Royal Entomological Society

Volume 48(2) | 2024

Antenna

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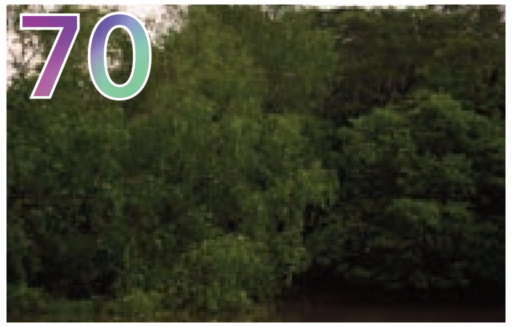

Experiences and some early results in monitoring congregating fireflies using night photography on a boat

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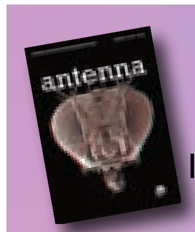

Antenna
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Index

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Cover Picture: 'Incoming!', a Buff-tailed Bumblebee queen, *Bombus terrestris*, photographed by Raymond J Cannon.

Editorial

Being involved in agriculture, the interface between food production and nature is always at the forefront of my mind, and has, of course, been identified as such in the recent *Insect decline and UK food security* report, as well as RES' Grand Challenges in Entomology. It was therefore very interesting to read about the work of consultant entomologists, like Steven Falk, who play a critical role in helping ensure anthropogenic activities, including agriculture and development, are undertaken with consideration for insects and other invertebrates in mind. The involvement of more consultant entomologists in the Society would, I am sure, be mutually beneficial, and worth exploring.

In yet another fantastic Research Spotlight, Stuart Reynolds heads down the slippery slope of investigation into insect size and discovers that size does indeed matter. In the past, though, the largest insects were very much larger than those we find today. Read Ed Jarzembowski's wonderful article delving into the first 408 million years of insects. Related to this, is correspondence lamenting the lack of storage facilities for palaeoentomological material and wondering whether the Society can help.

An article about the precise and challenging processes involved in the monitoring of fireflies in Malaysia from one of our international members, Veronica Khoo, was welcome, and has resulted in a firm reshuffle of my forthcoming travel destinations.

Richard Harrington's and Jesamine Bartlett's *Insects in the News* is an entertaining read. I'm sure we're all familiar with the sensationalist headlines perpetuating the trope of 'creepy crawlies'; hugely unhelpful, but sometimes amusing (in this context, at least!).

I particularly enjoyed the student competition essays, the winners of which each offered a unique style of writing, perspective, and clear interest and passion for entomology. Congratulations to them all.

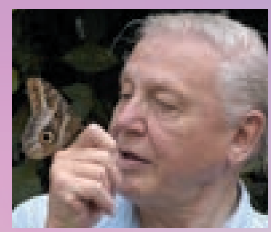
This issue's Featured Insect from Kevin Kavanagh explores a perhaps lesser known and surprising use of insects, while Librarian and Archivist, Rose Pearson, delves into 19th century library treasures, uncovering the art and science of nature printing.

There is plenty of Society News to report this time too, a highlight of which is the annual Verrall Lecture, presented by Rebecca Kilner, who will feature as the next issue's Honorary Fellow interviewee. Ben Hawthorne, Ayman Asiri and Vera Kaunath report on the vibrant Student Forum, which attracted a record number of delegates.

A very big thank you to the other editors and Jennifer Banfield-Zanin in particular for guiding me through my first ever issue as Editor of *Antenna*. Many thanks to the whole editorial team and to all our contributors.

Jane Phillips

Author Guidelines



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Antenna

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Letter from the President

I am writing this not long after many of us met up in London for the 2024 Verrall Lecture. What an inspiring talk by Professor Rebecca Kilner (Hon. FRES; University of Cambridge), where she presented an amazing series of observations and experiments exploring how behaviour affects evolution in burying beetles. Impressive science, fabulous photos, and lots of great questions from the audience! It was a pleasure to present Rebecca with the RES President's medal. It was lovely to see so many people there - thank you to everyone who attended. But if you missed the 2024 Verrall Lecture, or if you would like to listen to it again, the recording of the lecture 'Life after death: using burying beetles to determine how behaviour influences evolution' is available on the RES YouTube channel. Huge thanks to Dr Tilly Collins and Imperial College for hosting the event. For those of us able to attend, it was great to be able to continue our entomology conversations at the Verrall supper later that evening.

It has also been my pleasure to join many of our Honorary Fellows for an 'Honorary Fellows' Afternoon Tea', which provided an opportunity to thank them for their contributions to the Society, and to discuss the Society's current strategy and our future plans. We are keen to explore ways in which our Honorary Fellows might wish to be even more closely involved, and to share their knowledge and expertise to contribute to the Society's continuing success. For me, it was also an opportunity to reflect on how much progress the Society has made over the years – for example, it's fantastic that Insect Week is reaching its 20th anniversary – many thanks to Professor Chris Haines (Hon. FRES) who instigated its set-up during his time as President (2002-04). Insect Week is our annual celebration of the 'little things that run the world', and is dedicated to encouraging people of all ages to learn more about insects. This year, Insect Week runs from 24-30 June (more details on the Society's web pages, and www.insectweek.org).

Jane Hill, Rebecca Kilner and Luke Tilley at the Hon. Fellows' afternoon tea before Rebecca's Verrall Lecture.

We are now over half way through our current Strategy (2022-25), of which a Strategic Priority to 'Support the study and practice of insect science' aims for the Society to 'be the independent voice to decision makers for the application and advancement of insect science'. The Society set up a new 'Science, Policy and Society Committee' in summer 2023, and for the first time the Society submitted written and oral evidence (by Professor Lynn Dicks, trustee) to the UK House of Commons' Science, Innovation and Technology Committee report on insect decline and UK food security. A key priority for action is to evaluate how agricultural landscapes can be managed to help reverse insect declines whilst also providing food security. Please check the RES website 'news' section for our full response and link to the SITC report.

Please check the RES website for other news items, upcoming events, and lots of other useful information.

Jane Hill OBE
President
Royal Entomological Society

Correspondence

Fact and Fable: Life of WF Kirby

Dear Editors,
Following the Review of *Fact and Fable: Life of WF Kirby*, which I found to be 'fair comment,' there are one or two points I would like to clarify.

I am astounded that the Rev. William Kirby and W.F. Kirby should ever have been regarded as one and the same person. However, my mother often spoke of the confusion caused by THREE persons named William Kirby publishing entomological books.

The first was the eminent Revd William Kirby, founder of the Entomological Society. Second was W.F. Kirby (her grandfather) whose great skill lay in the international identification and cataloguing of insects at a time when their nomenclature was in the most appalling muddle. Third was W.E. Kirby *(sic)* her father – W.F. Kirby's only son. He was less prolific than the others, being a medical GP, but he did co-author two books with his uncle, August Kappel. Both men were keen to popularise the subject of entomology among the general public and therefore used both English and Latin names of insects in their publications. W.E. Kirby also published one of the earliest guides on butterflies and moths for the general public.

My purpose in writing the book was to set out the circumstances of W.F. Kirby's complicated life, enabling future researchers to contextualise their findings. For this reason, I did not want editorial spin clouding the facts. Instead, I separated out speculative elements by condensing them into verse. Notably, W.F. Kirby regarded himself as a poet and uses poetry in his very controversial book, *Evolution and Natural Theology*.

Ursula Kirby Brett

Palaeoentomology needs a safe base for its archives

Considerable advances have been made in our understanding of the glacial and postglacial landscapes and climate of Britain by the study of fossil insect faunas. The insect faunas often have the potential to fine tune anything that the coarser pollen and geomorphological data can provide. Saproxylic beetle species in particular can suggest key habitat structures such as the age class of the trees present, the growth form of those trees, and the openness of the forest vegetation. This knowledge comes from the behaviour of those same species of beetle under modern conditions – the present informs the past.

In KA's experience palaeoentomology has often been hampered by the lack of real-world experience of some practitioners, whose backgrounds are more likely to have been in archaeology or geology than in entomology or ecology. This may be compounded by poor communication between the various individuals, who have often relied too much on literature that was not written with this type of enquiry in mind. More direct dialogue is needed between archaeo-entomologists, Quaternary entomologists, and modern field workers.

A rather quixotic collection of the published habitat and distribution data has been put together with the European Quaternary fossil insect record in the BugsCEP database, but this has suffered from the complete failure of Microsoft to make versions of Access backwards compatible and so it is accessible to relatively few individuals. It has been one of KA's life projects to collate the dispersed information on the habits of saproxylic fauna and to make the new syntheses available for discussion. This has often identified poor understanding that has been shown by palaeoecologists in their publications. All too often a particular species is described as associated with 'forest' and therefore the vegetation must have been closed canopy woodland. Such simplistic interpretation is rife in the literature, although in mitigation it must be said that much of the work relates to rushed, poorly, often reluctantly, funded consultancy work for archaeologists whose agenda may be very different from that of their subcontractors. A cursory examination of the database indicates relatively few postglacial sites not directly related to archaeology, leading to a significant taphonomic bias. By way of example, the database shows that a proportion of the saproxylic beetles that have been found as subfossils only occur today in very open landscapes with scattered trees and this applies equally to faunas from previous interglacials, when the large vertebrate faunas were much more diverse – why then would they be closed-canopy species in the postglacial period? It does not make sense.

A key question which also arises from time to time concerns the reliability of species identification from the subfossil fragments. Humans are not infallible and whilst some may appear over-cautious in ascribing fragments to species, others may be more blasé; either may relate more to the time available for the work than to the competence of the individual concerned; checking of identifications as taxonomy and expertise advance is an essential element of scientific research. Immediately we reach an impasse – where have the subfossil remains been stored and how accessible are they? KA's latest problem has arisen through wishing to examine some samples from a PhD study where the researcher has sadly died very young. Communication with her PhD supervisor has identified that the samples are boxed up and on the shelf of a lecturer's room at her old university. The samples are at great risk of being lost as there is no obvious place for their long-term storage. This is an all-too-common problem. Modern insect collections generally find a home in a local, regional or national museum, although the declining number of suitably skilled curators in museums below the national level is of serious concern. Other collections may be deposited with the British Entomological & Natural History Society's rooms at Dinton Pastures Country Park. But where do subfossil specimens end up? Deposition with a local museum of a collection of card-mounted specimens from a number of local sites was fine whilst there was an interested curator in post but the material, never accessioned, could not be located a decade later. Hopefully it will still be there somewhere.

It occurred to KA, with an impending relocation of the RES Headquarters, that consideration might be given to establishing a resource centre for researchers into subfossil fauna. This could involve long-term storage facilities for voucher specimens together with facilities for their study. This would have the potential to revolutionise research into this important aspect of entomology. It is important that such collections are managed by us - the entomologists - rather than by bureaucratic institutions like museums. As the examples above indicate, only entomologists can truly appreciate their real value.

Keith Alexander
& Paul Buckland

Errata

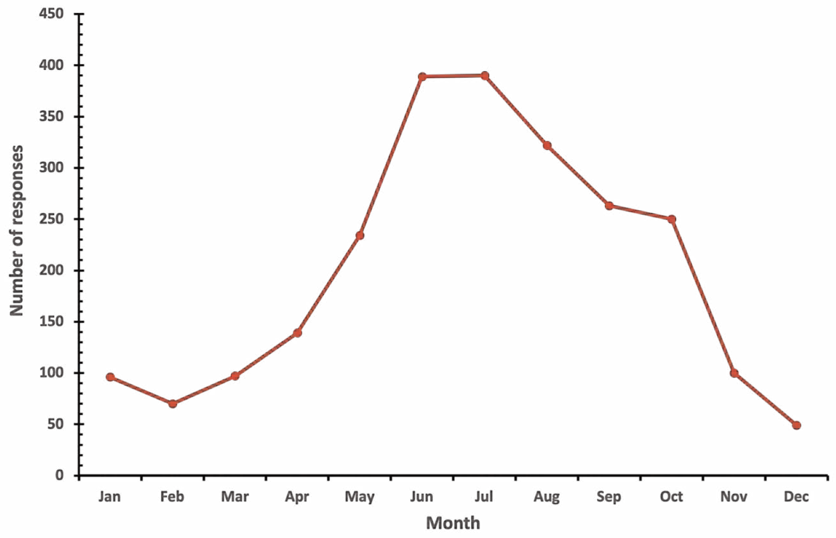
On p.32 of *Antenna* 48(1) (*44th Orthoptera Special Interest Group* meeting report), captions for Figure 5 and Figure 6, the Southern Sickle-bearing Bush-cricket and Great Green Bush-cricket were presented the wrong way around.

Also, it should be noted that *Forficula auricularia* is now considered to be *F. dentata* (p.22, *Featured Insect*).

Thank you to Peter Sutton for alerting us to these errors.

The graph on p.49 of *Antenna* 48(1) (*Royal Entomological Society Insect Identification Service 2023*) reproduced the 2022 monthly responses. The 2023 graph is reproduced here.

Thank you to Jim Hardie for alerting us to this error.



Monthly responses to insect identification queries during 2023.

RESEARCH SPOTLIGHT

Insects great and small: on the significance of size

"Why are there so many more kinds of insects than other animals? ... Most of the explanation lies simply in the small size of insects"

Robert M. May (1978)

Size matters

The size of an insect, especially small size, is a topic that is of perennial interest to theoretical ecologists, who have repeatedly asserted that being small is one of the features that have permitted the numerical dominance by insects of terrestrial animal communities, as well as their extraordinary speciosity (see the quotes above and below). Perhaps their enthusiasm for the subject depends to some extent on the ease with which size, especially body length, can be measured! Here I will try to persuade you that they are right to be interested in both the smallness and bigness of insects.

How big is a 'typical' insect?

My interest in insect size was stimulated by discovering (after only 46 years!) the Royal Entomological Society's excellent ninth symposium volume, '*Diversity of Insect Faunas*' (Mound *et al.*, 1978). One of the most original contributions to that meeting was that of the Australian-American-British mathematical ecologist Robert May, who produced a paper full of ideas that continue to motivate fresh research today. Noticing the overwhelming predominance of small insects in natural species assemblies, he illustrated this *inter alia* with two graphs that plotted UK beetle species numbers versus their size, using both linear and logarithmic axes (Fig. 1). While the linear plot shows well enough that most beetle species are small, the (inset) log-log plot is clearly superior in showing that the species-size data are distributed around a modal length of about 3 mm.

An example with this 'typical' size is the carpet beetle, *Anthrenus verbasci* (Dermestidae). This 'typical' value is surprisingly small. Many, even entomologists, will think of ladybirds (Coccinellidae) as being average sized coleopterans, but the invasive Harlequin Ladybird, *Harmonia axyridis* (probably now the most frequently encountered of these insects) is at about 7-8 mm in length, more than twice as big as a carpet beetle. Another familiar species, the Wasp Beetle, *Clytus arietis* (Cerambycidae), is about 16 mm, twice as big again. Obviously, there must be a lot of coleopteran species that are much smaller than 3 mm! An example of such an insect is *Octotemnus glabriculus* (Ciidae), an insect well known to me

> **“[What] enabled the pterygote insects to monopolise the majority of the vast number of niches … offered by the development of vegetation? … The answer, I suggest, is ‘size, metamorphosis and wings’”**
>
> T. R. E. Southwood (1978)

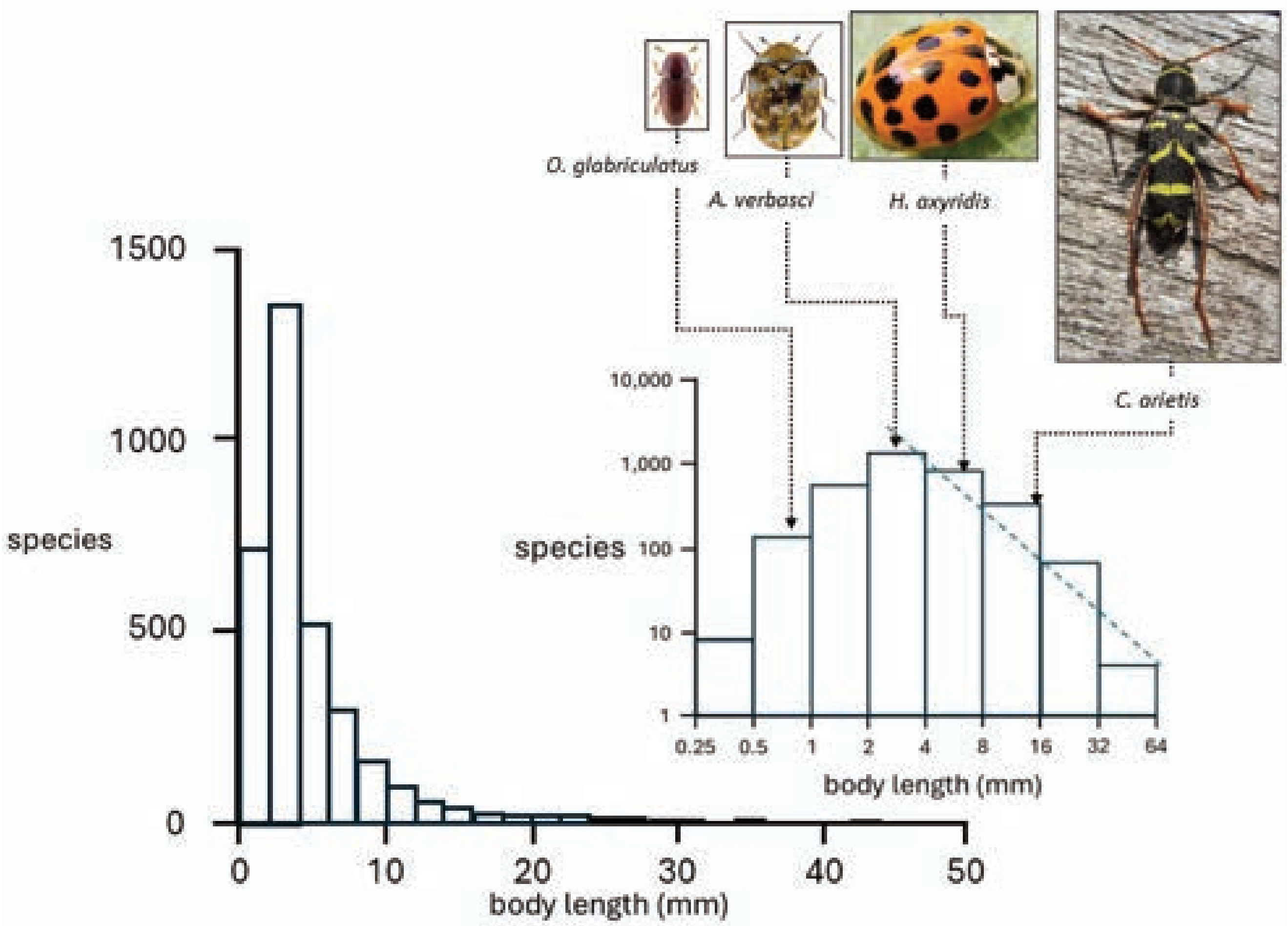


Figure 1. Species-size distribution for British Coleoptera, data taken from Fowler (1887). Main graph: Plotted on linearly scaled axes. Inset: Plotted on logarithmic axes to base 10 (vertical axis) and base 2 (horizontal axis). The dotted line in the inset graph represents the relation $S \propto L^{-2}$. Redrawn from May (1978). Credits for inset images of insects are: *Octotemnus glabriculatus* and *Anthrenus verbasci*, Udo Schmidt, CC BY-SA 2.0; *Harmonia axyridis*, entomart.be; *Clyto arietis*, Stuart Reynolds.

(Guevara *et al.,* 2000) that is only 1.5-2.0 mm long. It’s not well known because it is generally only found inside fungal fruiting bodies. There are indeed a lot of these tiny ciid beetles, with >100 spp. in the genus *Cis* alone.

Insect lengths are in fact distributed in what is termed a lognormal distribution. Statistical distributions of this type, first noted by Hemmingsen (1934), are commonly observed for species-size plots in many animal groups (a detailed paper on the subject of insect size is that of Schoener *et al.*, 1968). The key feature of this distribution, as Fig. 1 makes clear, is that within the range of body lengths that occur among various different species of insect, there is a strong concentration of species at the smallest end of that range. This is what May meant when he remarked upon the importance of small size for the diversification of insects as a whole (see the quotation at the head of the article).

May’s theory-rich paper attempted to account for this insect species-size distribution, but suffered from the relatively small sample sizes that were then available to him. To explore the question here, I have made use of a much larger dataset on the ‘typical’ adult lengths of 3,440 different species of hexapods relatively recently compiled for a different purpose by Ferns *et al.* (2016). In it, body length data were recorded without reference to sex from species in every extant order (n=32), as recorded in handbooks and species descriptions. I should make clear that Rainford *et al.* (2016) have also made an extensive inquiry into possible links between species size and the diversification of the hexapod

class, using a different dataset. Their statistical analysis is much more sophisticated than my own, but as we shall see comes to mostly similar conclusions.

