münster, where he studied landscape ecology and began teaching animal and community ecology. In 2016, Franz received a PhD scholarship of the German Federal Environmental Foundation (DBU) and moved to Osnabrück University.

Franz completed his PhD in 2021, highlighting key challenges for biodiversity conservation in semi-natural grasslands. In his thesis, Franz especially studied the response of butterflies, grasshoppers and plants to habitat fragmentation. Moreover, particular attention was paid to long-term shifts in grasshopper distribution in Central Europe and their effects at the community level. The findings of the thesis were published in eight papers which make an important contribution to entomological research.

Franz currently works as a postdoctoral research fellow at the Department of Biodiversity and Landscape Ecology, Osnabrück University. To date, he has authored 28 peer-reviewed publications, 18 of which are in international journals. He is currently involved in various research projects which are aimed at advancing conservation actions and promoting sustainable land use. A large part of his latest work is dedicated to butterfly and grasshopper monitoring. In his future research, Franz would like to investigate what measures help species cope in a rapidly changing environment to maintain biodiversity in the long run.

To find more about Franz's work, please visit the website of Thomas Fartmann's lab (https://fartmann.net/loeffler).

Royal Entomological Society

RES Award for Best Articles

The RES journal editors have recently selected the best papers in their journals from the previous two years. The content covers a broad range of entomology, and you can read the full articles on the journals website bit.ly/RESJournalPrizes22. Here we hear from the winning authors and journal editors about our latest best papers.

Agricultural and Forest Entomology

Royal Entomological Society

Horrocks, K.J., Ward, D. and Suckling, D.M. (2020), 'Can natural enemies of current insect pests provide biotic resistance to future pests?'.
Agr Forest Entomol, 22: 20-29. *doi.org/10.1111/afe.12353*

Lead author Kiran Horrocks is currently a PhD student at the Joint Graduate School between the University of Auckland and the New Zealand Institute for Plant and Food Research. His research interests revolve around applied entomology, with a particular interest in novel and sustainable approaches to insect pest management and biosecurity.

As insect pests invade new areas around the globe at an increasing rate, the economic losses that they inflict on agricultural crops are also escalating. A common, cost-effective and sustainable method used to control these pests is the importation of natural enemies that occur in the pests' native range. However, biotic resistance theory posits that pre-existing communities can resist biological invasions due to the presence of natural enemies, and little is known about the extent to which this may occur for insect pests that are yet to arrive. The authors constructed a dataset containing introduced parasitoid wasps in New Zealand, all insects that they utilise as hosts globally, and the pest status of these hosts. From this, they were able to infer that these resident parasitoids could potentially provide resistance against 442 pest species not yet in New Zealand. This approach could be used to inform responses to pest incursions.

The journal editor, Hefin Jones, said, "Although we can go back to the classic work of Elton in the late 1950s for the foundations of the 'biotic resistance hypotheses', unlike conventional biological control, relatively few studies have considered biotic resistance from resident natural enemies against invasive herbivores. In this study, Kiran Horrocks and his colleagues explore the native New Zealand ichneumonid fauna in an attempt to determine whether communities can resist species invasions as a result of their native natural enemies. This is really exciting!"

Photo: Kiran Horrocks

Ecological Entomology

Royal Entomological Society

Guariento, E., Wanek, W. and Fiedler, K. (2021), 'Consistent shift in nutritional ecology of ants reveals trophic flexibility across alpine tree-line ecotones'.
Ecol Entomol, 46: 1082-1092. *doi.org/10.1111/een.13052*

Lead author Elia Guariento grew up in the border region of South Tyrol, in the centre of the European Alps. He currently works as a researcher in ecology with a focus on entomology, community ecology and biodiversity at Eurac Research. Besides work he is a father of two, Mia and Ania, and loves to spend time with them in nature.

This work investigated the nutritional ecology of ants on five alpine tree line ecotones. By using both experimental baiting and chemical (stable isotopes) methods, they assessed the trophic role of these ecologically-important insects. They found that both the ant community as a whole, and two of the numerically dominant taxa, changed their trophic position over the gradient, taking a higher trophic position above the tree line. This observation underlines that naturally-occurring ant species can adapt their feeding behaviour and trophic position depending on resource availability, evidence that has thus far rarely been recorded for non-invasive ant species.