Fig. 2 shows the frequency of occurrence of $\log_{10}$-transformed species-specific lengths for all 32 orders combined. As expected, the curve is well described by a log-normal distribution. The biological significance, if any, of the lognormal relationship remains uncertain; such a distribution is to be expected for any variable that is itself the multiplicatively combined product of other normally-distributed variables (Koch, 1966). In the present case, the fit is quite good; there appears to be a slight excess of insect species on the left-hand side of the graph (*i.e.,* there is more than the expected number of species which are smaller than the lognormal mean) but the deviation is actually quite small. Distributions with a pronounced right-handed skew (*i.e.,* more large species than expected from the lognormal distribution) are commonly seen in species-size plots; a wide variety of evolutionary and ecological explanations for this skew has been considered (Novotny *et al.,* 1996; Kozłowski *et al.,* 2002) but there is no general explanation.

Simply averaging the lengths for all these hexapod orders isn’t good enough because the bulk of species is contained within a relatively small number of highly diverse orders. To allow for this, I computed a weighted mean length for all hexapods which gave a value of 12.9 ± 1.73 mm (mean ± S.D.). It’s probably too big, because very small insects are almost certainly seriously under-represented in the database. According to a widely used polynomial mass:length relationship derived for insects by Sage (1982), a hexapod of this length would be predicted to have a body mass (fresh weight) of about 54.5 mg.

The relative size of an insect

How does this ‘average’ insect size compare with that of other animals? This is interesting because size is an important factor in determining how many different kinds of animal can co-exist in any one ecosystem. This question was addressed in a classic paper by the ecologist G. Evelyn Hutchinson (1959), an important figure in developing the concept of ecological niche. Hutchinson maintained that animals using similar resources can avoid competition by partitioning a potentially broader niche through character displacement (Brown *et al.,* 1956),

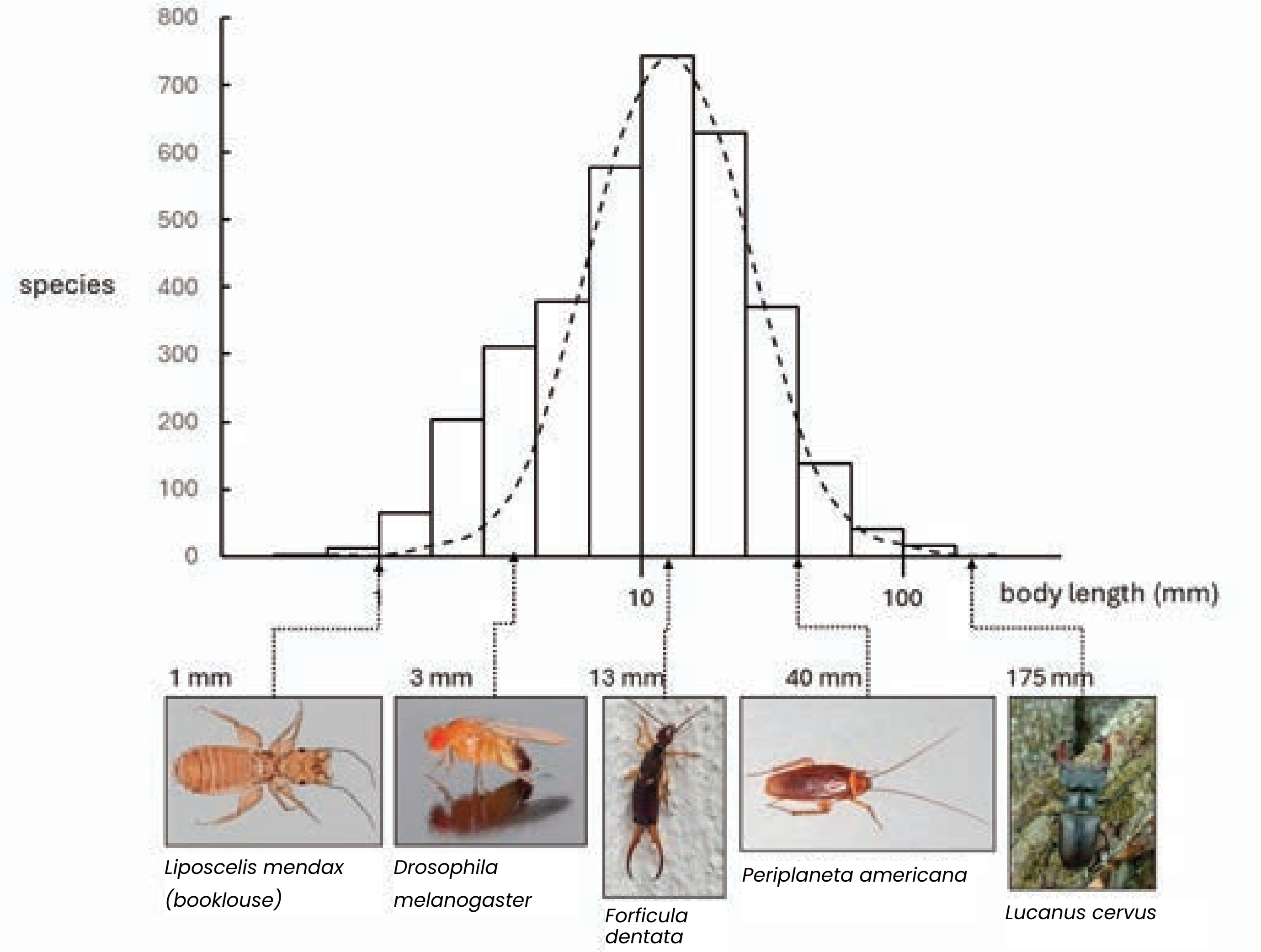


Figure 2. Species-size distribution for 3,440 species of insect from 32 orders. Columns show the number of species with described typical length in a range of 0.2 $\log_{10}$ units. The horizontal axis is logarithmically scaled but is labelled to indicate actual body size. The dotted line shows a fitted lognormal distribution centred on the modal value for the whole set. There is evidence of an excess of (smaller) species on the left-hand side of the curve. Below the graph are shown portraits of insects of various indicated body lengths. Original figure, data computed from Ferns *et al.* (2016). Picture credits: *L. mendax*, Australian Plant Health and Environment Laboratory (CC BY 3.0 au); *D. melanogaster*, André Karwath (CC BY-SA 2.5); *F. dentata*, Nikola Szucsich (CC BY-NC); *P. americana*, Gary Alpert (CC BY 2.5); *L. cervus*, J.F.Gaffard (CC BY-SA 3.0).

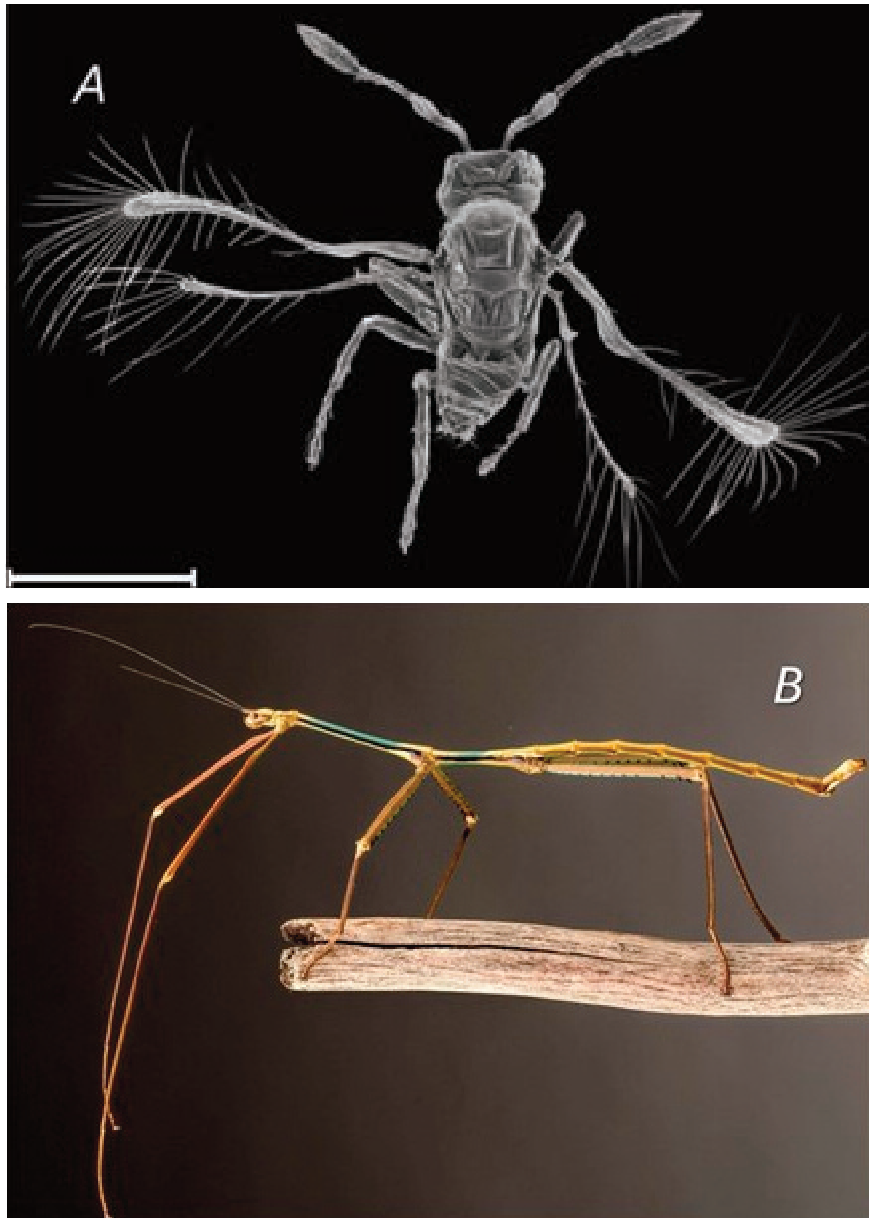


Figure 3. A very small and a very large insect. **A**. *Kikiki huna* (Hymenoptera, Mymaridae), the smallest recorded winged insect. Adult female, habitus dorsal, scale bar = 100 µm. body lengths for females of this species were measured at 158-190 µm (n=10). Photo: John T. Huber and John S. Noyes, CC BY-SA 3.0. (Huber *et al.,* 2013). **B**. *Phryganistria tamdaoensis* (Phasmatodea, Phasmatidae). Adult male, body length 190.6 mm (female can reach 228.7 mm). Photo: Joachim Bresseel and Jérôme Constant, CC BY-SA 3.0. (Bresseel *et al.,* 2014).

where the occupying animal's size is the character that is evolutionarily displaced.

The size range of insects does overlap with that of other animals. The smallest insects are generally either apterygotes, tiny feather-winged ptiliid beetles (Grebennikov, 2008), or parasitic wasps, 'fairyflies' (Mymaridae), all less than 1 mm long. The smallest insect is said to be the wingless male of the mymarid wasp *Dicopomorpha echmepterygis* (Mockford, 1997), which can be as small as 139 µm in length, but the winged female of this species is significantly bigger; the record for the smallest winged insect appears to go to another mymarid, *Kikiki huna* (Fig 3A), one of which was measured at 158 µm long (Huber *et al.,* 2013). At the other end of the size scale, giant phasmids in the genus *Phryganistria* (Fig. 3B) are strong contenders for the biggest insects in linear dimensions, some having been reported to reach body lengths of up to 640 mm (Hennemann *et al.,* 2008). Other giant phasmids *e.g., Heteropteryx dilatata,* are not so long but heavier, with an adult weight of up to 65 g (Bank *et al.,* 2021). It is frequently asserted that Goliath beetles (*Goliathus* spp., family Scarabaeidae, subfamily Cetoniinae) are the biggest insects on the basis that they are the heaviest; their fully fed larvae can weigh up to 100 g, but the adult itself is generally only about half that weight (Vendl *et al.,* 2016). Among other very large insects are the orthopteran giant wētā, *Deinacrida rugosa* (Anostostomatoidae), adult females of which can attain weights of 20 g (Kelly *et al.,* 2016), and the hemipteran giant toe-biter *Lethocerus maximus* (Belostomatidae), which can reach a length of 100 mm (Ribeiro *et al.,* 2018).

For comparison, the smallest vertebrate is a terrestrial frog from Brazil, *Brachycephalus pulex*, adult males of which have a snout-to-vent length (SVL) of just 7.10 ± 0.47 mm (Bolaños *et al.,* 2024). Although a number of other tiny amphibians have been discovered, it is evident that the extent of the competitive overlap between the smallest vertebrates and the average insect is actually very limited.

On the other hand, insects aren't by any means the world's smallest animals, with many of which they almost always co-occur in terrestrial habitats, especially in the soil. Perhaps the most numerous and diverse of these other invertebrates are Acari (mites); the smallest apterygotes overlap in size with both parasitic and free-living mite species, in which size distributions peak in the $\log_{10}$ size class of -0.5 to 0.0 units (*i.e.,* about 0.3-1.0 mm) (Walter, 1999). Other invertebrates also overlap in size with the smallest insects. Although most insects are significantly bigger than most rotifers (length 400-500 µm, maximum about 2 mm; Hyman, 1951) and tardigrades (length 100-500 µm, maximum about 1.7 mm; Brusca *et al.,* 2003), there is clearly overlap with both of these taxa at lengths of < 1 mm. The same is true of the largest single-celled protists, ciliates (Ciliophora), which range in length from 20-600 µm (Lynn, 2008). The long, thin highly flexible bodies of several other invertebrate groups (*e.g.,* annelids, nematodes, *etc.*) are so different from those of insects that it does not seem sensible to compare them. The smallest insects must frequently compete for niche space with other non-insect invertebrates. As

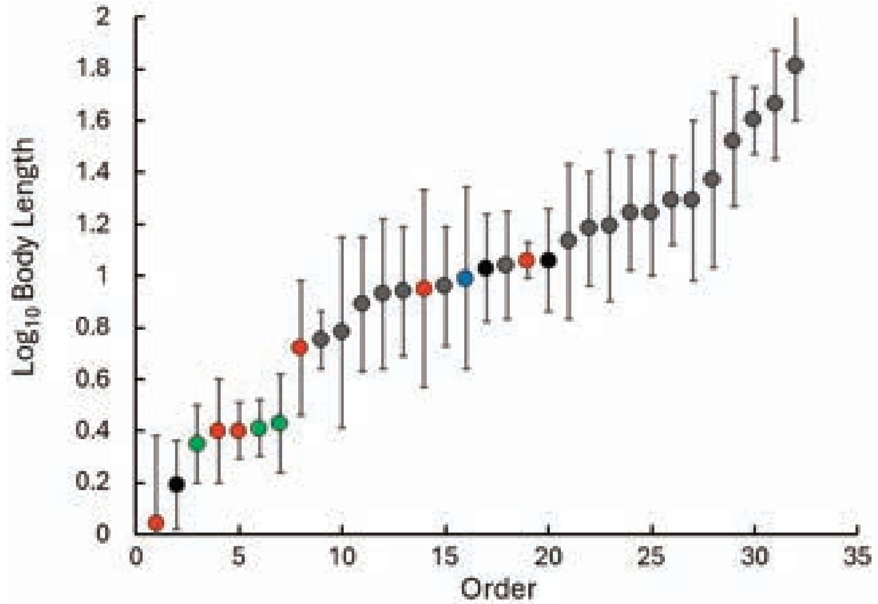


Figure 4. Log-transformed body length values (mean ± S.D.) for 35 hexapod orders are presented along the x-axis in order of their mean size; those orders that are entirely or mostly apterous are coloured red, while entirely parasitic orders are coloured green. Hymenoptera, an order in which many species are parasitic, is coloured blue (see text). The sequence in which the orders are presented is: Protura, Thysanoptera, Strepsiptera, Collembola, Zoraptera, Siphonaptera, Psocodea, Diplura, Isoptera, Coleoptera, Embioptera, Hemiptera, Diptera, Zygentoma, Ephemeroptera, Hymenoptera, Mecoptera, Dermaptera, Archaeognatha, Raphidioptera, Neuroptera, Plecoptera, Blattodea, Trichoptera, Mantophasmatodea, Grylloblattodea, Lepidoptera, Megaloptera, Orthoptera, Odonata, Mantodea, Phasmatodea. Original figure, data taken from Ferns *et al.* (2016).

we will see later, it's possible that the very existence of these similarly-sized invertebrates may have effectively limited the proliferation of insect species into the smallest size categories.

Different orders of insect have different mean body lengths

Of course, not all insect orders are the same, and this is emphasised by a graphic representation of data from the study of Ferns *et al.* (2016) (Fig. 4). Beetles (Coleoptera) as noted above are on average considerably smaller than members of other orders. My value for the weighted mean length of Coleoptera is at 6.03 ± 2.34 mm, considerably bigger than the value proposed by May (1978), presumably because his sample was restricted to UK beetles, which appear to be smaller than those occurring elsewhere in the world, but is nevertheless still only about half as long as the weighted mean for all insects (12.9 ± 1.73 mm). Other insect orders appear to be considerably larger with Odonata (40.2 ± 2.35 mm), Orthoptera (33.2 ± 1.78 mm), Phasmatodea (64.0 ± 1.62 mm) and Mantodea (45.5 ± 1.62 mm) all being markedly longer than the average insect.

Have these between-order differences in the body size of insects evolved as the result of natural selection, or have they arisen by chance? Having analysed a different hexapod species-size dataset to the one used here, Rainford *et al.* (2016) concluded that there is little or no phylogenetic component to the evolution of body length within the class; they also found only weak evidence that body size variation is associated with species richness. Mayhew (2007) had previously found no evidence that body length has influenced either cladogenesis or extinction rates among insects, and Rainford *et al.* (2016) again found no evidence for an inverse relationship between diversification rate and body length.

I agree with these conclusions. Looking at the mean order-specific body lengths from the Ferns *et al.* (2016) dataset as a whole, the whole set of average body lengths according to order is a pretty good fit to the lognormal distribution, suggesting that size is indeed randomly allocated among the orders. This is possible because the orders with most species are also the orders with mean lengths closest to the overall mean for the whole dataset.

Body length is also clearly uncorrelated with position in the phylogenetic age of the order, indicating that body size evolution among hexapods does not follow Cope's Rule, according to which, body size increases progressively during the lifetime of a taxon (Roy *et al.,* 2024). Length is also obviously unrelated to the number of species in the order, which could conceivably indicate that on divergence from its ancestral order, the first member of the new order would radiate to produce descendent taxa whose sizes become again distributed at random over the entire possible size range.

But I think that Rainford *et al.* (2016) may have been premature to conclude that "hexapod body size evolution is … dominated by neutral processes". To me, 'neutral processes' means that the character in question is invisible to selection because it carries no adaptive significance. Failure to detect differences in body length between today's superorders doesn't mean that selection on size has never been important, and it seems to me perfectly feasible to imagine a situation in which species packing according to size is indeed determined through evolutionary character displacement according to a general rule that applies in all or most insect orders. Moreover, some hexapod groups may be exceptions to this general rule, and display deviant species-size relationships, but are too small in species number to perturb the statistical picture for the whole class.

There are two notable features of the taxonomic distribution of insect body length that don't look like 'neutral processes' to me. First, apterygote hexapods (those orders in which no member species has wings), *i.e.,* the three non-insect orders Protura, Collembola, Diplura, and the primitively wingless insect orders, Archaeognatha and Zygentoma, as well as the pterygote order Siphonaptera (fleas), in which wings are now entirely absent, but which have presumably been lost, as well as the almost apterous order Zoraptera, are as a group mostly smaller than insects with wings (Fig. 3). The weighted mean

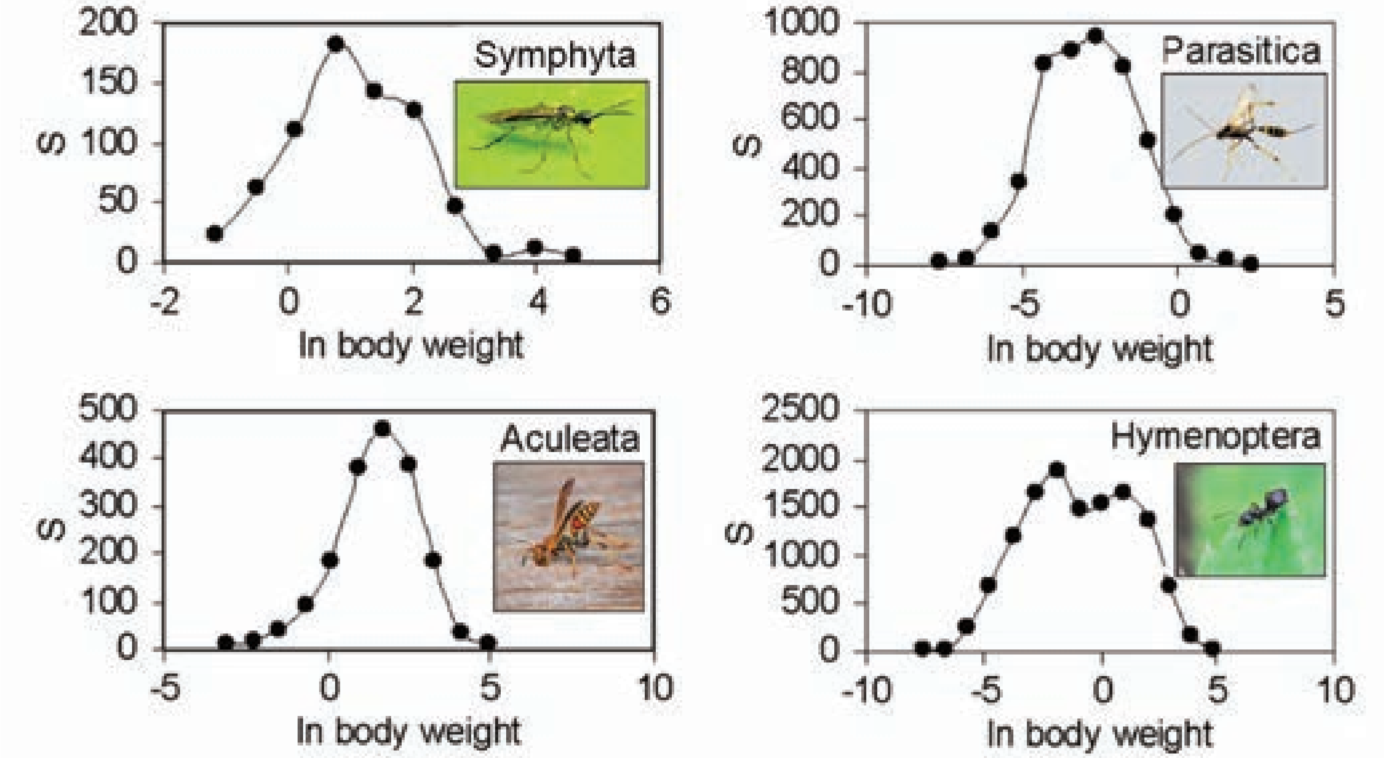


Figure 5. Natural log-transformed mean body lengths for individual species of Hymenoptera. Notice that the plot for Hymeoptera as a whole is bimodal, whereas plots for Symphyta, Aculeata and Parasitica are monomodal. S, species number. Data are from Ulrich (2006). The lines connecting the points in the graphs do not represent fitted curves. I have added inset panels to show representative species. Symphyta: *Tenthredo mesomela*, image by Guido Gerding, CC BY-SA 3.0; Aculeata: *Polistes dorsalis*, image by Fitz Clarke, CC BY-NC; Parasitica: *Acroricnus* sp., image by Katya, Moscow, CC BY-SA 2.0; Hymenoptera: *Lasius niger*, image by AfroBrazilian, CC BY-SA 4.0.

length of the wingless orders is 3.16 ± 1.74 mm, as opposed to 13.11 ± 1.72 mm for those with wings. This implies that regardless of their respective evolutionary histories, apterygote insects are smaller than pterygotes.

Second, as is apparent from Fig. 4, within the Pterygota, parasitic species are in general smaller than non-parasitic species. The body lengths of two entirely parasitic orders, Siphonaptera (2.57±1.29 mm) and Strepsiptera (2.24 ± 1.41 mm), as well as a third order, Psocodea (2.69 ± 1.55 mm), in which there is a strong representation of parasitic species, are all obviously considerably smaller than the general run of insects. Rainford *et al.* (2016) also noted that these fully or mainly parasitic orders appear to be significantly smaller than the rest.

The order Hymenoptera (ants, bees and wasps), well-known to have a high content of parasitic species, is particularly revealing. Examining a very large (12,601 spp.) and complete (88% of described spp.) dataset of European Hymenoptera, Ulrich (2006) found that this order has a clearly bimodal distribution of body size (Fig. 5). When its component species are classified by suborder as Symphyta (sawflies), Aculeata (ants, bees and stinging wasps), or Parasitica (parasitic wasps; strictly all Apocrita except Aculeata), however, all three suborders display more or less monomodal weight distributions. Whereas dry body weight values for the non-parasitic species have modal values of about 10 mg (Symphyta) and 100 mg (Aculeata), dry weights of those species with parasitic life histories (Parasitica) are distributed around a value about four orders of magnitude lower in value, with a modal dry weight of only about 0.001 mg. If you look carefully at the species numbers in Fig. 5, you'll see that parasitic species actually dominate the Order as a whole. The small overall body size of this group of hymenopterans is therefore not due to lack of wings but is most likely a direct consequence of their parasitic habit.

Small size may be a general characteristic of endoparasites that results from strong limitation on maximum size. Poulin *et al.* (1997) analysed the body lengths of a wide range of animal parasites and found that log-right-skewed body species-size distributions (*i.e.*, more large species than predicted by the lognormal distribution) are less frequent in parasitic species than expected. Size limitation on parasitoids imposed by the size of the host is known to occur in host-parasite relationships, as has been shown for aphids and their hymenopteran parasitoids by Cohen *et al.* (2005). One might well observe that since the number of hymenopteran parasitoids is so very large (Forbes *et al.*, 2018), parasitism itself must have been one of the strong drivers of diversification in insects as a whole; this might well lead us to conclude that it is actually parasitism that has driven the proliferation of very small insects rather than the other way around.

It's not about metamorphosis!

On the other hand, when I compare the weighted mean body lengths of those insect orders that undertake complete metamorphosis (Holometabola) (12.73 ± 1.89 mm) and those that don't (Hemimetabola) (14.82 ± 1.62 mm), I find that the two superorders do not differ. In agreement with this, although Rainford *et al.* (2014) had previously found that complete metamorphosis was a key innovation in the phylogeny of the class that has driven the subsequent hyper-diversification of insects, Rainford *et al.* (2016) could uncover no evidence of a link between complete metamorphosis and the size of extant insects.

I think this result is very interesting. Since their phylogenetic divergence approximately 350 Mya, the extent of holometabolan species diversity has increased remarkably compared to that of hemimetabolans, so that today around 80% of extant insect species belong to one of the 5 holometabolan orders (Rolff *et al.*, 2019). It is scarcely conceivable that such radiation could have taken place in the absence of any selection on body size. I suppose that what this means is that there is now no evidence of *maintained directional selection* on size, even if it had once been important in getting to where we are today. But there might still be pockets of species-space (*i.e.*, among the Apterygota and also among parasitic species, especially in the Hymenoptera) in which maintained downward selection on size did indeed occur over long periods of time.

Smaller insects have larger populations

In attempting to explain the slope of the fitted line on the right-hand side of typical species-size plots, May (1978) drew attention to the already well-known fact that in any one environment it is not only the number of species, but also the total number of individual insects of a particular size that is approximately inversely related to L^2 (where L is the insect's body length). Some 7 years later, work by Morse *et al.* (1985), confirmed this and showed that this size distribution can be modelled by utilising the then newly-proposed theory of 'fractal space' in the ecosystem that supports them.

A fractal is an iterated self-similar pattern that presents a larger and larger linear dimension to the observer when measured by steps of decreasing size (Mandelbrot, 1982). It was argued by Morse *et al.* that the population size of consumers that can be supported by any ecosystem is ultimately limited by resources (*i.e.*, nutrient flow). These resources originate from the primary producers (plants) distributed on and over surfaces that are clearly more extensive than the land area below. For this reason (just as Hutchinson *et al.*, 1959, had supposed) the larger the 'mosaic' plant surface on which an insect lives, the greater the supply of resources. Morse *et al.* proposed that this surface is fractally structured, and that when any particular dimension of the environment (effectively a transect) is probed by an insect with length L, the trophic resource available to it will be proportional to $L^{(1-D)}$, where D is the fractal dimension. A higher value of D leads to a steeper increase in resource availability with decreasing insect size, supporting a larger population of these smaller insects.

Morse *et al.* (1985) determined the value of D empirically for a range of different temperate and tropical vegetation types. Its value varied between 1.28 and 1.79 (mean = 1.44). Assuming that population size is determined by the availability of food, this led them to predict that the population size of insects depending on such an environment should be negatively related to insect length, the relationship having a negative slope of about -0.44. In habitats such as these, then, small insects should greatly outnumber large ones. Censuses of insect populations from several radically different terrestrial ecosystems, one of which is illustrated in Fig. 6, confirmed that insect population sizes were indeed negatively correlated with length. The fitted slope of the relationship indicated that the fractal dimension D of such environments had a typical

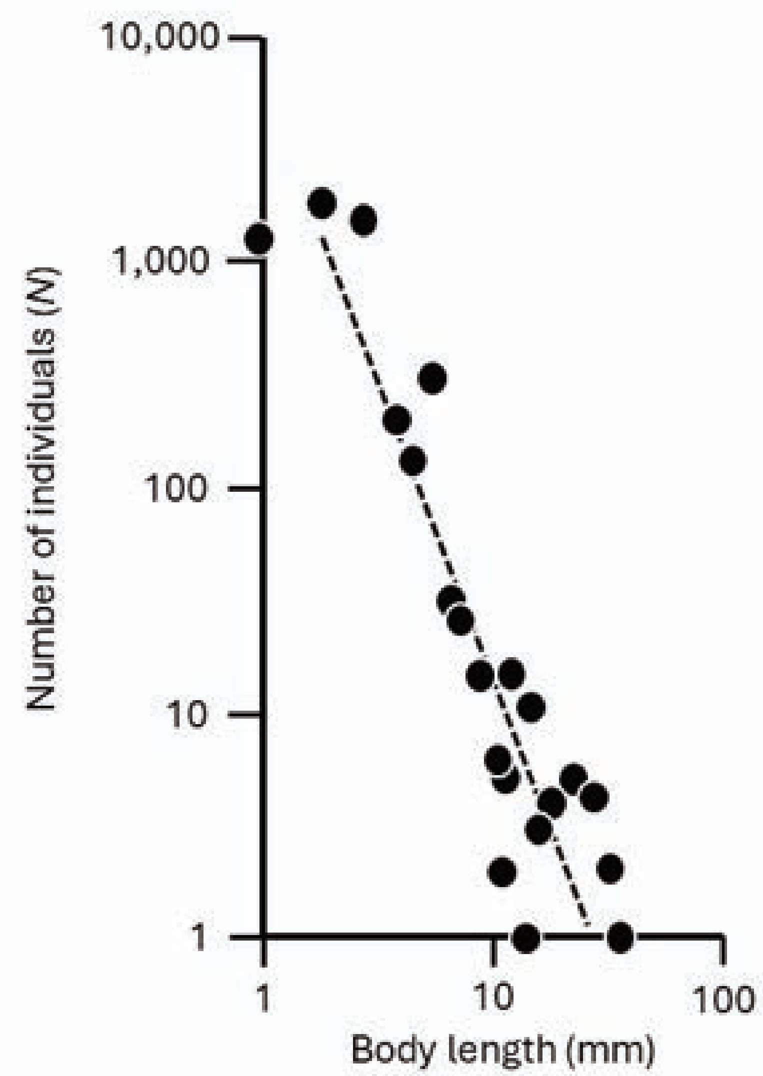


Figure 6. Number of individual arthropods (mainly insects) collected by sweep net from understory foliage in primary forest, Costa Rica, plotted against their size. The dashed line indicates a relationship in which $N \propto L^{(1-D)}$, where the fractal dimension D of the environment is about 1.4. Redrawn from Morse *et al.* (1985).

value of about 2.8. Thus, from the point of view of the insects, these ecosystems were even more 'fractal' than they had appeared to the researchers.

Species packing and the 'slippery slope'

But if there are more individual small insects than large ones in the ecosystem, then surely there should also be more small species? To a considerable extent, the implications for species numbers of Morse *et al.*'s fractal paper had already been prefigured by May (1978), in trying to explain the negative value of the slope on the right-hand side of his species-size curves (Fig. 1). Noting that it was well-known that larger populations of individual insects contain more species, he asked whether it was possible that the greater number of insect species with small body dimensions could be a natural consequence of the larger numbers of small individual insects. I won't go through the argument in detail, but after making some back-of-envelope calculations, May plausibly concluded that the predicted dependence of species number on species abundance was "nowhere near enough" to explain the observed increase in species number with decreasing insect size. Even if May had in 1978 known the results of Morse *et al.*'s field work, published seven years later, his conclusion would almost certainly have been the same.

Instead, May opted to explain the relationship between species number and insect size by revisiting a classic paper by Hutchinson (1959), which directly addressed the question of how many species can co-exist; this has since been dubbed the 'species packing problem' (MacArthur, 1969). Hutchinson proposed that any terrestrial environment has a granular or 'mosaic' character based on its physical structure, and that this granularity offers a greater variety of niches suitable for occupation by small species than is available to larger species. In other words, as insects get smaller, we can expect there to be more insect species packed into the environment, because it 'has more room for them'. This rather vague idea was worked out in more detail in a mathematical paper co-authored with Robert MacArthur (Hutchinson *et al.* 1959), which even Robert May described as "difficult" (I can only agree!). That paper proposed that the number of species S of length L present in any ecosystem should be inversely proportional to L^2, but there was no good explanation for why the number of species should reach a peak and then fall away on the left hand side of the species-size graph at very small sizes. Nineteen years later, May himself revisited the same idea, this time arguing that in the right-hand region of the species-size curve the observed slope is due to the environment's granular nature as a 2 – 3-dimensional surface. Although this sounds very like the fractal dimension explored by Morse *et al.* (1985), May's publication didn't mention the term 'fractal'. Remember too that here May was looking at species number, not the number of individual insects. May (1978) proposed that $S \propto L^{-y}$ where y = 2–3, and showed that this relationship appears to hold for British Coleoptera (Fig. 1B) as well as for British and Australian Lepidoptera, although in every case there was the usual deficit of the smallest species.

Loder *et al.* (1997) later pointed out that although a lot of effort had by then been devoted to looking at the slopes of the right-hand sides of such species-size curves, the biological significance of what they now dubbed the 'slippery slope' is unclear. Moreover, there is no theory that enables us either to predict the modal value of the distribution, nor to explain why there appears to be a cut-off point for small species. May's (1978) proposal, still the most plausible, is that at such small dimensions, occupancy of the niche by any particular kind of animal must be shared with similar-sized animals of kinds other than those being analysed. He says "for any one group (*e.g.*, beetles), ecological aspects of the species-size relation tend to be masked by the group blending into ecologically similar, but taxonomically different, groups at both low and high ends of its size range". Very small beetles, for example, may face competition from smaller but unrelated animals such as mites, as I mentioned above.

What May *didn't* consider was that there may actually be a minimum physical size for any particular kind of insect, or even for any kind of animal at all. Such a limit might operate only in those orders that contain very small or very large species, and so there would be little evidence for it when examining size distributions within the Hexapoda as a whole. If there were indeed minimum and maximum sizes for insects, then they would constitute an entirely different kind of mechanism for determining the species-size modal value and explaining the prevalence of right-skew in lognormal species-size curves. Such limits would depend on anatomical and physiological considerations rather than ecological-evolutionary processes. I'll consider this subject in a future *Research Spotlight* article.

Little things that run the world

Famously, one of the twentieth century's most eminent entomologists, E.O. Wilson (1987), pointed out that insects and other terrestrial arthropods are "the little things that run the world". Why 'little'? I suppose Wilson must have meant that insects are very much smaller than humans. Since the average adult human is 1.66 m tall (mean of both sexes, whole world: https://ourworldindata.org/), this means that the average insect is 129 times smaller in linear dimension than the average human. A hexapod of 'average' length would be predicted (on average) to have a body mass (fresh weight) of about 54.5 mg (Sage, 1982). Since the mean weight of single human is 62.0 kg (world data, average of men and women: Walpole *et al.*, 2012), the average human is more than a million times heavier (to be exact, 1,137,615 x) than the average insect.

So just as Wilson said, insects are indeed very small compared to humans, and it is appropriate to reflect on how little they need us. But perhaps Wilson had more in mind than that? As we have seen, the smaller they are, the more individual insects, and the more different kinds of insect there are. Perhaps what Wilson meant was that it is the smallest insects that really dominate ecosystem processes in the places where they live.

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Experiences and some early results in monitoring congregating fireflies using night photography on a boat

Figure 1. Fireflies flashing on a mangrove apple display tree at night along the Sepetang River. Long exposure of 15 seconds, with ISO 6400.

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The Sepetang River, located in the state of Perak in Peninsular Malaysia, flows through the town of Kuala Sepetang. This riverine area is abuzz with agriculture, aquaculture and nature tourism. Mangrove cruises, and tours to watch birds and dolphins, are some of the activities that visitors can enjoy. From dusk onwards, boat-rides to watch fireflies begin and continue for a few hours into the night. The dominant species of firefly here is *Pteroptyx tener*, a species which congregates in large numbers on trees along the riverbanks and synchronises its flash displays (Figure 1). A previous study found that fireflies congregated along the riverbanks of the Sepetang River from about 5 to 13 km from the river mouth (Jusoh *et al.,* 2010). In a survey that we conducted in 2020, *P. tener* congregated in patches from about 7 to 20 km from the river mouth — an area between Kampung Dew jetty and Kuala Sepetang town. The fireflies further downstream, which displayed high up on *Rhizophora* trees, were a different species as they had a slower flashing pattern.

Kuala Sepetang is less well known for its fireflies than Kuala Selangor, which is located well south of Kuala Sepetang in the state of Selangor. It is from the population in Kuala Selangor that we derive most of what we know about *Pteroptyx tener*. There, as well as in Kuala Sepetang, it displays mainly on the mangrove tree *Sonneratia caseolaris* (mangrove apple), although it also displays on many other tree species (Nada & Kirton, 2004; Ohba & Wong, 2004; Nada, 2011; Wong & Yeap, 2012; pers. observ. 2020). During the day, the fireflies are often found underneath the leaves of the display trees. Only the males flash synchronously (Case, 1980). Flashes begin at dusk and last until the early hours of the morning, but are most numerous and bright during early hours of the night (Khoo & Kirton, 2012).

In a global survey conducted in January 2019 among 350 participants of the Fireflyers International Network (FIN, a scientific organisation comprising individuals with interests and expertise in firefly ecology, behaviour, taxonomy and conservation), Southeast Asian respondents ranked habitat loss as the greatest threat to firefly conservation, followed by light pollution, water pollution and pesticide usage (Lewis *et al.,* 2020). While threats are known and surveys have been conducted around the world to determine the distribution and abundance of firefly populations in different habitats, there is a lack of data on the health of the firefly populations within these habitats.

In 2006, Forest Research Institute Malaysia (FRIM) developed a non-destructive photographic method to monitor fireflies as an effort towards conservation of the firefly population along the Selangor River in Malaysia (Kirton *et al.,* 2012; Khoo *et al.,* 2016). It involves digital night photography using an SLR camera with a zoom lens and a sturdy tripod and has been described in detail in Kirton *et al.* (2012). At the Selangor River sites, the photography takes place on stable ground. Images of long stretches of firefly display trees are taken from across the river on the riverbank. The images are analysed using image analysis software to obtain counts of bright spots produced by the flashes of the fireflies. These counts are used as an index of abundance for the adult fireflies. Besides being a tool to assess the health of the firefly population, it is also useful for studying firefly behaviour (*e.g.,* Khoo & Kirton, 2012). The monitoring programme takes place along stretches of display trees in predetermined sites on a fixed frequency that is centred on the new moon each month. Initial implementation of a firefly monitoring programme along this river was supported by the Malaysian Department of Irrigation and Drainage (DID) and Danish International Development Agency (DANIDA), and thereafter, subsequent funding was provided by the Malaysian Economic Planning Unit, the Selangor State government through the Selangor Economic Planning Unit, and the Selangor Waters Management Authority (SWMA). The programme continues to this day.

Any attempt to use photography for firefly monitoring at the Sepetang River would require adaptation of the method, as there is no stable ground on which to set up the camera along the riverbank. The riverside vegetation is dense, and there are no paths or clearings into the inland vegetation, making it necessary to carry out photography from within a boat. This poses many challenges, as the boat is dragged by the constant water flow and is easily rocked by the movements of people on the boat or by waves generated when other boats cruise by. Therefore, the boat needs to be moored by tying it securely to sturdy vegetation to minimise movement (Figure 2). Occasionally, when the tide is low, one end of the boat may be grounded in shallow water to help stabilise it. The number of people aboard the boat needs to be kept minimal. They need to remain still, and photography is carried out when the water is relatively calm. The frontal tripod leg needs to be held down firmly by someone so that the tripod and camera do not shift but remain in the same position throughout photography, even if the boat rocks when another boat passes (Figure 3).

With this method, it was possible to produce images that were clearer than when the boat was free-floating on the water. In images taken at a long exposure time of 8 s with the boat moored (Figure 4a), the bright spots produced by individual fireflies overlapped, forming a single spot that was generally well defined. However, when the boat was left untied, the bright spots produced by individual fireflies broke into a linear series of spots (Figure 4b) due to movement of the boat. At an exposure time of 0.5 s, it is possible to capture two flashes of an individual firefly because *P. tener* flashes at an average frequency of 3.7 times per second (Case, 1980), making the interval between flashes approximately

Figure 2. Boat secured tightly to a nypa palm clump to minimise movement.