The journal editors thought it was a very good piece of field biology, combining experimental and observational methods, that attracted a lot of attention in all its various forms.

Photo: Elia Guarient.

An unlucky *Phyllobius* sp. fell close to a mound nest of *Formica rufa* complex (most likely *F. lugubris*). Credit: Elia Guariento

Insect Conservation and Diversity

Royal Entomological Society

Boyes, D.H., Evans, D.M., Fox, R., Parsons, M.S. and Pocock, M.J.O. (2021), 'Is light pollution driving moth population declines? A review of causal mechanisms across the life cycle'.
Insect Conserv Divers, 14: 167-187. *doi.org/10.1111/icad.12447*

Lead author Douglas Boyes was a talented entomologist and PhD student examining the impacts of artificial light at night (ALAN) on moth populations. Prior to this he studied Biological Sciences at Brasenose College, Oxford, graduating with first-class honours in July 2017. He continued to study at Oxford, earning an MSc in Biodiversity, Conservation and Management with distinction and again conducting a research project focussed on moths. Douglas sadly died during his studies and a tribute can be found here: at *butterfly-conservation.org/news-and-blog/tribute-to-douglas-boyes.*

In this paper, Douglas and colleagues reviewed the literature to assess the effects of ALAN across moth life cycles and found evidence of diverse impacts across most life stages and key behaviours. They found strong evidence for effects of ALAN (including varying effects of lamp technology) on moth behaviour and physiology, but little rigorous, direct evidence that this scales up to

Photo: Douglas Boyes

impacts on populations, arguing that more research is necessary in this important area. The review set the foundations for a programme of work in entomology and is already impacting policy and management.

The handling editor Alan Stewart said, "The impact of light pollution on natural ecosystems has become a major research growth area in recent years. It could be one of the more insidious contributors to the widely publicised insect declines. This paper was the first to review the evidence for possible effects of light pollution across all stages in the life cycle of moths. The point the authors make about the lack of direct evidence on the impact of ALAN on populations is also of key importance. The award of the prize is all the more poignant because, shortly after this paper was published, the principal author Douglas Boyes died suddenly and entomological science lost a very promising young talent."

Medical and Veterinary Entomology

Royal Entomological Society

Ronai, I., Tufts, D.M. and Diuk-Wasser, M.A. (2020), 'Aversion of the invasive Asian longhorned tick to the white-footed mouse, the dominant reservoir of tick-borne pathogens in the U.S.A.'. Med Vet Entomol, 34: 369-373. *doi.org/10.1111/mve.12441*

This paper was led jointly by Isobel Ronai and Danielle Tufts. Dr Ronai is a Postdoctoral Fellow in the Department of Organismic and Evolutionary Biology at Harvard University. Her research interests are in ticks and tick-borne diseases of medical and veterinary importance. Dr Tufts is an Assistant Professor in the Infectious Diseases and Microbiology Department at the University of Pittsburgh, Pennsylvania. Her current interests include vector-borne diseases, pathogen transmission pathways, ecological drivers of pathogen emergence, host-vector-parasite interactions, invasive species introductions, and coinfection dynamics.

The Asian Longhorned Tick (ALT) was recently discovered in the USA and has rapidly spread across 17 states. This invasive species is a vector for several zoonotic pathogens in its native range; however, its ability to acquire and transmit USA-endemic pathogens depends on its association with reservoir host species, particularly the White-footed Mouse, a primary reservoir for various pathogens. The authors designed a behavioural assay to investigate the interactions of larval ALT and potential mammalian hosts, including humans, using hair samples. They discovered that ALTs actively avoided mouse and human hair significantly more often compared with other mammalian hosts (dog, cat, white-tailed deer). This study identified a unique tick-host interaction behaviour, suggesting that some ticks utilise a species-specific property in animal hair for host selection. The aversion of ALT to the White-footed Mouse and humans reduces the likelihood of this tick becoming an important vector for USA endemic zoonotic pathogens.

The editors chose this short communication as their outstanding publication because of the clear research questions and elegant study design which included innovative assays to understand the behaviour of an invasive tick species.