Figure 3. Camera and tripod set up on a raised platform in the boat. During photography, the frontal tripod leg is held down firmly as shown.

0.27 s. This can then result in double spots from a single firefly in 0.5-s images if there is movement of the camera. Similar double spots may occur when wind blows the trees or when an individual firefly is flying. Such separated spots produced by the same firefly can usually be recognised by their close proximity to each other and, in the case of movement of the tree or camera, by the repetition of closely spaced double spots at the same distance and angle to each other throughout the image. Mooring the boat and tying it securely to vegetation minimises the likelihood of double spots in the images, as can be seen even in longer exposures of 8 s (Figure 4a) and 15 s (Figure 1). At 0.5 s, images taken with the boat moored were comparable with those taken at the same exposure time with the camera on land at the Selangor River (Figure 5).

Another challenge when photographing at night from a boat is framing the exact same stretch of river vegetation in the camera viewfinder each time monitoring is carried out. On land, ground markers, tripod levelling, a plumb-line and a compass mounted on the camera flash

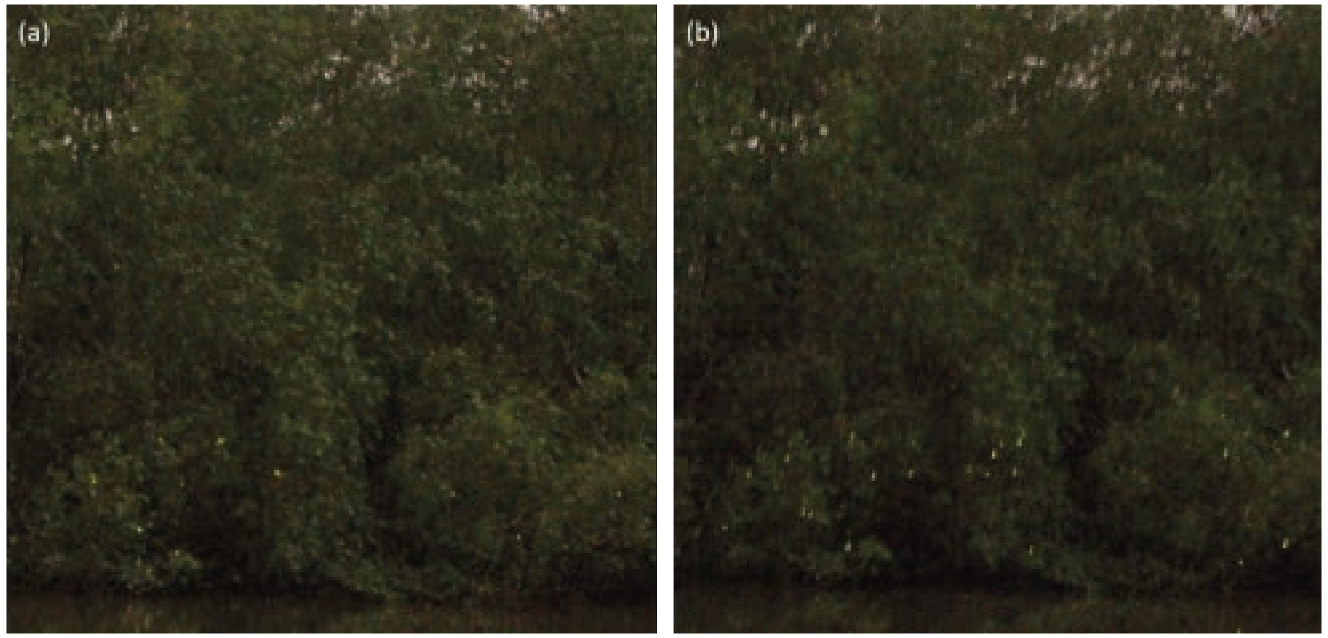

Figure 4. Night-time images of firefly flashes on display trees along the Sepetang River taken from a boat at an exposure time of 8 s. **(a)** Boat moored and securely tied to nypa clumps. **(b)** Boat left to float freely.

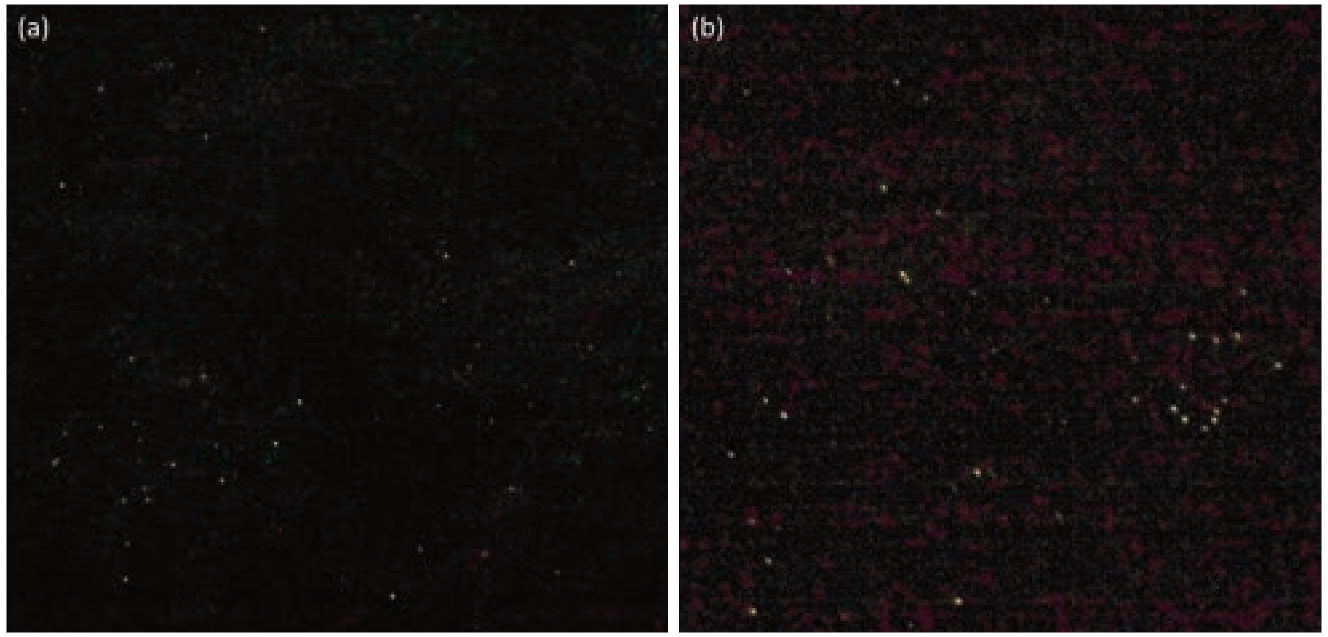

Figure 5. Enhanced night-time images of firefly flashes on display trees taken at a 0.5 s exposure time at **(a)** Sepetang River, from a moored boat, and **(b)** Selangor River, from land.

bracket are used to reproduce the same angle of view, and thus frame the same stretch of vegetation across the river. In a river, the movement of the boat makes it impossible to position the camera by predetermined locations and angles. Instead, reflective tags were tied to the edge of the foliage of the display trees for reference and a torchlight was shone briefly to locate the reflective tags during framing. Test images and an image of the previous session were also compared to help angle the camera correctly.

Unlike the Selangor River, the largest firefly displays along the Sepetang River occur in patches on solitary mangrove apple trees or on two trees side by side. Longer stretches of trees along this river have very few fireflies. Therefore, a single camera frame is sufficient to monitor the fireflies at any given site along this river. At the Selangor River, the camera has to be panned to capture multiple frames that cover the entire stretch of display trees. Sufficient sites would be needed at the Sepetang River because firefly congregations can move from one display tree to another over time. Monitoring sufficient trees along this river would provide a representative sample on which a population index can be based. Sites were chosen based on two criteria. Firstly, the consistent presence of large numbers of displaying fireflies seen during three bimonthly preliminary surveys; secondly, the availability of clumps of nypa palms to which the boat could be tied on the opposite bank of the river and, where possible, a shallow shore to enable the boat to be grounded in the mud.

Sample photographic images for monitoring were taken in six sites located in the mid-section of the distribution of *P. tener* between Kampung Dew jetty and

Figure 6. The six sites (blue pins) at which photography was carried out on the Sepetang River. Original map source: Google Earth.

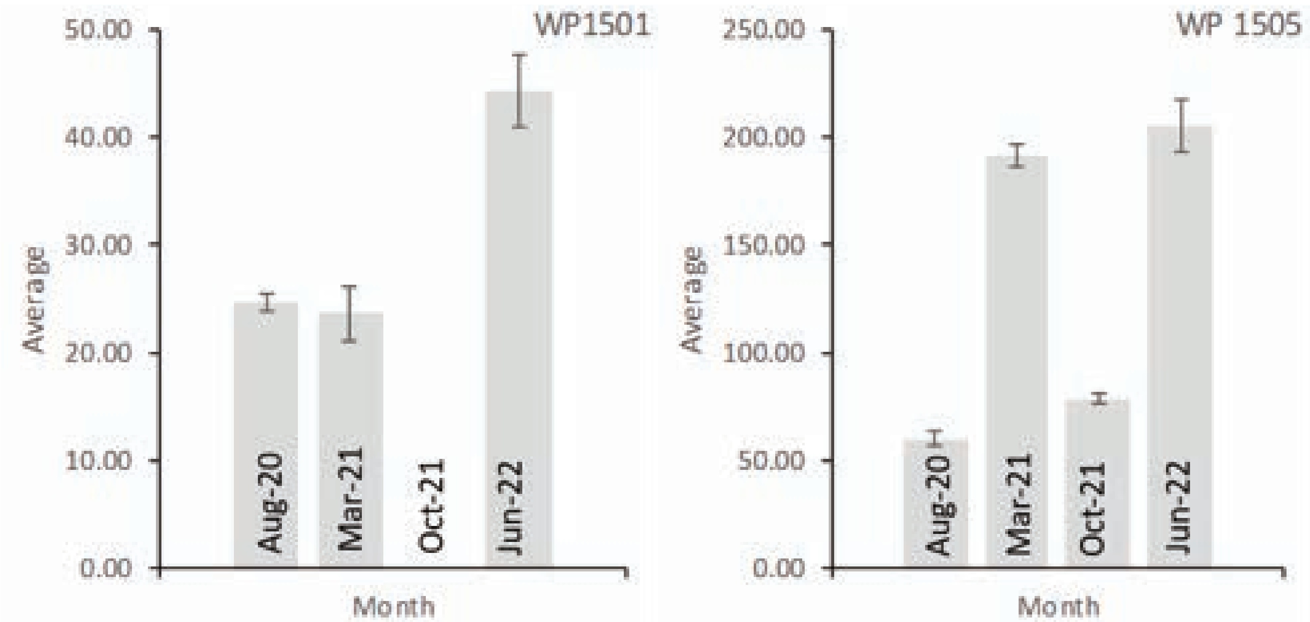

Figure 7. Index of abundance of fireflies (counts of bright spots in images) at two sites along the Sepetang River, WP1501 and WP1505, at four different periods between August 2020 and June 2022.

Kuala Sepetang town (Figure 6). Further downstream towards Kuala Sepetang, the river widens to the extent that the trees are too far away to be photographed from the opposite riverbank. Monitoring images were taken at four 7-to-8-month intervals from August 2020 to June 2022. Covid-19-related travel restrictions implemented during parts of the years 2020 and 2021 prevented monthly monitoring from being carried out. Images were captured using a Canon EOS 5D Mark II with a Canon EF 70–200mm f/2.8 L IS USM lens at site-specific focal lengths of between 70 and 85 mm. Camera settings similar to those in the firefly monitoring programme at the Selangor River were used, *i.e.*, an exposure time of 0.5 s, wide aperture of f/2.8 and high sensor sensitivity of ISO 3200. Images were post-processed by raising the gamma level to brighten the firefly flashes captured in the images. The number of bright yellow spots was counted using image analysis software to obtain an index of abundance of the fireflies.

Counts for two sites—WP1501, located furthest downstream, and WP1505, located midway—are shown in Figure 7. The graphs for these sites show how the abundance of fireflies at one site can differ from the abundance at another at the same time period. They also show that fireflies may be absent from a site at one time period and be abundant at another period. Together, these graphs demonstrate that monitoring by night photography from within a boat is possible if sufficient precautions are taken to ensure the stability of the boat and support of the camera.

Acknowledgements

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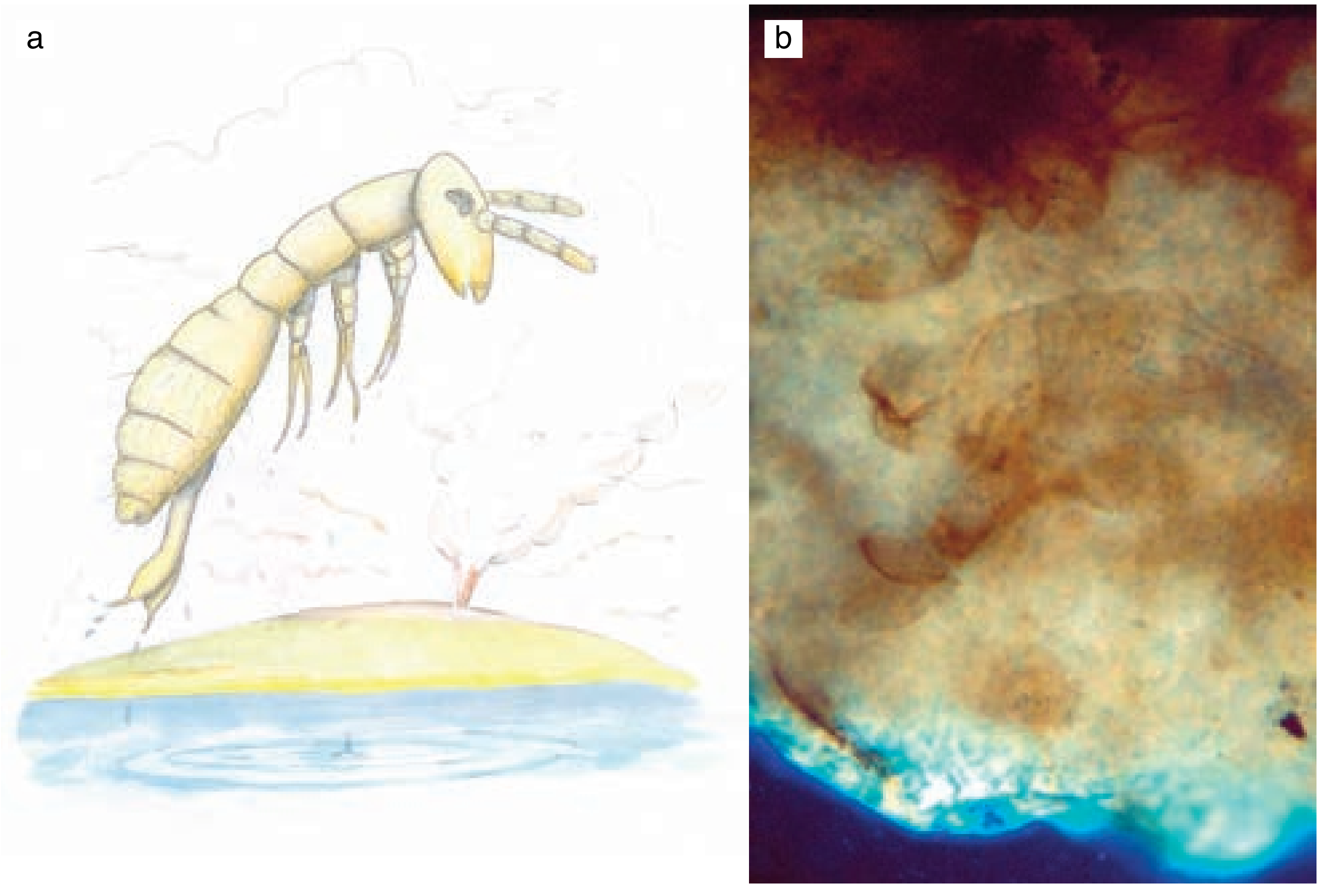

Figure 1. a. *Rhyniella praecursor*, 1.5 mm long, fish-eye view; **b.** abdomen in chert.

British & Irish Insects: The first 408 million years

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In the beginning

The natural history of insular North-West Europe often commences with the deglaciation of Britain & Ireland (B. & I.) starting 11.7 thousand years ago (Kya) (*e.g.*, Wildlife Trusts, 2023). The terrestrial fauna is considered to have arrived either before sea levels rose too high in prehistoric times (when it's regarded as native) or was introduced later and naturalised (especially in historic times, notably by the Romans). The story is, of course, more complicated than that, not least because the glaciers never covered the whole of Britain and interglacials could be warmer and more attractive to poikilothermic wildlife than cool-temperate Britain today. There is now a growing corpus of archaeoentomological and palaeoentomological work on subfossil insects to complement the biological story and climate modelling of the northern hemisphere between now and 2.58 million years ago (Mya), geologically known as the Quaternary Period or, popularly, the ice age (*e.g.*, Elias, 1994).

The B. & I. fossil record takes us further back, through greenhouse periods (lacking polar ice caps), past an earlier ice age (cold house), to the world's earliest-known hexapods (insects *sensu lato*). It therefore encompasses a little under 410 million years (Mys) of insect evolution. Not only did B. & I. change their boundaries and landscape, but also their latitude and longitude during that time, as geological processes (not necessarily of Earth origin) exerted their influence. In this essay, I present a deep-time snapshot of B. & I. insect history, in which the coming and going of a still-living Tibetan dung beetle (*Alocoderus holdereri* (Reitter)) in the English Midlands and South-East England during the Late Pleistocene, 12–126 Kya (Coope, 1973) is merely the idiomatic tip of the iceberg. I dedicate this piece to the memory of Herbert Goss, nineteenth-century Secretary of our Society, then called the Entomological Society of London, nature conservationist and author of a more comprehensive fossil insect review (Goss, 1880). By fossil, I generally mean insects lithified or amberised, *i.e.*, preserved in rock or as inclusions, not soft sediment (*pace* Quaternary palaeoentomologists). If you wish to see some fossil and sub-fossil insects, they are housed in various national and regional museums, including local government and university collections, *e.g.*, see Kelly (2017) and his articles in the previous two years of this magazine. The papers cited below are only a selection and often contain useful bibliographies. Should you wish to find some fossil insects, the fieldwork programmes of our national and regional geological societies are worth exploring *e.g.*, see the Geologists' Association of London online.

An enduring springtail

Our story begins in the land we now call Scotland, near the village of Rhynie in the county of Aberdeenshire, around 408 Mya in the Pragian Age of the Early Devonian Epoch. The area then lay in the southern part of the Laurussian Continent at a palaeolatitude of some 28 degrees South (Trewin *et al.*, 2004). The treeless landscape, now a cattle field, was dominated at the time by hot springs and geysers, like Yellowstone National Park in the USA today. A siliceous sinter coated plants and animals in the vicinity to form a hard, durable rock, the Rhynie chert, preserving them for posterity. *Rhyniella praecursor* Hirst & Maulik, an extinct collembolan (springtail) found in the chert, chiefly by the Revd Cran in the last century, is still the world's oldest-known entognathan hexapod (Penny and Jepson, 2014). This minute grazer was already equipped with *Podura*-like claws and a furcula (furca) to walk on water and jump on land respectively (Fig. 1) to avoid arthropod predation. There then follows a global 80 My gap in the palaeoentomological record and an unclaimed prize to fill it (Hošek, 1994) – after which time we also have true insects (ectognathans) present, including pterygotes, in the fossil record as discussed recently in this magazine (Ross, 2021).

There be giants

Our story therefore takes us next to 325 Mya when, during the ensuing 60 Mys, B. & I. were famously covered by low latitude Carboniferous 'coal swamps' (peat mires), the distant Gondwanan glaciation influencing sea level and low-lying land areas reminiscent of the Quaternary. The mires were in a palaeoequatorial forest belt, often compared with a modern rainforest biome, *e.g.*, the Amazon basin in Brazil, except for the notable absence of angiospermous flowering plants and amniotic flying animals. The flora was then dominated by arborescent clubmosses and aerial biota by insects, some of which left their marks on the plants. The insects belong to the Palaeozoic fauna, meaning that of ancient life. If later eras popularly recognise the dominance of vertebrates (see below), then at least the Carboniferous Period may be referred to as the age of insects, even if they were thinner on the ground at first. The most familiar Palaeozoic hexapods are the celebrated giant dragonflies (the protodonatans or meganisopterans). Comparatively rare, they are known from Britain, although the record holder, with a wingspan of up to 70 cm or so, is *Meganeura monyi* Brongniart from France, which you can view in the National Museum of Natural History in Paris, upstairs in the Palaeontology Gallery (but go sooner rather than later in case moved to Dijon). We have the more modest *Tupus diliculum* (Whalley), a Bolsover dragonfly from the English Midlands, with a span approaching half a metre. The origin of the gigantism continues to be debated (*e.g.*, was it hyperoxia or Cope's Rule?) although not all these ancient dragonflies were gigantic. Thus, the damselfly-like *Bechlya ericrobinsoni* Jarzembowski & Nel, from Radstock in South-West England, had a wingspan of just under 6 cm. The discovery of these fossils is indelibly linked with the historic mining of now-demonised coal, a compressed fossil peat. Carboniferous insects, though, come from the associated aquatic sediments, typically early-mineralised ironstone nodules, as classically monographed by Bolton (1921–1922). These deposits, exploited during the Industrial Revolution, have produced other extinct palaeopterous insects in addition to dragonflies, especially the broadly mayfly-like palaeodictyopteroids (some of which were phytophagous and also big, implying a mutual arms race?). Both the adults and nymphs of the latter (*e.g.*, *Rochdalia* Woodward from Rochdale in England and *Lithomantis* Woodward from near Ayr in Scotland) still figure in discussions on the tergal/pleural origin of insect wings (Reynolds, 2020). (The debate is ongoing – *e.g.*, Ohde *et al.* (2022) in support of tergal origins.) There are also extinct orthopteroids and cockroachoids present. These, too, contribute to our understanding of Archaeorthoptera and Dictyoptera. By geological standards, Bolton's palaeoentomofauna was compact, albeit diverse, and specimens comparatively large by insect standards. Later fieldwork has shown that there were actually more fossil insects to be found in the abundant rock on colliery tips, especially during reworking of mudstone spoil, facilitating more detailed palaeoecological reconstruction (Stagg *et al.*, 2018).

Missing the big dying

After the Carboniferous comes the Permian Period, during which holometabolous insects survived and thrived. B. & I. having been incorporated in the supercontinent of Pangaea, the humid climate now changed to an arid one, resembling the interior of present-day Australia. Insectiferous deposits are thus lacking due to oxidation and evaporation until well into the Triassic, missing what is often considered the Earth's greatest mass extinction in the last half-billion years. This was at the Permo-Triassic (P/T) boundary, although for insects it may have been just a turnover (Schachat and Labandeira, 2021). We have yet to discover a mainland insect fauna, but remote territories have produced tantalising finds, such as the extinct *Permagrion falklandicum* Tillyard, a protodamselfly, in the South Atlantic.

On to the age of dinosaurs

The Late Triassic is the earliest epoch with a British entomofauna in the succeeding Mesozoic Era (palaeontological 'Middles Ages') and was investigated by the pioneering Revd Brodie in 1845, who was profiled recently in this magazine (Jarzembowski, 2023). After a pluvial episode, the insect record picks up again towards the end of the epoch, some 205 Mya, as in the Cotham Marble (actually a lagoonal limestone) in the Severn Estuary of South-West England (Swift and Martill, 1999), and even fissure fills on either side of the estuary. Holometabolans were now well established, ranging from ancient caddisflies, like *Necrotaulius* Handlirsch, to beetles defying natural classification; also present are stem scorpionflies and an early chironomid midge (Chandler, 2010). Gone were many Palaeozoic palaeopterans and heterometabolans and the Mesozoic entomofauna has a more modern aspect at ordinal level.

Insects in Jurassic seas

The lagoonal Triassic deposits are followed by the marine Lias, passing up into the succeeding Lower Jurassic, which is well exposed along the English Channel/La Manche at the Jurassic Coast World Heritage Site in the counties of Dorset and Devon. The drifted or drowned Liassic insects found there in certain limestone bands may be better preserved than in some terrestrial deposits. They include fossil species of damsel-dragonflies (anisozygopterans; Fig. 2), a group now found relict in Asia; grasshoppers and crickets (orthopterans) before grasses evolved, and a unique moth (microlepidopteran) (Coram, 2014). There are, in addition, ten extant orders of insect represented by extinct cockroaches (Blattodea), earwigs (Dermaptera), true bugs (Hemiptera), beetles (Coleoptera), lacewings (Neuroptera), snakeflies (Raphidioptera), scorpionflies (Mecoptera), true flies (Diptera) and a single stick insect

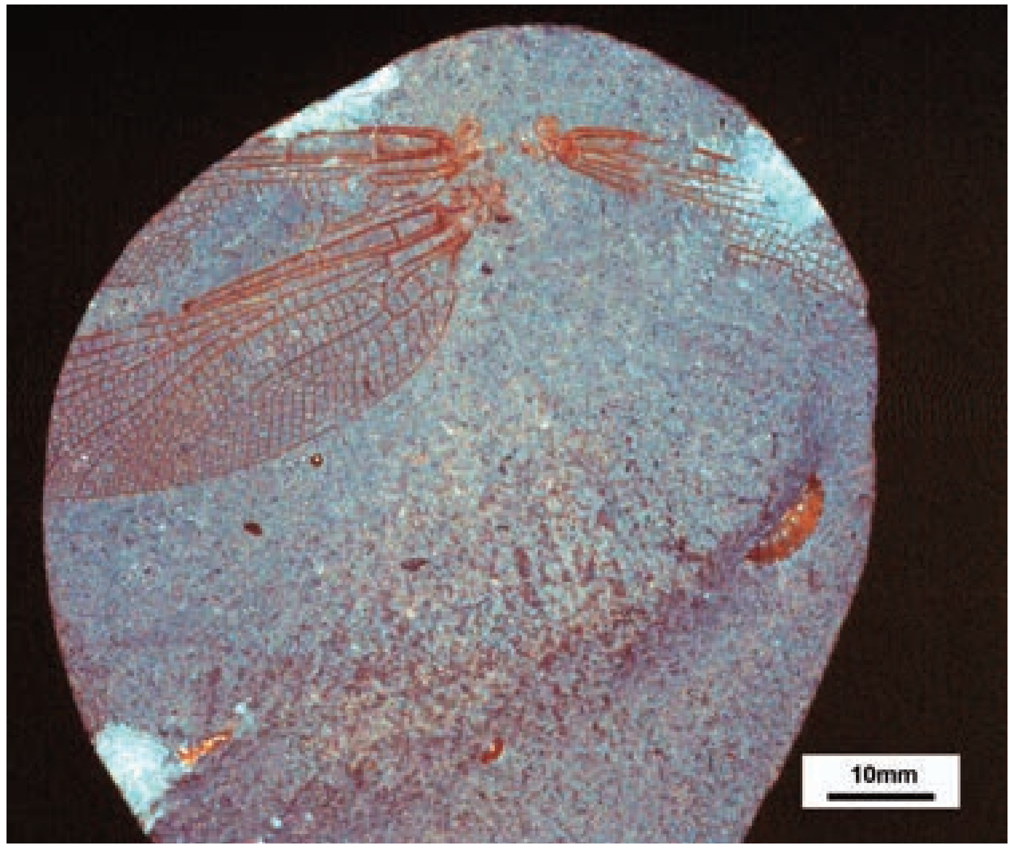

Figure 2. Heterophlebiid wings in Lias pebble.

(Phasmatodea) and caddisfly (Trichoptera). The muddy Lower Jurassic is followed by the oolitic Middle Jurassic deposited in a shallower, more energetic marine environment with a few large insects (especially beetles) in the Stonesfield Slate of Central & South-West England (now also called the Eyford Member as not a slate!). A notable species present is *Palaeontina oolitica* Butler, an extinct cicada-like bug, originally thought to be a Jurassic butterfly in the nineteenth century on account of its size and open venation. Detailed comparison of the veins, not to mention absence of scales and contemporary angiosperms, plus the discovery of palaeontinid bodies in the Solnhofen limestone of Bavaria, Germany, subsequently revealed its hemipteran affinities (Wootton, 1971). From an entomological perspective, imperfect rock fossils can be a challenge to interpret, but so are broken pots and faded frescos to a historian. Just as archaeology has developed to assist the latter, so has palaeontology to augment biology in deep time, with excavation (and prediction) as common tools, accompanied by serendipity and detective work.

The Upper Jurassic saw a return to muddy conditions with the occasional dragonfly buried at sea of which *Tarsophlebiopsis mayi* Tillyard from the Ampthill Clay Formation may be mentioned as it was unusually entombed inside an ammonite shell. It also survived erosion by Quaternary (Pleistocene) glaciers in Hertfordshire.

The longest period: the Cretaceous

The Cretaceous, starting 145 Mya and lasting 79 Mys, is the longest geological period in the Phanerozoic Eon (which we still share with insects). After submergence under shallow Jurassic seas, the Early Cretaceous is dominated in B. & I. by the opening of the North Atlantic Ocean and accompanying uplift; there were even uplands at times in Londinia, the future site of London, now in a river valley. Rifting was accompanied by non-marine deposition for the first 24 Mys: the Purbeck beds of Dorset and Wiltshire with evaporates (resembling sabkhas in the present-day Gulf of Aden) are followed by the Wealden of the Weald and the Isle of Wight with

Figure 3. Surrey dragonfly, male, wingspan 92 mm, counterpart in Wealden phosphatic concretion.

sandy rivers and mudplains. There are 16/17 orders of insect found fossilised in limestones (Coram and Jepson, 2012), ironstones, siltstones and even phosphates (Austen and Batten, 2018). In addition to the orders found earlier in the Jurassic, but now with different species, there are also thrips (Thysanoptera), rare mayflies (Ephemeroptera) and barklice (Psocodea), a stonefly (plecopteran), a termite (isopteran) and, evidently, a grylloblattodean (ice crawler). The termite, *Valditermes brenanae* Jarzembowski from the Weald Clay Formation of Surrey, known from alates, is one of the earliest-known social insects; now as then, the best British termite is a dead one (Suttie, 2022). The same formation and county have also produced the Surrey Dragonfly, *Valdaeshna surreyensis* Jarzembowski (Fig. 3), an extinct true dragonfly (anisopteran; Follett, 1996). By the Jurassic, insects had lost their Palaeozoic aerial supremacy to Mesozoic flying reptiles (pterosaurs). Two contrasting flight adaptations are seen in the two species above, with venation specialisation in the dragonfly and wing casting after massed flights in the termite. Earlier groups still survived, however, so that there are four suborders of dragonfly in the Wealden deposits, compared with two in Britain today, now with birds and bats as top aerial predators.

Such is the abundance (thousands) of Early Cretaceous insect remains in southern England that, whilst they present a taxonomic challenge (especially the higher beetles), they provide a palaeoecological snapshot of entomofaunas on the geological eve of the angiosperm radiation (Angiosperm Terrestrial Revolution (T.R.), encompassing the Cretaceous T.R. and change from Mesophytic to Cenophytic flora). Thus, butterflies, bees and ants are conspicuous by their absence and cockroachoids evidently cleaned up after dinosaurs (Vršanský *et al.*, 2013). Parasitoid Hymenoptera, however, were well established; extinct aphids, archostematans (archaic beetles) and coleorrhynchans (moss bugs) as well as a matsucoccid (scale insect) and bittacid (hangingfly) made occasional appearances; extinct silky lacewings (psychopsids) were the most common neuropteroids. Today, archostematans, psychopsids and coleorrhynchans are no longer found in B. & I., the latter being strictly southern hemispheric: such a North/South divide is not always apparent in the Cretaceous. Some taxa had contemporary eastern (Asian) relatives, *e.g.*, the extinct brachycerous fly genus *Sinonemestrius* Hong & Wang is recorded in Surrey, England and Shandong, China. Nature reputedly abhors a vacuum and in the dearth of diurnal Lepidoptera, extinct psychopsid-like kalligrammatids with sucking beaks and deimatic eyespots (Fig. 4) would have visited gymnospermous inflorescences. Mesozoic forests were dominated by various conifers, clubmosses having become confined to floodplains. Subcortical wood boring by insects (trace/ichno-fossils; Fig. 5) shows that the beetle potential for pathogen transmission existed long before there were deciduous trees prone to fungal infection, such as elms. Judging by the accumulation of their cases in Lower Wealden river deposits, caddis larvae thrived in Cretaceous lowlands, unlike other freshwater insects. They did not, however, produce Asian-style bioherms and cases are commonly constructed from clam-shrimp carapaces belonging to a group of crustaceans ('conchostracans'/spinicordatans) curiously absent from Britain today (although present in continental Europe).

Our Early Cretaceous palaeoclimate was Mediterranean-like with hot, dry summers and some of the fossil insects are charcoalified (fusainised) providing evidence of wildfire ecology. Wealden amber with chironomids from the Isle of Wight, however, suggests a moist spring in the coniferous forest on higher ground by comparison with younger Baltic amber (Larsson, 1978). Native amber with insect inclusions (Fig. 6), however, now

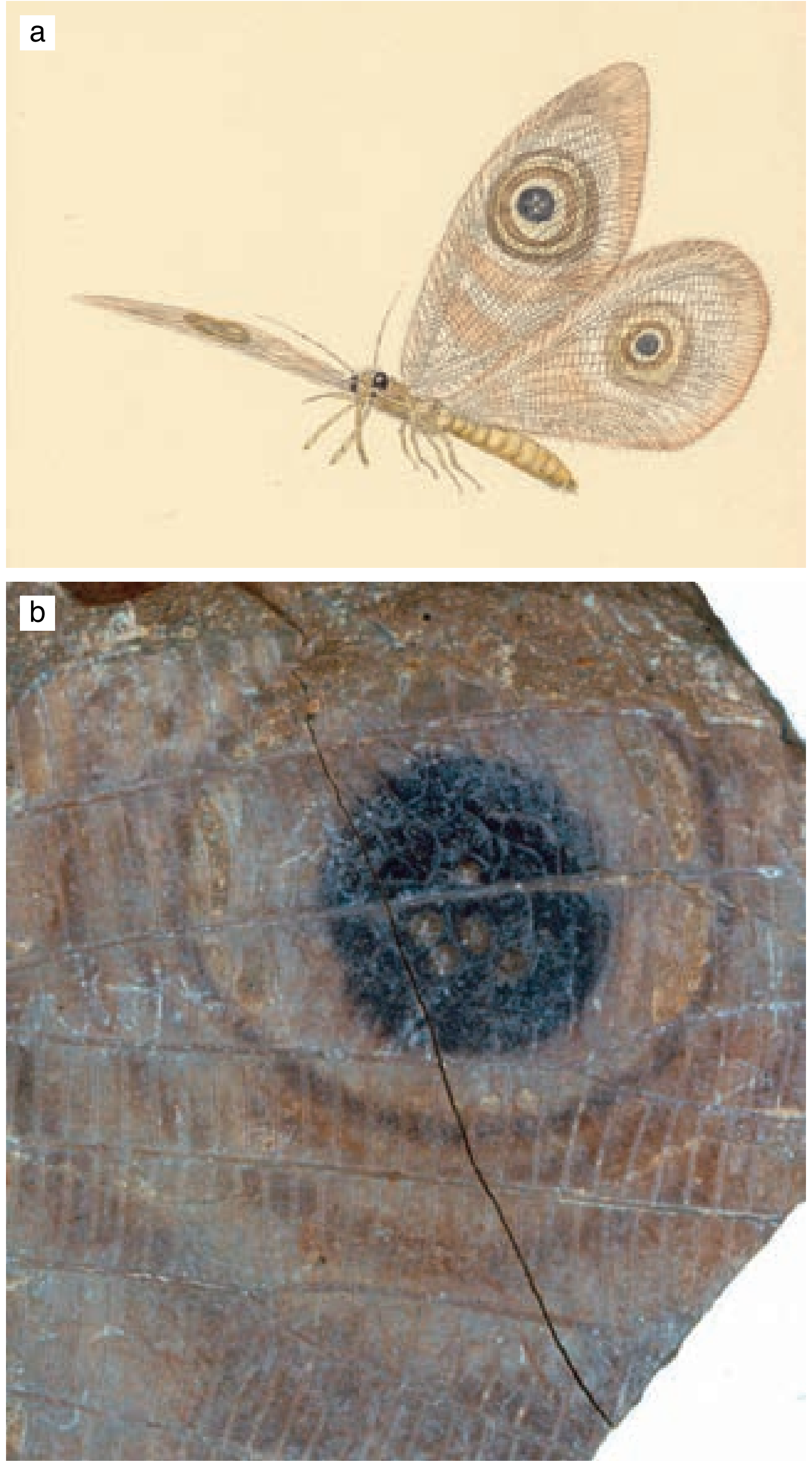

Figure 4. a. *Kalligramma crowsoni*; **b.** eyespot, 14 mm diameter, in Wealden Tilgate Stone.

dates back 125 Mys, providing a valuable taphonomic window in the early Cretaceous Resinous Interval, although it is not as abundant, or of jewellery grade, like younger amber. It complements the rock record, *e.g.*, the potential prey (leafhoppers) of an amber wasp (embolemid) occurs in Wealden sedimentary deposits (Perkovsky *et al.*, 2021).

Dodging asteroids

The sea returned for the next 55 Mys of the Cretaceous and we lose the B. & I. insect record again. This is compounded by earth movements across the most famous extinction event of them all at the Cretaceous/Palaeogene boundary aka K/T boundary which saw the demise of the non-avian dinosaurs, especially in North America. This event is attributed to a bolide, augmented by Deccan volcanic emissions, but as before, insects apparently walked away from mass extinction (see Schachat and Labandeira, 2021). No doubt dermestid beetles helped clean up the cadavers afterwards, as they did earlier in the Cretaceous.

A new era

Finally we reach the Cenozoic (previously Kainozoic) Era, popularly the age of mammals, encompassing the last 66 Mys and including the 'Tertiary' and Quaternary – the latter where we started above. The 'Tertiary', though long recognised, is now divided into the Palaeogene and Neogene periods (Lower and Upper Tertiary). The latter period is missing from our story due to widespread erosion in B. & I. associated with the Alpine orogeny (mountain-building phase due to European/African plate collision). The last event uplifted and shaped southern Britain leading up to the ice age, including creating the Thames Valley now containing London and the Vale of St Albans with the RES HQ nearby. The Palaeogene is noted climatically for the Palaeocene-Eocene Thermal Maximum (PETM), whereas the Oligocene is marked by the onset of global cooling and the beginning of ice sheets on Antarctica, which are still significant today. This impacted insect distribution whilst the entomofauna took on a more modern aspect with extant genera in the Palaeogene and extant species in the Quaternary (*e.g.*, Stringer, 2006).

Giant ants and the PETM

The B. & I. Palaeogene insect record starts circa 58 Mya in the late Palaeocene Epoch, among the spectacular lava flows of Northern Ireland and the Scottish islands. In the Ardtun Leaf beds on the isle of Mull, deposited in lakes and rivers when the volcanoes were dormant, is a small but interesting entomofauna with some 16 species in six orders described to date. It includes a fossil hairy cicada, *Eotettigarcta scotica* Zeuner, tettigarctids now being a relict family found living only in southern Australia. There is also the Jerusalem cricket-like

Figure 5. *Paleoscolytus sussexensis*, 9 cm across, in ironstone-filled wood compression.

Figure 6. *Libanodiamesa simpsoni*, wingspan 3 mm, Wealden amber.

Zeuneroptera scotica Zeuner and crane-fly *Dicranoptycha europaea* Zeuner, the latter belonging to a widespread modern genus not found in Australia.

Of comparable age, give or take a couple of million years, and nearly at the opposite end of B. & I., is a former quarry at Cold Ash in Berkshire, southern England, also with plant beds but in a coastal-plain setting. Angiospermous trees were now well established and there the Reading Formation has preserved a gall and insect leaf mines, including the eponymous *Stigmellites gossi* Jarzembowski, a microlepidopteran.

The succeeding Eocene Epoch (56–34 Mya) has notable British entomofaunas in three out of four of its international stages. In the Early Eocene London Clay (a marine formation actually found across much of south-eastern and southern England) is a coleopteran (beetle) fauna unusually preserved in iron pyrites. The insects have been filled in the round by this mineral, originating from the activity of sulphate-reducing bacteria on the sea floor, after they sank waterlogged along with drifted woodland plant remains. The fossils are uncommon in the clay, but Martin Venables of Bognor Regis (on the South coast of England in the county of West Sussex) discovered that they were robust enough to withstand erosion and concentration on the beach by the sea. The fauna he recovered by sieving the sand was described by the coleopterist Ed Britton and includes an extinct species of the throscid *Pactopus* LeConte, a small false click beetle, now endemic to western North America (Bone, 2017). Pyritised larvae and even hemipterans, including the first British enicocephalid (unique-headed bug; Fig. 7), were subsequently discovered in the London Clay of Kent (Štys, 2010).

Prior to its development, the mid-Eocene was well exposed in the Bournemouth Group of West Hampshire in southern England (Jarzembowski, 1996). Some nine insect orders were to be found including ant and termite genera more common in the Late Eocene across the Solent in the Isle of Wight. The entomofauna is, however, still notable for having produced the wings of extinct giant formiciine ants with

Figure 7. *Pyrenicocephalus jarzembowskii*, scale 0.1 mm, StereoElectronMicrograph, London Clay.

wingspans of 4–14 cm, originally thought to be sawflies (Symphyta) until complete specimens were found in the German Messel Lagerstätte, a sedimentary deposit with exceptionally well-preserved fossils.