Photos: Isobel Ronai (above) and Danielle Tufts (below)

Insect Molecular Biology

Royal Entomological Society

Chaverra-Rodriguez, D., Dalla Benetta, E., Heu, C.C., Rasgon, J.L., Ferree, P.M. and Akbari, O.S. (2020), 'Germline mutagenesis of *Nasonia vitripennis* through ovarian delivery of CRISPR-Cas9 ribonucleoprotein'. Insect Mol Biol, 29: 569-577. *doi.org/10.1111/imb.12663*

Author Omar Akbari is a Professor in the School of Biological Sciences, Department of Cell and Developmental Biology at the University of California, San Diego. His lab research focuses on studying the basic genetics and physiology of mosquitoes with the overarching goal of developing innovative, novel, creative, synthetic biology-inspired genetic control technologies for reducing the burden of mosquito-borne diseases on humans.

CRISPR/Cas9 gene editing is a powerful technology to study the genetics of rising model organisms, such as the jewel wasp *Nasonia vitripennis*. However, current methods involving embryonic microinjection of CRISPR reagents are challenging. Delivery of Cas9 ribonucleoprotein into female ovaries is an alternative that has only been explored in a small handful of insects, such as mosquitoes and whiteflies. Here, they developed a simple protocol for germline gene editing by injecting Cas9 ribonucleoprotein in adult *N. vitripennis* females using either ReMOT control (Receptor-Mediated Ovary Transduction of Cargo) or BAPC (Branched Amphiphilic Peptide Capsules) as ovary delivery methods. They demonstrate efficient delivery of protein cargo such as EGFP and Cas9 into developing oocytes via P2C peptide and BAPC. Additionally, somatic and germline gene editing have been demonstrated. This approach will greatly facilitate CRISPR-applied genetic manipulation in this and other rising model organisms.

The editors marked this as an important paper that will help to broaden the use of new gene manipulation techniques in wasps and other Hymenoptera.

Photo: Omar Akbari

Physiological Entomology: How Insects Work - Linking Genotype to Phenotype

Royal Entomological Society

Matsuda, N., Kanbe, T., Endo, J., Akimoto, S.-I. and Numata, H. (2020), 'Suppression of autumnal sexual morph production in spring by a seasonal timer in an aphid'. Physiol Entomol, 45: 103-109. *doi.org/10.1111/phen.12322*

Naoki Matsuda received his Ph.D. in 2020 from Kyoto University, Japan, under the supervision of Prof. Hideharu Numata. He is currently working as a research fellow at the National Institute for Basic Biology, Japan, where he studies an interaction between the aphid and its obligate symbiotic bacterium from the perspective of the seasonal life cycle of the host aphid.

Aphids are known to have a 'seasonal timer', which suppresses responsiveness to short photoperiods as an autumnal cue during a few months over generations from an overwintered generation. However, an adaptive significance of the seasonal timer had been unknown. This winning article experimentally showed that the seasonal timer is adaptive for avoiding untimely autumnal response in spring: aphids in which the seasonal timer had expired responded to spring short days, while aphids in which the seasonal timer was operating did not. This study showed, for the first time, that a photorefractory period lasting over generations is a trait of ecological importance.

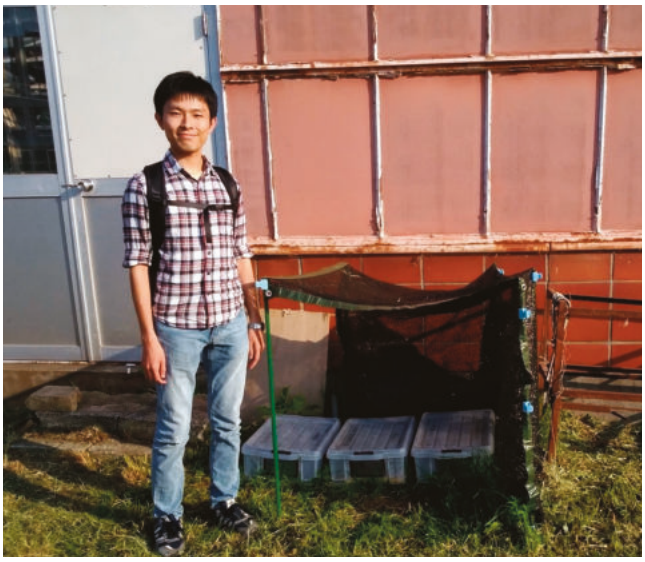


Photo: Naoki Matsuda

Systematic Entomology

Royal Entomological Society

Schoville, S.D., Bougie, T.C., Dudko, R.Y. and Medeiros, M.J. (2019), 'Has past climate change affected cold-specialized species differentially through space and time?' Syst Entomol, 44: 571-587. *doi.org/10.1111/syen.12341*