Our Late Eocene contains the most diverse entomofauna, with hundreds of species now known from just a single horizon, the lagoonal Insect Limestone in the Gurnard Member on the northern coast of the Isle of Wight (Gale, 2019). Much of this rich entomofauna may be found in two recently published volumes of the *Transactions of the Royal Society of Edinburgh* (*TRSE*; *Earth and Environmental Science* Special Issue(s) 2014 (**104**) and 2019 (**110**) parts 3/4), so will be described only briefly here. The 17 extant insect orders represented include the first British praying mantis (Mantodea) and ribbon-tailed lacewing (Neuroptera), the latter justifying the use of a nemopterid in the British Entomological Society logo. Also present are the oldest British butterflies (Fig. 8) and bees, last British archostematan beetles, a termite genus (*Mastotermes* Frogatt) now only found relict in Australia, and numerous drowned alates of extinct weaver ants (a living worker recently graced the cover of *Antenna* **41(4)** (2022)). Perhaps the most evocative fossil insect, however, is a wasp-mimicking soldier-fly, shown on the cover of *TRSE*, which can still fool some fossil collectors ~35 Mys later! Sadly, figs (*Ficus* species) have not been confirmed in the palaeoflora to complement the chalcidoid fig wasps found.

The Insect Limestone is particularly fine-grained and the exceptional preservation has been likened to opaque amber due to its many articulated fossil insects. Therefore, before we leave the Eocene, it should be mentioned that Baltic amber, which dates back circa 45 Mya, may be sometimes washed up on the East coast of England and contain insect inclusions (Jarzembowski, 1999). It is considered to originate from Quaternary deposits formed in the North Sea basin when sea level was lower and 'Tertiary' rocks were eroded by European rivers. Some of the subfossil resin found on modern beaches, however, comes from human trade, especially when used in the old lacquer industry. It may be added that it was the search for amber and tin in North-West Europe that produced the earliest written reference to B. & I. (Bretannikē: Pytheas, *circa* 2.353 Kya; now lost manuscript).

Only the earliest Oligocene insects are preserved in our area, with four orders recorded from the Hamstead Member of the Isle of Wight (Jarzembowski *et al.*, 2010). It may be significant that the ant recorded is not a tropical weaver ant.

Where are we going?

Forecasting the future is challenging, especially in the natural sciences, on account of their complexity. Judging by progress so far, our coverage of British fossil insect diversity (now over 1,500 formally described species, *e.g.,* online EDNA database) may have reached a measure of parity with recent fauna by the second quarter of the current millennium. By then, expanding conurbations may well have seriously limited opportunities for fossil collecting (*pace* environmentalists). In fact, there is currently only one active inland palaeoentomological Site of Special Scientific Interest left in southern England, although much of the coastline is still open to marine erosion from Atlantic storms, providing suitable geological exposures (Jarzembowski, 2021). With international taxonomic co-operation, new finds are periodically described, especially from the popular Wealden of the Weald or Jurassic Coast, *e.g.,* Gorochov and Coram (2023). There are also occasional student projects *e.g.,* Pretorius (2023). Palaeoentomologists are much rarer than fossil insects. We therefore need to preserve undescribed material for future study. This is at a time when some museums are bulging or even downsizing and others are increasingly concerned with social science. From a storage

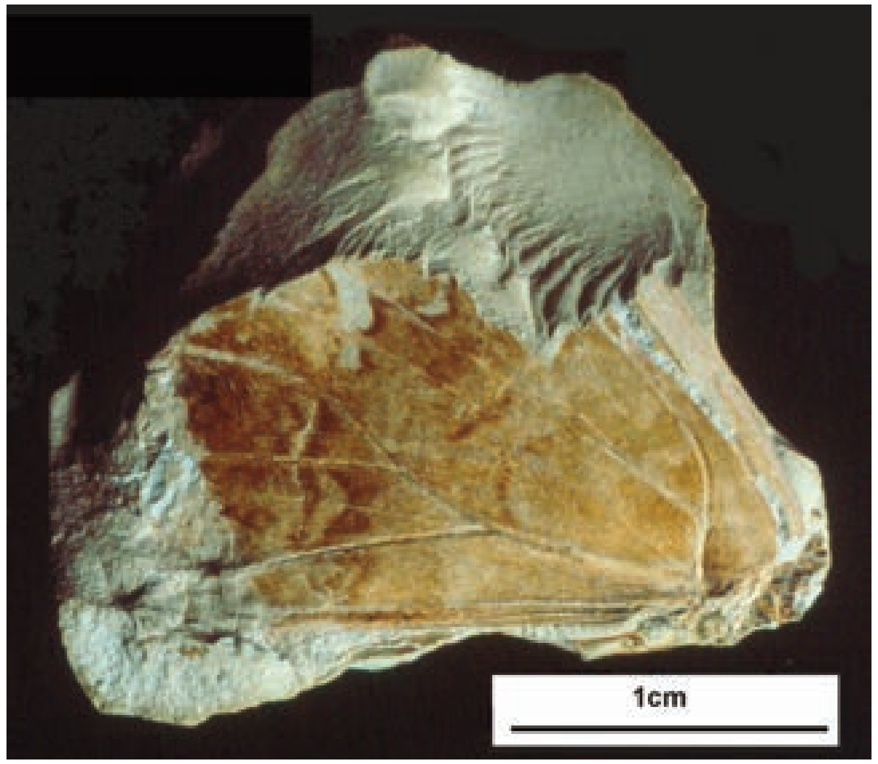

Figure 8. *Nymphalites zeuneri*, part, Insect Limestone, Gurnard Member.

perspective, fossil insects at least have the advantage of small size!

The fossil record is proverbially incomplete and B. & I. cover only 0.002% of the Earth's surface. Such is the variety of global deposits that other countries have contributed significantly to the fossil record of insect evolution. Was the latter underpinned by catastrophe avoidance, morphological conservatism and climate tracking as suggested above? Beyond Euramerica, there are the Permian *Glossopteris* forests of Africa and the Mesozoic volcanic lakes of Asia being investigated; new discoveries range from Antarctic beetles to fossil bees' nests in South America and fresh amber deposits in Australasia, just to mention a few initiatives. Perhaps Society members will now be inspired to write about **their** regions?

The Revd Brodie seconded geology only to astronomy in scope and status, but even if palaeoentomology is a bit like charting the stars, it's becoming less nebulous with new techniques (such as micro-CT), better finds and older inclusions. The story of insects is more than end-membership in neolatin on a phylogenetic tree. Fossil insects give entomology a deep-time dimension and historical significance of place. They thus provide a greater sense of identity to what we call an insect.

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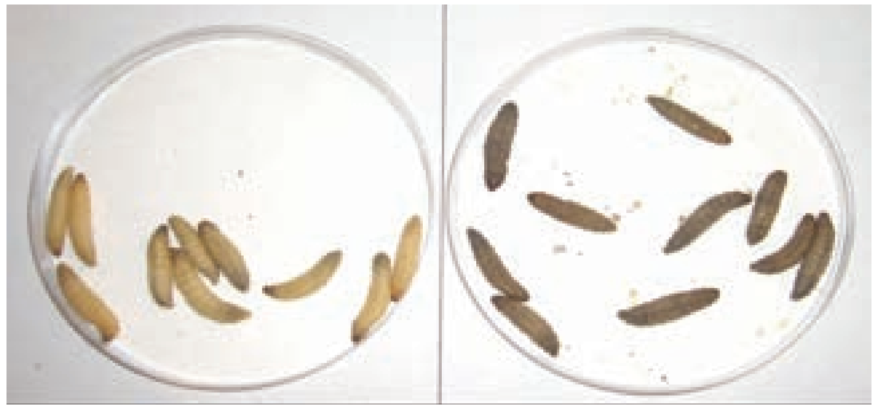
Featured Insect



Galleria mellonella larvae used in biomedical research. Larvae prior to infection (a) and 24 hours after infection with a lethal dose of *Aspergillus fumigatus* (b). The dark colour of infected larvae is due to melanisation.

Scientific name: *Galleria mellonella* (Linnaeus 1758)

Common name: Greater Wax Moth

Order: Lepidoptera

Family: Pyralidae

Greater Wax Moth *Galleria mellonella*

The immune response of insects shares many similarities with the innate immune response of mammals and, as a consequence, a variety of insects (*e.g.*, *Drosophila melanogaster*, *Manduca sexta*, *Bombyx mori*) is now widely used in biomedical research to assess the virulence of pathogens or measure the *in vivo* toxicity and efficacy of antimicrobial agents. The results generated show a strong correlation with those generated from conventional mammalian testing. Larvae of *Galleria mellonella* (Order: Lepidoptera: *Galleridae*, the wax moth) are now widely used and have the advantage over murine testing systems of inexpensive, generating results rapidly and are not subject to the legal/ethical restrictions associated with mammalian testing. Larvae can be infected with a pathogen orally by force feeding or by injection directly into the haemocoel through one of the prolegs. The response of the larvae to infection can be monitored by assessing the time to death, the extent of melanisation, quantifying the proliferation of the pathogen *in vivo*, characterising changes in the population of circulating haemocytes or by quantifying the alterations in the expression of larval immune genes or proteins. *Galleria mellonella* larvae can be used to study the development of a pathogen *in vivo* and to characterise the pathogen-host interactions that lead to the pathologies evident in cases of human infection. Infection of *G. mellonella* larvae with *Listeria monocytogenes,* for example, leads to the development of melanised nodules on the larval brain which are similar in structure to the nodules that form in the human brain during *L. monocytogenes* infection. Using this knowledge, it is possible to develop and optimise strategies to prevent or limit the development of disease-associated pathologies in *Galleria* larvae before assessing their effectiveness in mammals. *Galleria mellonella* larvae are used to assess the *in vivo* efficacy of novel antimicrobial compounds and help to identify promising candidates before murine evaluation is attempted. Characterising the larval immune response to pathogens also highlights similarities with the innate immune response of mammals. For example, *Galleria* haemocytes phagocytose pathogens, degranulate and produce superoxide in an identical manner to mammalian neutrophils. The pathogen recognition receptors in *G. mellonella* larvae (Toll, IMD pathway) show many similarities to those in mammals and allow the immune system to rapidly and effectively identify pathogens. Although *G. mellonella* is considered a pest of beehives where it eats the wax and honey, it has become an essential part of biomedical research where it is used as a rapid means of assessing the virulence of pathogens or in evaluating the *in vivo* efficacy of novel antimicrobial agents and provides a means to streamline testing before proceeding to murine studies.

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Insects in the News

January to March 2024

Richard Harrington and Jesamine Bartlett

Following the last issue's review of insect stories that made the popular press, infinitely more people wrote to say they enjoyed it than they didn't (*i.e.*, one person wrote to say they enjoyed it). So, here we are again.

Despite it being winter in the Northern Hemisphere, several insect stories made the news, many of them lepidopteran. *The Daily Telegraph* reported that Paris was plagued by caterpillars of the Pine Processionary Moth (*Thaumetopoea pityocampa*), the needle-like hairs of which "can kill cats and dogs and cause heart attacks in humans". "How long until they process through the Channel Tunnel and lay waste to the Garden of England" lamented the editorial. But, apparently, a Hoopoe colony in Folkstone is lying in wait for them, so we can breathe easy. Turns out that Jamie Dornan, the *Fifty Shades of Grey* actor was hospitalised by the caterpillars in Portugal last year. Staying with moths, Sam Fabian of Imperial College has a new theory as to why they come to light. They have, he says, evolved to tilt their backs to wherever is lightest which, for millions of years, was the sky. Now, tipping their backs towards artificial lighting sends them into endless loops around lamps. What's more, according to Evert Van de Schoot of the Catholic University of Louvain, Belgium, city moths have evolved a weaker response to light to help protect them from such a fate.

On to butterflies and, according to Mark Collins of the *Swallowtail and Birdwing Butterfly Trust*, the UK's Swallowtail last year had its worst summer since records began, because of saltwater incursion into the Norfolk Broads and winter flooding. It's no surprise to me (RH) that butterfly watching reduces stress, according to those who took part in *Butterfly Conservation*'s Big Butterfly Count last year. Indeed, the first butterfly of the season, often a Brimstone (*Gonepteryx rhamni*), brings me almost inexplicable joy, as it does for Joe Shute, *The Daily Telegraph*'s *Weather Watch* writer. A picture of a Gatekeeper butterfly (*Pyronia tithonus*) on *The Guardian*'s website topped an article entitled "Meadow Brown butterflies adapt to global heating by developing fewer spots". Work by Richard ffrench-Constant at the University of Exeter showed that females reared at higher temperatures had fewer spots, one hypothesis being that this makes them less visible in dry, brown grass. *The Daily Telegraph* won the 'corniest headline' title with "Butterfly spotting". Worse, though, was the much overused "Deliver us from weevils", from a gardening writer reporting on nematode applications to kill Vine Weevils (*Otiorhynchus sulcatus*), and "You cannot bee serious" topping an article on how a swarm of bees halted tennis star Carlos Alcaraz's match against Alexander Zverev at Indian Wells.

Bed bugs dominated our last report, and they haven't gone away. Writing for *Vox*, Benji Jones said that the global epidemic will continue until we come up with a control method that is affordable to everyone. Civil Servants in London were told to work from home after infestations were found in offices of, ironically, the Health Security Agency. A London woman was charged with manslaughter for fatally poisoning a girl with an illegally imported pesticide she used to kill bed bugs.

Hello dear members in Australia. For you, of course, it's been summer. We were very sorry to read about, paraphrasing *The Daily Telegraph*, the dreaded Red Imported Fire Ant (*Solenopsis invicta*) forming flood rafts to spread through your storm-ravaged country. "They will devastate Australia's environment and agriculture, cost our economy billions and we could see 140,000 extra medical visits every year". A more delightful story from your shores was that of a newly discovered longhorn beetle, *Excastra albopilosa*, which was almost mistaken for bird poo. It is apparently known as the Punk Beetle because of its "shaggy white socks" and is so different from other longhorns that it has been assigned to a new genus. You also have some interesting spiders, webs of which are trapping DNA from kangaroos and koalas and providing useful information to study their population genetics. "This cheap and non-invasive method could be a game changer in how we explore and protect our terrestrial biodiversity", said Joshua Newton, a doctoral student at Curtin University.

CBS news in the USA reported a mysterious plague of insects bugging Chicago. They turned out to be Soybean Aphid (*Aphis glycines*) swarming off senescing crops. The same channel warned that this year, cicadas with a 13-year and 17-year life-cycle will emerge synchronously for the first time in 221 (13 x 17) years. Ear plugs at the ready if you live in Illinois or Indiana. Elsewhere, *The Guardian* reported that Italy has given the go-ahead for cricket-based flour to be used in human food. *Inside Climate News* reported research showing that the level of air pollution in many cities is great enough to shorten the distance from which insects can smell the flowers they need to pollinate.

The *NL Times* wrote that the Dutch are voting for their Insect of the Year, with celebrities advocating for the five finalists. "The aim is to make insects more popular among the general public and to put unknown species more in the spotlight." Wonderful! Oddly, Connecticut has the European Praying Mantis (*Mantis religiosa*) as its State Insect. Schoolchildren are, perhaps understandably, lobbying to have it replaced by one of the autumn meadowhawk dragonfly species or the Spring Azure Butterfly (*Celastrina ladon*).

The last word goes to *The Telegraph*'s great cartoonist, Matt. Amidst news of increasing concerns regarding sex scenes on film sets, he pictures a female mantis next to its headless mate saying "OK, next time we'll hire an intimacy coordinator".

Many thanks to Hugh Loxdale and Stuart Reynolds for feeding us stories. If you spot any insect stories in the popular press, especially if you are not UK-based, please send them to richard@royensoc.co.uk.

OPINION PIECES

Focus on the Freelancers

The author sweeping with a long-handled insect net at a site in Warwickshire.

Steven Falk FRES
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RES Marsh Award winner, 2012

I'd like to put the spotlight on a small but special sector of the entomological (and RES) community, one that does not often get mentioned in the pages of *Antenna* yet plays an important role in British entomology and insect/invertebrate conservation. I'm talking about the experienced, freelance ecologists specialising in applied entomology that earn their living as professional consultants (hereafter termed consultant entomologists). We undertake a variety of work (listed in more detail further on) and can be crucial for ensuring that insects/invertebrates are considered alongside other wildlife during development proposals, wildlife site designation, wildlife site management, agri-environmental schemes, and single-species conservation projects. Our clients can include developers, multi-disciplinary consultancies, local authorities, statutory agencies (*e.g.*, Natural England and the Environment Agency), governmental organisations (*e.g.*, Forestry Commission, Highways England and Network Rail), NGOs (*e.g.*, wildlife trusts and other conservation charities), research institutes (notably the UK Centre for Ecology & Hydrology aka CEH), AONB's, national parks and academic institutes.

There are about twenty of us operating full-time in Britain, several more part-time, sometimes mixing entomology with some herptile, bat or bird work. Outside of the British Isles we are almost unheard of, so possibly a British endemic? Our sector is characterised by entomologists with an exceptional ability to generate long and detailed species lists from a site survey, then interpret and present those data to a high standard, and finally to negotiate the needs of insects/invertebrates to a diverse array of clients and other interested parties across a broad range of sometimes very challenging circumstances (often characterised by many competing issues and limited contract budgets). Consultant entomologists need to be competent across a large taxonomic scope and to have the analytical abilities to turn lots of species and site information into a relatively small number of clear-cut messages and recommendations. Bear in mind that there are about three times the number of invertebrate species in Britain as there are bird species in the world, and to do their work well consultant entomologists also need expertise covering botany, habitat ecology, the British planning system *etc.* on top of their entomological expertise.

Consultant entomologists go into the field armed with an assortment of collecting equipment, which might simultaneously include a long-handled insect net, heavy duty sweep net, beating tray, suction sampler, pitfall traps, pan traps, sorting trays, tubes, pooters, plus the preservation liquids and killing fluids needed to produce the samples for analysis back in the lab. Most surveys are carried out during the day, but some contracts require moth-trapping too. Depending on the nature of the site and time of year, an experienced consultant entomologist could generate a list of over 300 species on the best of days. If a site is compartmentalised (and they usually are when doing detailed surveys) one day might eventually result in several thousand individual records once samples are fully processed. What is more, those species lists will be incredibly accurate because consultant entomologists are skilled at identifying things. They've often been doing it since youth. They have access to much of the latest identification literature (and updates), good personal reference collections, amazing memories, and are constantly networking to stay abreast of latest thinking.

However, consultant entomologists are also good at recognising the limits of their abilities. They will form alliances to help maximise the productivity and accuracy of their output. It is no exaggeration to say that I've seen good consultants produce more data in one day than some PhD students manage to produce in 3 years. I'm not trying to shame academia, but the reality is that academic entomology (particularly at the MSc and PhD level) is often strangely and worryingly detached from the work of entomological consultants. Many universities seem unfamiliar with the standards, approaches and expectations associated with consultancy work. In turn we can be nervous of their output because the field skills of researchers (*e.g.*, specimen collection and field identification) can be poor, and specimen identification under the microscope can have very low accuracy rates. Linked to that disconnect, consultant entomology seems to be poorly promoted as a potential career path within academia which is a shame, because it is a relatively well-paid and exciting way of pursuing professional entomology and can have a very positive impact.

So, what is it like to operate as a freelancer? If you imagined a cut-throat, Machiavellian world of fierce rivalry, you could not be further from the truth. Within the sector there are lots of tight collaborations, contract-sharing, and mutual support underpinned by respect, trust and often good friendships. In 2024, about a dozen of us held what will hopefully be our first annual Zoom meeting to discuss issues, share information and see how we can shape the external factors that affect our work. These include things like Pantheon software (used to analyse invertebrate assemblages), species status reviews (which assign statuses to the rarer and more threatened insects/invertebrates), and the recently published Biodiversity Net Gain (BNG) framework which has massive implications for our work. We also regularly form alliances, sometimes short term (teaming up for a single survey contract), sometimes long-term (more regular teaming up for surveys or sharing out identification).

My entomological expertise is strongest for flies, aculeate Hymenoptera, butterflies and other pollinators, which I survey using my particular set of survey skills and techniques. The entomologists I often team up with typically concentrate on beetles, bugs, spiders *etc.* using a different set of skills and techniques. Pairing up like this can generate a list of 500–600 species on the best days and generate lists of 1,000–2,000 species at a site where enough visits and techniques are employed. Suffice to

Consultant Andy Jukes studying oil beetles at Highgate Common, Staffordshire, a site that was declared an SSSI largely based on insect data gathered by consultant entomologists.

OPINION PIECES

say, this is a brilliant way of encountering new species and learning more about the habitat needs of individual species. For any readers who know what 'Pan-species Listing' is (the semi-competitive pursuit of developing a long 'life-list' of plant, animal and fungal species recorded in Britain), you probably won't be surprised to learn that consultant entomologists are very well represented in the top echelons of the national ranking (see https://panspecieslisting.com/). They are often skilled botanists, birders and mycologists too *i.e.*, far from being blinkered 'bug hunters'.

As indicated above, come autumn many consultants exchange samples between one-another. I get fly, bee and aculeate wasp samples (usually in alcohol) collected by a number of other consultants. I'm fast, accurate and have learned to identify pickled material almost as well as dry material. I can quickly assess species for national conservation statuses and spot important assemblages. In turn I will send most of the bugs and beetles I've collected to others because I lack confidence in these groups and do not want to make mistakes. We allow for this in our budgeting, and it makes sense. I don't want to spend a week identifying beetles when somebody else can do that same task in just a few hours. Some of the very best consultants will tackle nearly all insect/invertebrate groups themselves with a high level of competence. They are a particularly special category, some of the finest entomologists Britain has ever produced, and deserve to have framed portraits hanging on the walls of RES headquarters alongside Verrall and Southwood. Suffice to say, I'm not one of them.

You might think that the work we do is so niche, and the market so small, that there would not be enough work to go around. The truth is there are not enough of us, and we need to encourage more people to acquire the skills and experience to join our sector. The needs of insects and other invertebrates are increasingly being factored in when development proposals appear, wildlife sites are being managed, and agri-environment schemes are being formulated and monitored. Many organisations understandably prefer to use consultant entomologists than employ in-house ones. This may smack of a zero-hours culture, but it can work out well. Consultant entomology can be well-paid and exciting. Long-standing relationships can form with clients, creating a decent level of financial security. So here is a breakdown of the main activities that consultant entomologists undertake.

Consultant Andy Musgrove using a suction sampler at a contract site near Teesport.

Detailed baseline entomological surveys and site evaluation

Insect/invertebrate surveys to evaluate sites are regularly required for larger development proposals that impact wildlife habitat, and are often linked to impact assessments (see below). Good species lists are also important to support the designation of Local Wildlife Sites (LWSs) or Sites of Special Scientific Interest (SSSIs) by helping to identify the most important insect/invertebrate locations in an area. Many LWS and SSSI citations have insects/invertebrates as their primary interest and helping to designate them is one of the most valuable contributions we can make. Detailed surveys are also frequently commissioned for existing SSSIs or LWSs by organisations such as wildlife trusts, Natural England (or equivalents), the RSPB, the National Trust and AONBs to develop and review management objectives. Examples of detailed baseline surveys can be found online (*e.g.*, Falk, 2017; Falk & Kirby-Lambert, 2020).

Impact assessment

This involves predicting the direct or indirect, positive or negative, impacts that might result from a development. It requires a good understanding of species ecology, habitat ecology, hydrology, and the technical aspects of the development proposal. For example, the construction phase of a development often creates lots of disturbance and destroys important invertebrate habitats, or habitat combinations, that are not easily recreated. Bear in mind that many insects have complicated lifecycles that can involve larval needs plus a plethora of adult needs. Losing half of a wildlife site rarely means simply a halving of all the insect and invertebrate populations present. If the half of the site lost has all the nice wetland, or all the nice grassland, any species with part of their lifecycle dependent upon that part of the site will likely be lost (Falk, 1998). An experienced consultant entomologist can quickly assess the type and scale of impact, then provide advice on how to minimise impact (mitigation) and how to replace loss (compensation). Entomologists are generally very good at contributing to mitigation and habitat creation plans. They often have a comprehensive and complex understanding of habitats. They can spot issues and opportunities that non-entomologists miss and have a strong vision of what 'success' looks like.

Site/scheme monitoring

Consultant entomologists are often called upon to help monitor changes and trends. Is a site improving, deteriorating or transforming? Sometimes the methodology is already established by the client but in many instances the entomologist must design it. That might involve the use of standardised trapping (malaise, pitfall, pan), transects or timed counts. CEH is a particularly important source of contract work here. This includes the ongoing Pollinator Monitoring Scheme (PoMS) (UK Pollinator Monitoring Scheme, 2023) and a recent 4-year study of agri-environmental schemes (Staley *et al.* 2022).

Autecological and other targeted research

Many threatened insect/invertebrate species have poorly understood conservation requirements. Consultant entomologists are often called upon to study them in minute detail (much as Jeremy Thomas did for the Large Blue *Phengaris arion*) and then monitor the effects of management upon them. Examples of species that have benefitted from contract work include the Wartbiter (*Decticus verrucivorus*), the Field Cricket (*Gryllus campestris*), the Great Yellow Bumblebee (*Bombus distinguendus*) (Smith, 2021) and Cosnard's Net-winged Beetle (*Erotides cosnardi*) (Telfer, 2016). The Darwin Tree of Life project is another example of targeted research. This project is attempting to sequence the full genome of as many species as possible. To do that (at least for an insect) you need to catch the critter, accurately identify it whilst it's alive (try checking the genitalia of a live fly!) and snap-freeze it at -80°C before it dies. The University of Oxford (notably Liam Crowley) has been particularly proactive in recruiting consultant entomologists for this because we are very good at catching and accurately identifying lots of species in a short period of time. A few hours at Wytham Woods regularly secures 50–100 species for sequencing. Using experts also means greater success in obtaining scarcer and more elusive species.

Natural England Commissioned Report NECR224

A review of the status of the beetles of Great Britain

The stag beetles, dor beetles, dung beetles, chafers and their allies - Lucanidae, Geotrupidae, Trogidae and Scarabaeidae

Species Status No.31

First published 31 October 2016

www.gov.uk/natural-england

NATURAL ENGLAND

Most of the recently published status reviews for British insects have been written by consultant entomologists.

A bee identification workshop led by the author at Elsecar, Yorkshire.

Great Yellow Bumblebee (*Bombus distinguendus*) (left) and Wart-biter Bush-cricket (*Decticus verrucivorus*) (right), two of the many rare and endangered insects that have benefitted from the input of consultant entomologists.

OPINION PIECES

The author at CEH, Wallingford, verifying pollinator specimens for the PoMS project.

Specimen identification

As well as identifying specimens for each other, consultant entomologists will critically identify the samples from CEH and other organisations undertaking standardised sampling. One area I've been developing is the critical identification of pollinator specimens gathered by MSc and PhD students. Ideally this should involve the verification of their determinations, so that they get a feel for their own accuracy rates whilst I ensure that the final determinations used for analysis and publication are trustworthy. Some students have phenomenal natural talent. Others are very poor and seem to get little support. Without some form of guidance and specimen verification there is the real risk of inadequate work being published by peer-reviewed journals. I regularly see peer-reviewed pollinator papers that do not appear to have used external expert verification. The students seem oblivious to the need for it, but more worryingly, so do their supervisors! Using consultant entomologists to assist academic research not only improves the quality of the output but provides a great opportunity for students/researchers to discuss their results with an expert and learn more about the subject area.

Subject-specific research reports

Many valuable, subject-specific reports are pulled together by consultant entomologists. Examples include wood ant nest translocation (Jukes & Price, 2017) and a review of the pollinators associated with decaying wood, old trees and tree wounds (Falk, 2021). Related to this are the status reviews produced by statutory agencies such as Natural England and the Joint Nature Conservation Committee (JNCC). These provide rarity grades to our scarcer and more threatened insects/invertebrates. Most of those published in the past 10 years have been written by consultant entomologists (*e.g.*, Drake, 2017; Lane, 2019). Many of the reports published by Hymettus have also been produced by consultant entomologists. Few of these reports get published in peer-reviewed journals and they rarely get cited in them either, even when they are available via ResearchGate and other platforms. They are important documents and academics ignore them at their peril.

Training workshops, talks and guided walks

Consultant entomologists frequently lead identification courses for the Field Studies Council. I used to lead 3–4 weekend bee workshops each year prior to Covid. We will also lead training events for wildlife trusts, statutory agencies, local authorities, and farming groups. Guided walks, lectures and evening talks are another useful source of income. These events are a great way of opening people's eyes to the world of insect conservation.

Insect/invertebrate photography

Most consultant entomologists undertake some insect and habitat photography. It can be important for report production or for fixed point habitat monitoring. A spin-off of that photography is that images can then be sold commercially to magazines and other publishers. Prices can be kept lower than the big photography stockists. More crucially, accuracy of identification is substantially higher, and the needs of clients can be discussed and shaped.

Writing books, articles, leaflets and information panels

Publishers and other organisations will pay for help in producing leaflets, information panels and magazine articles. Consultant entomologists can often produce high quality copy quickly and provide the images too. Occasionally, something more substantial such as a book might be possible (*e.g.*, Falk, 2015). Even if the author's advance is small, long-term royalties and book sales at events can be useful.

Filming and media work

Consultant entomologists regularly assist in productions such as The One Show, Countryfile and Springwatch. Sometimes they get featured in front of the camera. More often they are acting behind the scenes to help produce the stunning footage and accurate narration you finally get to enjoy on your screen.

Conservation brainstorming

Consultant entomologists can make an important contribution to discussions concerning insect/invertebrate conservation whether that be the conservation of specific rare species, biological recording, status reviews, or the management of specific habitats and sites. Much of this is unpaid (consultant entomologists do not charge for everything they do) but it can help shape the contracts that eventually appear. Some consultant entomologists have been particularly concerned over the Biodiversity Net Gain framework and lobbied Defra and Natural England hard. It resulted in quotes in the national press, and eventually a small Zoom meeting with Defra to explain our concerns. We did not get many of the improvements we had hoped for, but few others within conservation raised those concerns or secured an audience with Defra. We continue to lobby here. Consultant entomologists also have strong links to the Chartered Institute of Ecology and Environmental Management (CIEEM), producing articles for their *In Practice* magazine (*e.g.*, Jukes, 2021; Wilson, 2021) and establishing professional protocols and standards for invertebrate survey work.

Creating and improving protocols and procedures

Consultant entomologists tend to be natural innovators, constantly striving to improve efficiency by modifying or inventing equipment and protocols. They have been crucial in helping to develop Pantheon software, the Index of Ecological Continuity and improving survey techniques.

Student/apprentice supervision

Some consultant entomologists will assist student projects or take on trainees such as fresh graduates keen on entomology. It is one of the ways we attempt to bring new blood into our sector. But we need more of this, and student training budgets could be used more to facilitate it.

I hope this article has convinced you that freelance entomology can be a varied and rewarding career, one that can help shape the world and achieve real conservation gain. I'm not suggesting that anybody can leave university and automatically succeed as a freelancer. You may need spend a few years working within a conservation NGO or larger consultancy to develop your skills and expertise. Another way to gain experience is by doing small contracts at weekends or using leave days. But whatever path you decide to take, it would be good if academia, supported by the RES, could do more to recognise, promote and support entomologists wishing to join this sector and work more closely with existing consultant entomologists.

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In praise of the scientific naming of nature

Figure 1. This image was created with the assistance of DALL·E 2 and was inspired by the encounter between Alice and The Gnat in Lewis Carroll's popular novel "Through the Looking-Glass, and What Alice Found There" (1871).

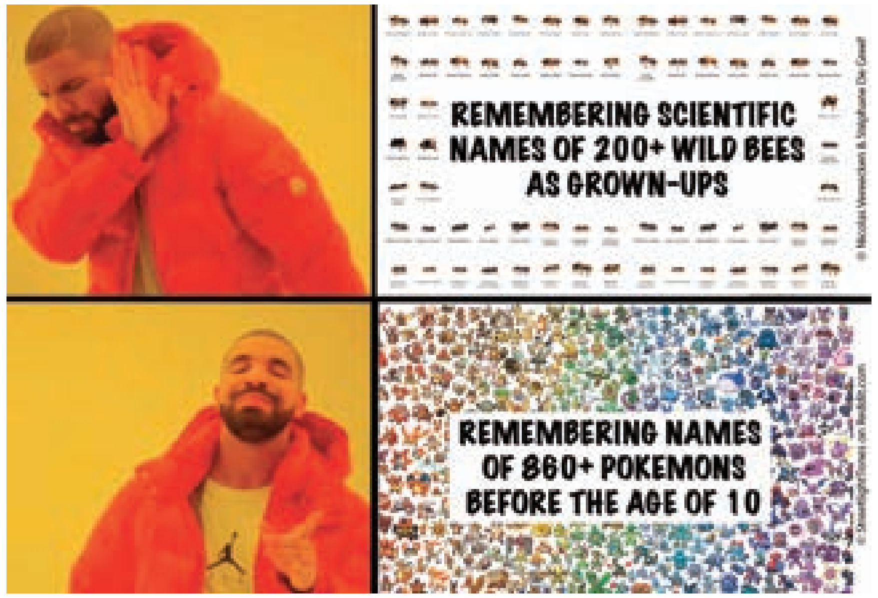
Nicolas J. Vereecken *et al.*
Université libre de Bruxelles, Belgium

It certainly was a VERY large Gnat: 'about the size of a chicken,' Alice thought. Still, she couldn't feel nervous with it, after they had been talking together so long.
'— then you don't like all insects?' the Gnat went on, as quietly as if nothing had happened.
'I like them when they can talk,' Alice said. 'None of them ever talk, where *I* come from.'
'What sort of insects do you rejoice in, where YOU come from?' the Gnat inquired.
'I don't REJOICE in insects at all,' Alice explained, 'because I'm rather afraid of them — at least the large kinds. But I can tell you the names of some of them.'
'Of course they answer to their names?' the Gnat remarked carelessly.
'I never knew them do it.'
'What's the use of their having names' the Gnat said, 'if they won't answer to them?'
'No use to THEM,' said Alice; 'but it's useful to the people who name them, I suppose. If not, why do things have names at all?'

The discourse around the complexity and memorability of scientific names *versus* the simplicity and accessibility of vernacular names is a long-standing one, frequently raised by naturalists, science communicators, and conservationists. Some of these professionals have advocated for the adoption of an alternative, unregulated naming system that heavily relies on vernacular names. This system is often used within niche circles, such as online forums and regional publications, where it is thought to offer a more intuitive and less intimidating entry point into the study of biodiversity, particularly for the lay public and enthusiasts.

Our new Opinion paper published in *Systematic Entomology* (Vereecken *et al.*, 2024) challenges these views and draws on the extensive experience of co-authors based in Europe, Australia, Asia, and North and South America. We have worked with bee species globally and counter the argument against the use of scientific nomenclature in both general and scientific texts by presenting five compelling reasons why scientific names, despite their perceived complexity, are crucial for promoting understanding and literacy about bee species, and indeed, in the broader realm of biodiversity. In this paper, we do not argue to outlaw vernacular names, but rather we insist on the need to use them in conjunction with scientific names, and to preserve the universality of the scientific binomial taxonomic system, a cornerstone of biological science that enables precise, unambiguous communication about species across different languages and potential cultural barriers.

There is clear evidence that individuals of all ages can surmount the perceived difficulty in understanding and using scientific names, and that with a genuine interest in the organisms themselves and some initial guidance on the construction and meaning behind binomial scientific names, the general public can



The graphical abstract for Vereecken *et al.* (2024), courtesy of the authors.

understand and appreciate the logic and beauty of scientific taxonomy. As other examples to illustrate our point, we draw an analogy with how successfully generations of children and young adults have become familiar with the complex taxonomy of Pokémon over the past two decades, and we refer to the fact that the general public regularly uses scientific names like *Rhododendron* and many more, including the famous *Tyrannosaurus rex*. This phenomenon demonstrates that with engagement and appropriate educational strategies, especially from the outset, the public can indeed become comfortable with, and even enthusiastic about, scientific nomenclature.

The preference for common names, sometimes even exclusively for them, has severe repercussions. We cannot protect what we don't know, and with common names being inconsistent, confusing, misleading, and having no one-on-one mapping to any taxonomic category, it hampers our ability to communicate, learn about, and conserve biodiversity. We are facing a global biodiversity crisis, including wild bees, and if we are to address this, it is absolutely vital we communicate about species correctly. Promoting the use of scientific names promotes scientific and taxonomic literacy, allows for effective communication, avoids unnecessary Anglo-centrism, democratises science, and ensures species receive proper conservation attention. It is also fun!

Scientific names are not the property of academics or some sort of elitist jargon, but rather they are fundamental tools for fostering communication and collaboration. By promoting a deeper understanding of scientific names, we advocate not only for a more informed public but also for the protection of scientific integrity and the facilitation of communication among stakeholders in conservation, environmental education and citizen science.

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Royal Entomological Society

Society News

Mint Moth (*Pyrausta aurata*). Photo: Fabian Harrison.

News from Council

Council Meeting
Council met online on 21st February 2024.

CEO's Report
The CEO reported on Key Performance Indicators, membership numbers (at a record high of 2,213), policy and public affairs, the move of The Chelsea Flower Show Garden, grants and partnerships, publishing (including involvement with two books) and conferences (sponsorship of the European and International Congresses of Entomology).

Management Accounts and Forecast
The Director of Finance gave an update on the financial performance of the Society for the period ending 30th November 2023 and the forecast for the financial year 2023/24.

Trustee Training Review
Trustees took part in two two-hour training sessions in January. The first focused on the responsibilities of being a trustee and the second on effective chairing of committees. Trustees agreed that the content was very useful. A third session will take place in Spring 2024, focusing on trustee responsibilities around fundraising. There was discussion on how often such courses should be offered to new and existing trustees and what other topics might be useful.

RES Head Office Relocation
The CEO gave an update on the head office relocation project. The working group met on 9th January and a brief from the agents engaged to manage the project is expected soon.

Budget and Business Plan
THE CEO and Director of Finance presented the budget for 2024/25, which underpins all strategic priorities. The budget was approved by trustees, as recommended by the Finance Committee, after noting the importance of articulating the reserves policy to members.

RES Garden Relocation Cooperation Agreement
The CEO presented a cooperation agreement for the relocation of the RES Chelsea Garden to Stratford Cross. This sets out the responsibilities of the RES and Lendlease Development and has been scrutinised by the RES Senior Leadership Team and the Society's legal representatives. After requesting a few amendments, trustees approved the agreement.

Equity, Diversity & Inclusivity Committee Proposal
Trustees approved the establishment of an EDI Committee, to be chaired by the President Elect or Past President and comprising members of each RES committee and others as appropriate.

Committee Reports
Reports were presented by the chairs of the Library Committee, Education & Training Committee, Outreach Committee (*in absentia*) and Finance Committee. The Business Development and Fundraising Manager gave an update on her activities. The CEO gave a health and safety update.

Journals and Library

Treasures of the RES Library and Archive

Rose Pearson
RES Librarian and Archivist

In the third of our columns showcasing some of the highlights of the RES Library and Archive collections, we look at one of the most unusual items in the library, with illustrations printed from real butterflies, **Butterflying with the Poets, A picture of the poetical aspect of Butterfly Life with Nature printed illustrations** (1864) by Joseph Merrin.

The illustrations in this book are made through a process known as Nature Printing, specifically Lepidochromy, which involves printing directly from specimens of real butterflies. The wings are placed between two sheets of paper, and pressure is applied through a press, producing a coloured image of the wings and body, with the antennae drawn in later with ink.