Sean Schoville is an Associate Professor in the Department of Entomology at the University of Wisconsin-Madison whose research focuses on how organisms evolve in response to environmental change. Dr Schoville approaches these problems using population genomics and functional genomics methods, while integrating ecological and physiological data. His research addresses fundamental and applied research questions in the fields of evolution, ecology, conservation and agriculture.

Ice crawlers forage nocturnally at freezing conditions, typically on snow, and are highly distinctive. Much remains to be learned about their basic biology, and specimens remain exceedingly rare in entomological collections. The goal of this paper was to improve the understanding of their biodiversity and evolutionary relationships in North America, and how that was shaped by past climate variation. By developing a large genetic dataset for a set of ice crawler samples spanning their known geographical range, the authors show that there is substantial undescribed, cryptic species diversity and very high endemism at local geographical scales. Using spatial reconstructions of ancestral ranges based on the geographic and genetic data, they estimate that species retreated to nearby, highly localised refugia at the edge of ice sheets during glacial episodes. Finally, using a modeling approach to assess when ice crawler species were formed through time, they show that, surprisingly, dry climatic periods during the Miocene (rather than cold, glacial conditions in the Pleistocene) caused ice crawlers to diversify. This suggests that for cold-specialised insects such as ice crawlers, unfavourable dry conditions may have led to long periods of isolation and allowed for evolutionary lineages to proliferate.

Photo: Sean Schoville

An adult female ice crawler, *Grylloblatta* spp., foraging on snow at night in the White Mountains. This individual is part of a cryptic species complex in California. Credit: Sean Schoville

Obituary

Dr Roger Blackman

24th July 1941 to 17th March 2022

President of the Royal Entomological Society 1998–2000

Richard Harrington (text) and Mariusz Kanturski (tables)

Introduction

There can be very few scientists studying any aspect of aphids whose papers have not cited the works of Roger Blackman. To his name, I add that of former President Victor Eastop (1924–2012), for the two of them formed an inspirational, complementary and indefatigable pair at London's Natural History Museum. Together they were responsible for, amongst many other seminal works, the three testaments of the aphidologists' bible: *Aphids on the World's Crops*, *Aphids on the World's Trees* and *Aphids on the World's Herbaceous Plants and Shrubs*, later brought together and regularly updated by Roger in the online version, *Aphids on the World's Plants*, a role taken over now by Colin Favret.

Life and times

The back cover of Roger's extraordinarily brilliant introduction to aphids, just called *Aphids*, tells us a little about his early life; but first I want to tell you about that book. Following a succinct introduction to aphid morphology, life-cycles, morph determination, genetics, development, behaviour, feeding and nutrition, natural enemies, ant mutualism and population dynamics, there is a host-plant list, notes on common British species and a key to common British genera. It finishes with techniques for studying aphids, including the world-renowned (amongst aphidologists!) 'Blackman Box'. Roger arranged for me to visit the great Dick Hille Ris Lambers at his home in Ede-Wageningen. Dick told me that he would never have been able to write that book himself, as he would always be thinking about exceptions, even though those didn't matter in relation to the target audience. He described the book as a triumphant masterpiece. Roger was just 33 when it was published.

So, to the back cover. Roger was born in Heston, in the London borough of Hounslow. He went to Isleworth Grammar School and then to Bristol University, where he graduated in Zoology in 1962. He studied for a Ph.D. at Imperial College's field station at Silwood Park, working on the feeding habits of ladybirds. His supervisor was the aphidologist Michael Way, sometimes referred to as 'the father of IPM'. Mike worked particularly on the ecology and control of *Aphis fabae* (Black Bean Aphid), so it is perhaps no surprise that Roger became as interested in the prey as the predator. His first job was as an entomologist with the Commonwealth Institute of Biological Control (now CABI) and he spent most of his three years in Patagonia (Argentina) funded by the New Zealand government, searching for parasitoids and predators of that country's pasture insect pests. In 1968, he returned to Silwood to begin work on aphids, initially on morphological variation, cytology and genetics. In 1973 he moved to the Natural History Museum where, in 1986, he gained Individual Merit Promotion. He officially retired in 2001 (in those days you had to leave at 60) but continued to work at the Museum as a Scientific Associate until his death.

Research highlights

Overview

Rogerhad always been interested in the biology of aphids, particularly with respect to their variability and its environmental and genetic control, the evolution of their relationships with their host plants and, of course, taxonomy. He made several notable discoveries which aphidologists now take for granted, the most important of which are outlined below.

Apomictic parthenogenesis

For aphidologists, it seems hard to imagine a time when it was not known that aphids reproduce by apomictic parthenogenesis. In other words, no meiosis is involved.

Mature egg cells are produced by mitotic divisions, and these cells develop directly into embryos. Offspring are thus clones of their mother, and genetically identical except for any mutations occurring during or after oogenesis. Roger showed this through both experimental and cytological techniques. He comprehensively rebutted a theory that, during development of a parthenogenetic egg, crossing over occurs between homologous chromosomes with consequent recombination of genetic material ('endomeiosis'). He also made big advances in the understanding of mechanisms of spermatogenesis in aphids (showing that it does not need to involve chiasmata during meiosis), oogenesis and sex determination.

A chromosome translocation linked to insecticide resistance

The aphid with which Roger is most famously associated is *Myzus persicae* (Peach–Potato Aphid or Green Peach Aphid). This aphid is a major agricultural pest, the more so because of its propensity for developing resistance to insecticides. The first insecticide group to fall victim was the organophosphates, and Roger found this resistance to be associated with a chromosomal translocation. Roger was the first person to apply *in situ* DNA hybridisation techniques to aphid chromosomes and, with the help of Jennifer Spence, he used these to study the location and inheritance of insecticide resistance genes in *M. persicae*, the orientation of X chromosomes during spermatogenesis, and the inheritance of chromosome fusions and dissociations.

Androcycly

Another important phenomenon in aphids, discovered by Roger, is androcycly whereby, in certain species, some lineages which are parthenogenetic and never produce sexual females (oviparae) can produce a few males. This is important because it means that the trait for overwintering in the mobile form as opposed to an egg (*i.e.*, continuous parthenogenesis) can be passed through the sexual phase when males from lineages showing androcycly mate with oviparae from holocyclic genotypes. *Myzus persicae* is a prime example of this. Thus, it can take advantage of warm winters by continuing parthenogenetic reproduction without host alternation, giving it a flying start in spring but, in cold winters (which can kill the mobile stages), it can survive as a cold-tolerant egg provided that the primary host (Peach) is available. This adaptability contributes to the pest status of the species. The important cereal pest, *Rhopalosiphum padi*, is another example.

Taxonomy

Roger's extensive taxonomic work has centred on the use of cytological, biochemical and morphometric data to analyse aphid species complexes and, in collaboration with Vic Eastop, providing identification and information manuals for the rest of the worldwide aphidological community. In no other economically-important insect groups are researchers blessed with such resources.

As well as his keys to aphids, at the first-ever International Symposium on Aphids (held in Jablonna, Poland in 1981) Roger produced a marvellous key to the aphidologists there gathered. Here are some sample couplets:

4 Colour of dorsal cephalic hairs mainly white or grey . . . 5

  Colour of dorsal cephalic hair not grey or white. Darker . . . 6

5 Hairs on lower mandible forming a wedge-shaped mass, much longer than broad, and longer than rostrum . . . Hille Ris Lambers

  Hairs on lower mandible forming a short, conical mass, shorter than broad, and shorter than rostrum . . . Eastop.

Another couplet uses 'Opinions evident' vs 'Opinions much less evident'. Some workers are described as 'specimen only seen pickled in alcohol'!

Awards and honorary positions

Roger was presented with the Bicentenary Medal of the Linnaean Society of London in 1979. This is awarded to just one person each year in recognition of exceptional achievements of a biologist under the age of 40. He was President of the Royal Entomological Society from 1998 to 2000 and has contributed much to the Society in numerous ways.

Conclusions

As well as accomplishing a phenomenal amount of pioneering research himself, Roger's work has been invaluable to the achievements of almost all those studying aphids. He had never sought the limelight, his only ambitions being to do good science and make it easily accessible to others. Some aphids are pests, although many are completely benign. Most play an important part in ecosystem function and some are of conservation concern. They are good models for fundamental science. No matter what people's motivations are for an interest in aphids, Roger made it easier for them to achieve their goals.

This obituary is adapted from an appreciation to be published in Zootaxa *to celebrate Roger's 80th birthday. Sadly, Roger died before publication of the festschrift.*

Harrington, R., Polaszek, A., Watson, G.W., Kanturski, M., Favret, C. and Ouvrard, D., 'Roger Blackman 1941–2022 – an appreciation'. *Zootaxa* (2022, in press).

Valid patronyms described to honour Roger Blackman

Genus

- *Blackmania* Kanturski & Wieczorek, 2015

Species

- *Aphis blackmani* Kadyrbekov, 2019
- *Capraphis blackmani* Mier Durante, Ortego & Nieto Nafría, 2009
- *Elatobium blackmani* Binazzi & Barbagallo, 1996
- *Geopemphigus blackmani* Muñoz Viveros & Remaudière, 2000
- *Neuquenaphis* (*Neuquenaphis*) *blackmani* Nieto Nafría & Brown, 2019
- *Eutrichosiphum blackmanum* Ghosh, 1993

Several more patronyms will be published in the special issue of *Zootaxa*, dedicated to Roger Blackman.

Valid species authored and co-authored by Roger Blackman

Subgenus

- *Adelges* (*Annandina*) Favret, Blackman & Stekolshchikov, 2015

Species

- *Amphorophora* (*Amphorophora*) *tuberculata* Brown & Blackman, 1985
- *Aphidura corsicensis* Nieto Nafría, Blackman & Martin, 2014
- *Aphidura libanensis* Nieto Nafría, Blackman & Martin, 2014
- *Aphis* (*Aphis*) *bozhkoae* Eastop & Blackman, 2005
- *Aphis* (Aphis) *cornuta* Blackman & Brightwell, 2019
- *Aphis* (*Aphis*) *polii* Barjadze, Blackman & Özdemir, 2015
- *Euceraphis borealis* Blackman, 2002
- *Euceraphis papyrifericola* Blackman, 2002
- *Euceraphis quednaui* Blackman, 2002
- *Geoica harpazi* Brown & Blackman, 1994
- *Geoica wertheimae* Brown & Blackman, 1994
- *Glyphina pseudoschrankiana* Blackman, 1989
- *Kaochiaoja sikkimensis* Joshi & Blackman, 2017
- *Macrosiphum* (*Macrosiphum*) *eastopi* Barjadze & Blackman, 2017
- *Myzus* (*Nectarosiphon*) *icelandicus* Blackman, 1986
- *Stomaphis* (*Parastomaphis*) *knechteli* Binazzi & Blackman, 2003
- *Stomaphis* (*Stomaphis*) *bratislavensis* Czylok & Blackman, 1991

Subspecies

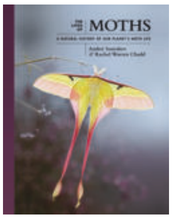
- *Myzus* (*Nectarosiphon*) *persicae nicotianae* Blackman, 1987

Royal Entomological Society

Antenna Reviews

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

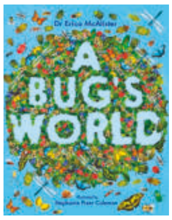
The following reviews have been added to the *Antenna* website:
https://www.royensoc.co.uk/publications/book-reviews/



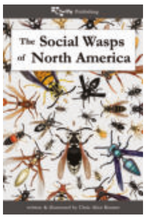
The Lives of Moths:
A natural history of our planet's moth life
Andrei Sourakov & Rachel Warren Chadd
Published by Princeton University Press
ISBN 9780691228563
Reviewed by Ray Barnett

The Insect Crisis
Oliver Milman
Published by Atlantic Books
ISBN 9781838951177
Reviewed by Chris Shortall

Insectpedia: A Brief Compendium of Insect Lore
Eric R. Eaton
Published by Princeton University Press
ISBN 9780691210346
Reviewed by Richard Jones



A Bug's World
Erica McAlister
Published by Wren & Rook
ISBN 9781526362988
Reviewed by Richard Jones



The Social Wasps of North America
Chris Alice Kratzer
Published by Owlfly Publishing
ISBN 9781737892700
Reviewed by Seirian Sumner

The Silken Thread
Robert N. Wiedenmann & J. Ray Fisher
Published by Oxford University Press USA
ISBN 9780197555583
Reviewed by Philip Howse

An Identification Guide to Garden Insects of Britain and North-West Europe
Dominic Couzens & Gail Ashton
John Beaufoy Publishing
ISBN 9781913679255
Reviewed by Andrew Salisbury

EVENTS

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

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

September 2022

Tue 6
6 September - 8 September
Pollinators in Agriculture (residential conference with the AAB and BES)

Sun 11
11 September - 17 September
XI International Anniversary Symposium on Aphids (external event)

Tue 13
13 September - 16 September
ENTO '22 (hybrid event)

Wed 14
14 September
Annual General Meeting (hybrid event)

Mon 26
26 September
Genomics Special Interest Group (hybrid event)

October 2022

Sat 1
1 October
AES Annual Exhibition (external event)

November 2022

Wed 2
2 November
Orthoptera Special Interest Group (hybrid event)

Sun 13
13 November - 16 November
ESA, ESC and ESBC Joint Annual Meeting 2022 (external event)

March 2023

Wed 1
1 March
Verrall Lecture

Sat 4
4 March
Young Verrall Lecture

April 2023

Mon 13
13 April
Global Soil Biodiversity Conference 2023 (external event)

Wed 26
26 April
Behaviour Special Interest Group (hybrid event)

October 2023

Wed 2
16 October - 20 October 2023
XII European Congress of Entomology (ECE) (external event)

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

J. O. Westwood Medal for Excellence in Insect Taxonomy

CALL FOR NOMINATIONS

In response to the urgent need to expand and recognise the research effort in insect taxonomy and to encourage monographic revisionary work, the Royal Entomological Society supports an award for excellence in insect taxonomy each year.

Criteria: The best comprehensive taxonomic work on a group of insects or related arthropods (including terrestrial and freshwater hexapods, myriapods, arachnids and their relatives). Typically, this will be a taxonomic revision or monograph. Open to authors from any country who demonstrate the highest standards of descriptive taxonomy in the work nominated.

Prize: A specially struck silver gilt medal inscribed with the winner's name and £1,000 prize from the RES. Also costs incurred in attending the International Congress of Entomology, European Congress of Entomology, or other major meeting (specified by the adjudicators) to present their work.

Eligibility: Any individual or group whose work meets the criteria and who is/are living at the time the work is submitted for consideration.

Cycle: Annual, entries accepted up to 30th September in the year preceding the awarding year.

Adjudication: By a selection panel consisting of senior and international RES Fellows.

Entry: By nominating letter from the author(s) themselves or other nominator, accompanied by two letters of support and three copies of the work, sent to: Westwood Medal, Royal Entomological Society, The Mansion House, Chiswell Green Lane, St Albans, Herts, AL2 3NS, UK, or electronically to westwood@royensoc.co.uk.

The award is named in honour of the leading 19th century British entomologist, John Obadiah Westwood (1805–1893). Westwood was the inaugural holder of the Hope Chair of Entomology at the University of Oxford, when it was established by the Reverend F. W. Hope in 1863. Westwood was one of the original group of founding members of the then Entomological Society of London in 1833 and served as President for three separate periods, 1851–52, 1872–73 and 1876–77. In 1883 he was elected to the unique position of Honorary Life President of the Society. He was a prolific author and published on most groups of insects and illustrated his own works, and those of many others, with his exquisite drawings and paintings. It is particularly appropriate that our award should be dedicated to this early pioneer of insect taxonomy.

www.royensoc.co.uk/westwood