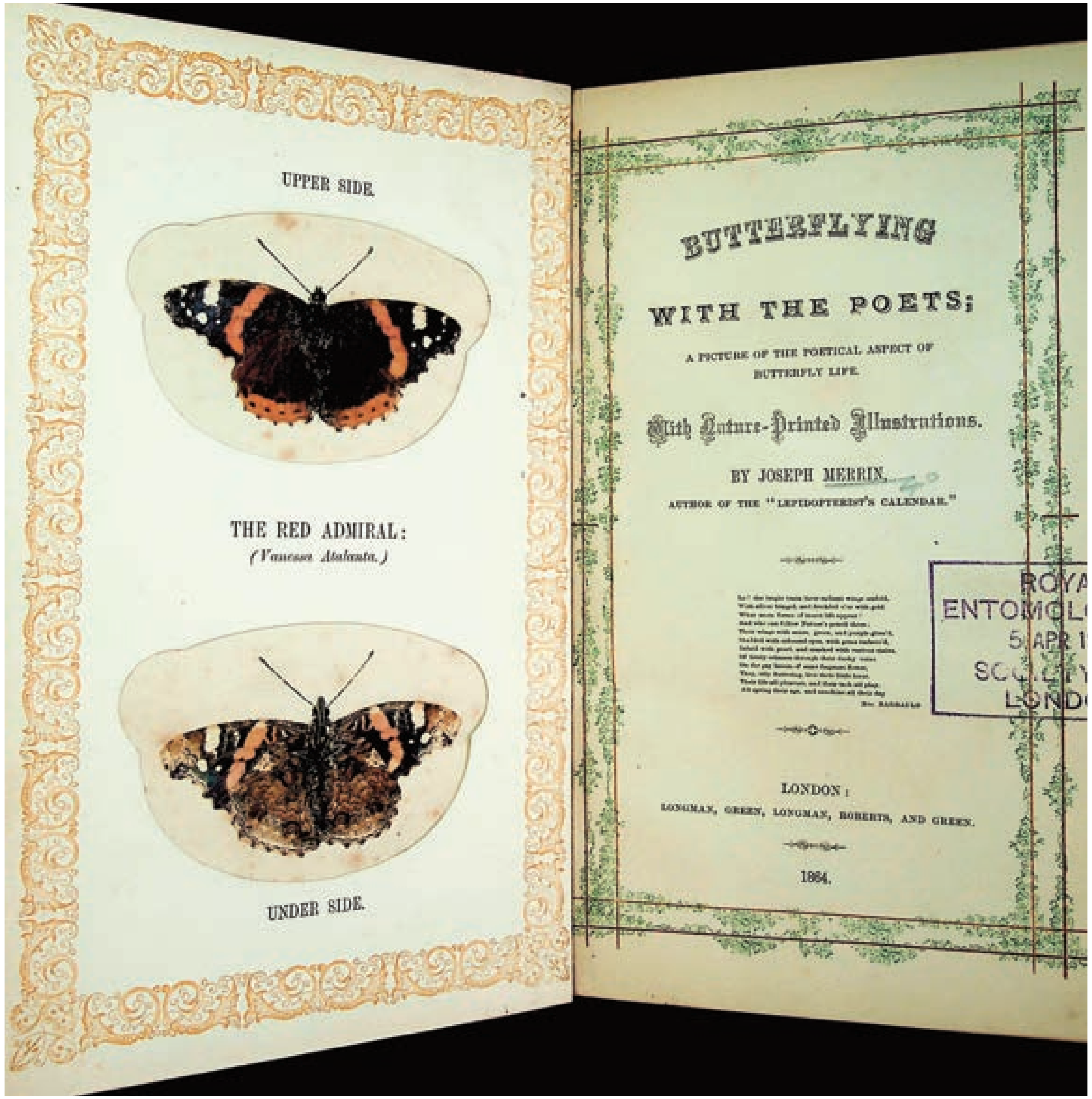
The book contains descriptions of each of the 65 species of British butterfly then known. Each species of butterfly is accompanied by a description of the insect, details of its habitat and feeding habits, as well as praise for its beauty, and a selection of relevant verse. Writers quoted include William Shakespeare, John Keats and William Wordsworth, and the volume also includes the author's own poetry.

For 15 of these species, two specimens are used to create prints of the front and back of butterfly, giving a total of 30 illustrations. This was an expensive and labour-intensive process, and editions were understandably extremely small. In 1970, a Mr P. N. Crow exhibited a volume of this work at a RES meeting, noting that the work was privately printed by the author, in an edition of just five copies, of which two were not completed.

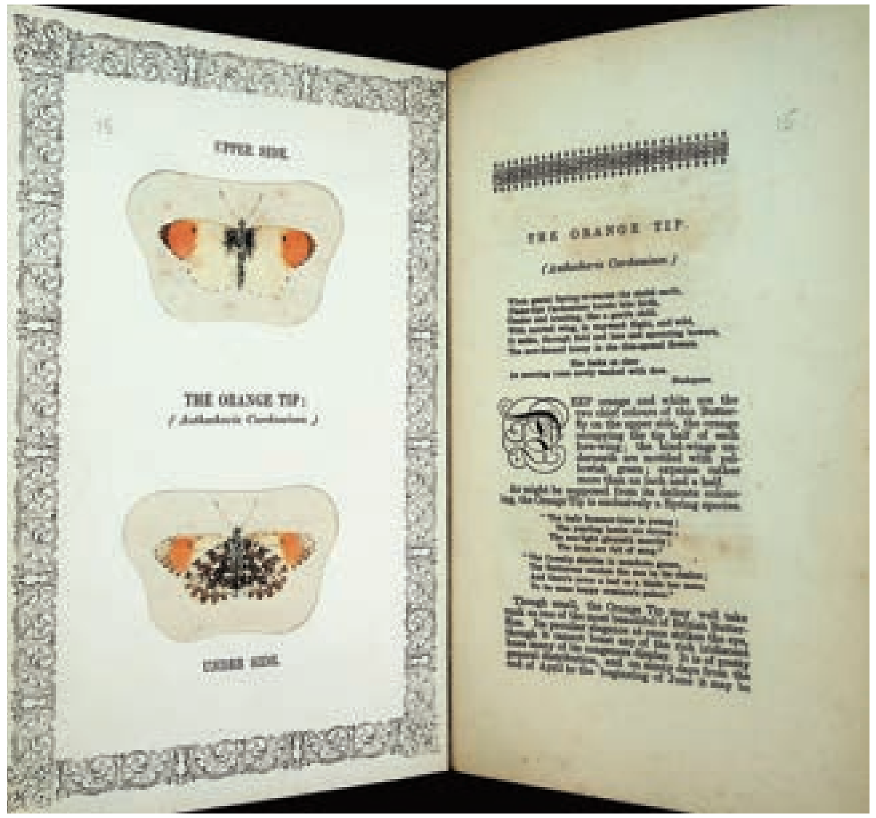
Merrin also wrote more conventional works on Entomology including '*The Lepidopterist's Calendar*' published in 1860, which is also held in the RES Library. He was regarded as an authority on the Large Blue butterfly and also worked as a journalist.

While examples of Lepidochromy are relatively rare, there are two further examples in the RES Archive. These are described as **Transfers of Saturniid moths** and were made by R. W. Lannin and presented to the RES by Captain Roy Hew Russell Stevenson of Rhodesia in 1949. The prints are nearly 15 cm across and feature the species *Nudaurelia macrothyris* and *Athletes semialba.*

These and other early entomological works can be viewed in our Library in St Albans. Email library@royensoc.co.uk or call 01727 899387 to make an appointment.



Title page of *Butterflying with the Poets* (1864) by Joseph Merrin.



Illustrations printed directly from two Orange-tip butterflies, *Anthocharis cardamines*, with quote from Shakespeare's *The Taming of the Shrew*.

A nature print of the moth *Nudaurelia macrothyris*, with hand drawn body and antennae.

Royal Entomological Society

RES Student Science Communication Award 2023

The results of the 2023 Student Science Communication Award were announced in February. Twenty-one entries were submitted from students based in the UK, Italy, the US, and Canada. Members of the RES Outreach Committee, Dr Victoria Burton, Postdoctoral Researcher at the Natural History Museum, London, and Dominique Vassie, freelance artist and Editor of INSTAR magazine, judged the entries.

"We really enjoyed reading all of this year's entries. There was a lovely mix of interesting stories on insect science, insects in culture and insect conservation. We were also really happy to see a variety of different styles of written science communication and lots of original approaches. Thank you to those who took time to enter, we hope you all continue to explore ways of sharing the wonders of insects with those around you!"

Juan Carlos Cambronero-Heinrichs, a PhD student at the University of Padua, Italy, was awarded first place for 'Reclaiming *Mariola*'s wings', about taking ownership as an adult of an insect name used by childhood bullies. The article has illustrations from Grettel Andrade, PhD student at the University of Costa Rica.

"I was doubting about the essay, writing in English is challenging and the manuscript had several versions. The text is very personal and to be proud is never easy. Mixing my identity as a gay person and my love for insects is something I wanted to do for a long time; this competition just felt like the perfect opportunity. It was also very important to speak on a topic I thought I could never open about when I was younger. I am thrilled about the award, and I will say it is a shared win between me and the artist who created the beautiful illustrations. Grettel Andrade is a PhD student in a program on Society and Culture at the University of Costa Rica, and her vision embellishes the essay with neotropical bees and plants. We thank the Royal Entomological Society. We are truly excited about the publication of our work."

Eric Jackson, a graduate student at Columbia University, United States, was awarded second place for, 'A God on Six Legs', about the contrasting views of insects in different cultures and societies.

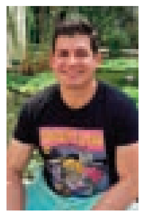
"Thank you so much for the opportunity to participate in the competition. I thoroughly enjoyed the freedom of creativity that was given to participants on how we could communicate our topic. I recommend anyone who has a joy of both entomology and storytelling to participate in this competition. I'm very grateful to the judges for giving me second place."

Altrim Mamuti, an undergraduate student at Columbia University, United States, was awarded third place for, 'From Freedom to Boxes: A Journey Unchecked', about the ethics of illegal insect specimen trading.

"As an emerging biologist, I am deeply passionate about writing about the natural world, particularly when it comes to the conservation of insects. Despite their crucial role in ecosystems, insects often find themselves on the fringes of conservation efforts, overlooked in favour of more charismatic species. Through my participation in the RES Sci Comm competition, I hope to bring attention to the plight of endangered insect species and raise awareness about the importance of their conservation."

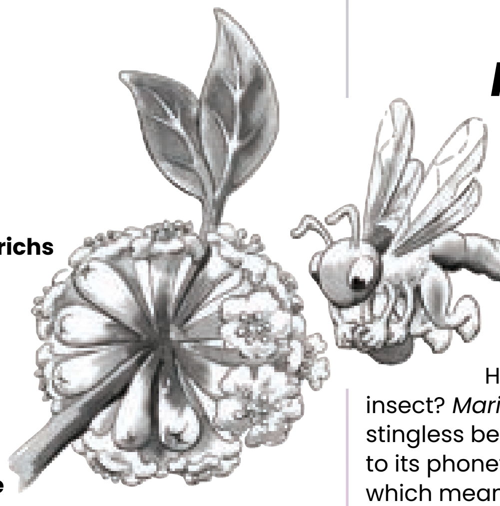
Fran Sconce

1st



Juan Carlos Cambronero-Heinrichs
(Text)

Grettel Andrade
(Illustrations)



Reclaiming *Mariola's* wings

There was once a child who was called names. The laughs pained them, and they struggled to make friends. This child spent most of the time in their head, thinking about the insults. There was nobody on their side. Everybody thought they should never show any sign of pride.

Have you ever been called the name of an insect? *Mariola* is a vernacular name given to the stingless bee *Tetragonisca angustula*. It is probably due to its phonetic proximity to the Spanish word *marica*, which means *fag*, why people use it to refer to us, male homosexuals. All over Latin America and Spain, there are other insect names used to insult us, such as *mariquita* (ladybug) and *mariposa* (butterfly). All these insects have wings and can fly, very similar to *fairies* in

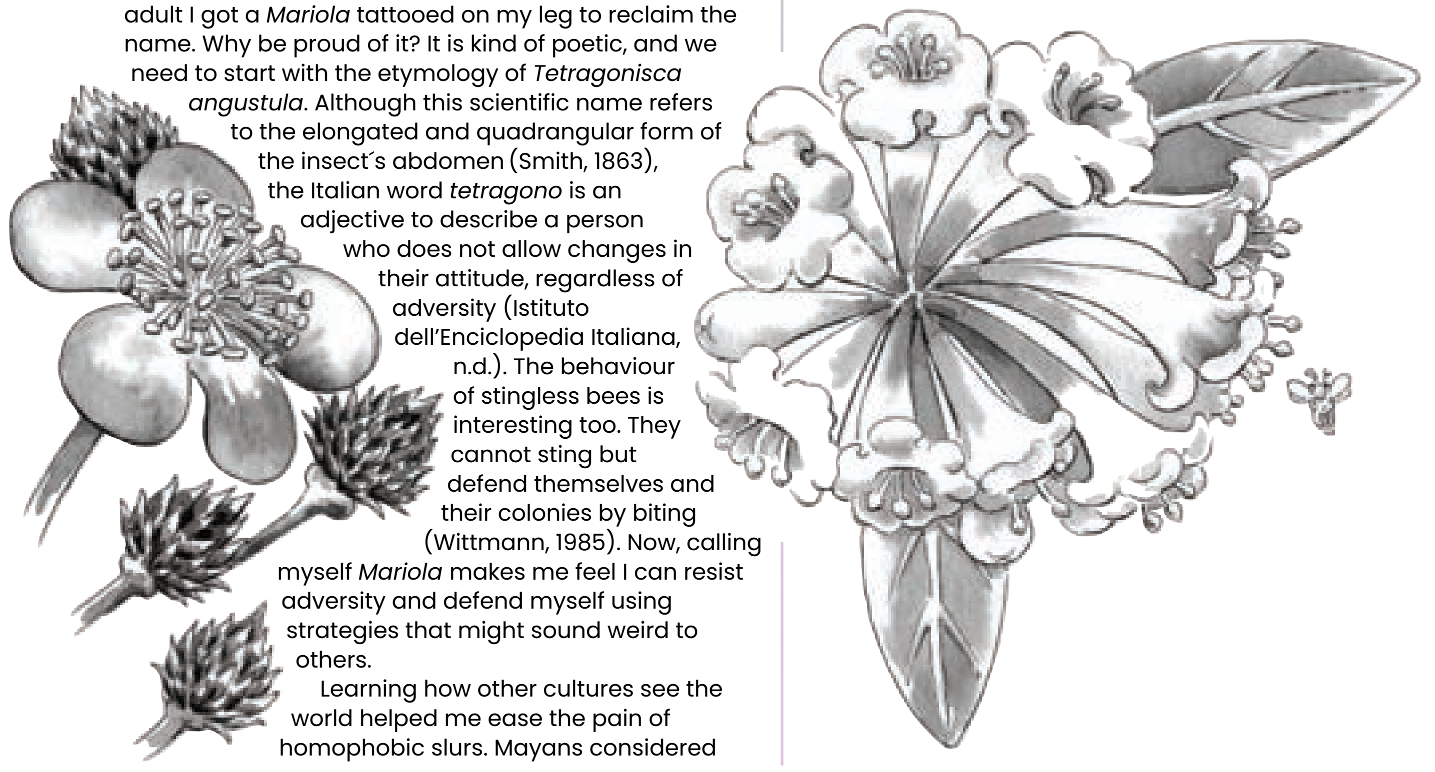
the English language (La Fountain-Stokes, 2007). I suppose that people thought both queers and insects were fragile and could not defend themselves; they were wrong.

It took me several years to accept my wings. As gender activists did with the word *queer*, I responded to hateful comments by metamorphosing the slur into a language of resistance (Cervone *et al.,* 2021*)*. As an adult I got a *Mariola* tattooed on my leg to reclaim the name. Why be proud of it? It is kind of poetic, and we need to start with the etymology of *Tetragonisca angustula*. Although this scientific name refers to the elongated and quadrangular form of the insect´s abdomen (Smith, 1863), the Italian word *tetragono* is an adjective to describe a person who does not allow changes in their attitude, regardless of adversity (Istituto dell'Enciclopedia Italiana, n.d.). The behaviour of stingless bees is interesting too. They cannot sting but defend themselves and their colonies by biting (Wittmann, 1985). Now, calling myself *Mariola* makes me feel I can resist adversity and defend myself using strategies that might sound weird to others.

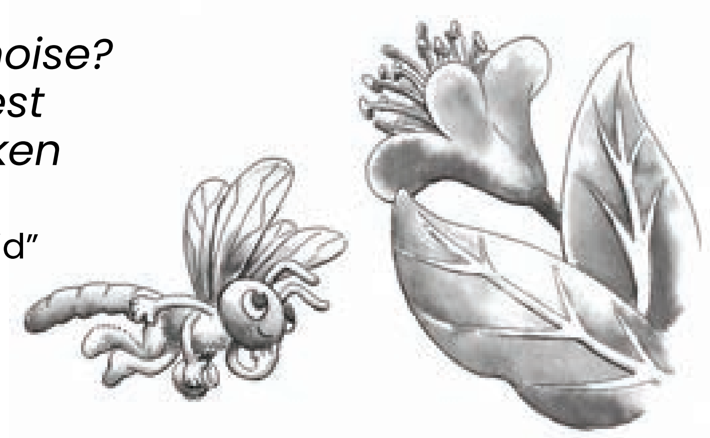
Learning how other cultures see the world helped me ease the pain of homophobic slurs. Mayans considered stingless bees sacred animals, and a few codices show the ceremonies where people offered food and incense to gods, so they provide abundance of flowers for honey production (Tozzer & Allen, 1910). Before the Spanish conquest, in Meso-American civilisations it was also common to have same-sex relationships (Neill, 2009). There was a time when stingless bees were sacred animals for a civilisation where homosexuality was normal.

My memories of *Mariolas* aren't all bad. When growing up, I maintained colonies of these bees in the family garden. From time to time, we extracted small amounts of honey from the colonies, and it was truly a nice and sweet treat. Before being called *Mariola*, this was to me the name of a useful insect. Honey from stingless bees has been traditionally used for its medicinal properties since pre-Columbian times (Vit *et al.,* 2013) and my mother treats wounds with it. My father used *Mariolas* as pollinators in our small plantation, during the time he produced papayas. Being called this name no longer sounds so bad, right? I am also proud that I was able to conduct scientific research on *Mariolas*. For my undergrad thesis I focused on their interaction with bacteria that show an antibiotic effect on human pathogens (Cambronero-Heinrichs *et al.* 2019). With the publication of the manuscript, I felt that I was conquering the name that was once imposed on me by bullies.

Perhaps calling myself *Mariola* is not normal but calling insect names to offend others should not be either. Reclaiming the name took me a long cognitive process. Children that suffer from bullying are not born prepared to 'bite' back their antagonists, and more violence is not the answer. Being bullied is associated with severe mental health problems, including self-harm, violent behaviour, and psychotic symptoms (Arseneault *et al*. 2010). To be a victim of bullying and to be called an insect common name had a strong impact on my personality, to the point it was difficult to trust or become friends with heterosexual people.



Please could you stop the noise?
I'm trying to get some rest
From all the unborn chicken
Voices in my head.
-Radiohead, "Paranoid Android"
(OK Computer, 1997)



The name *Mariola* is now an important and positive part of my personality, but it is very frustrating that it all started with a bunch of kids making fun of me. I have not known of my bullies for nearly two decades, and here I am writing about them. This was very impactful and influenced how much I thought about insects. It sounds a little sad, but during that time, I was watching documentaries instead of making friends. I wish that I could have talked about my problems with my parents, but those problems could not be discussed at that moment. Now, I am proud of my wings and the name *Mariola*.

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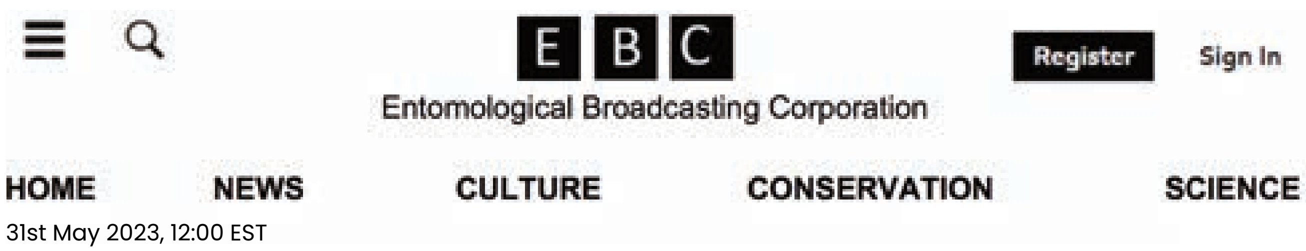
2nd

Eric Jackson

A God on Six Legs



Khepri: Egyptian God of the Sun. Artwork by Eric Jackson.

What if I were to tell you that for millennia many god-like mythical beings walked on six legs? They reigned over the passage of the sun, controlled life and death, and are credited for the birth of the universe itself. In this recent EBC episode I got a chance to interview one of those six legged gods: Khepri, the Egyptian Scarab God of the Sun. We discussed his origins and representation in ancient Egyptian culture, his past and present societal significance, and his thoughts on the current mindset towards insects and how to change them.

So, to kick things off, it's likely that many of our listeners haven't heard of you, Khepri. Give us a quick rundown of your origins and what you represent.

Khepri: My origins are pretty straightforward, but my representation changed multiple times in ancient Egyptian culture. Early ancient Egyptians imagined me into existence from their observations of dung beetles. They watched how these beetles roll dung around and associated that with the movement of the sun (Ward, 1994; Ratcliffe, 2006; Hogue, 2009). Thus began my job of lugging the sun across the sky. Do you understand how heavy the sun is? I have to do that every day. Then once it's done, I die and resurrect myself to repeat the same thing the next day.

You mentioned that your representation changed multiple times. I've read that as far back as 2700 BC you were only a sun god, but after 200 BC, you became known as the God of Resurrection.

Khepri: YUP! Lift sun into sky. Die. Resurrect myself. Repeat. Ancient Egyptians believed that all dung beetles were males (Ward, 1994; Ratcliffe, 2006). This is due to their knowledge of beetle life cycles being limited. They believed dung beetles procreate themselves (Ward, 1994; Ratcliffe, 2006). Thus, they imagined me creating myself from nothing.

You definitely played a significant role in how ancient Egyptian society viewed insects, especially beetles.

Khepri: It's incredible! My connection with scarab beetles, specifically the species known as the Sacred Scarab, led ancient Egyptians to associate them with birth, life and second life in eternal existence. Scarab figures are almost always found on Egyptian mummy stone coffins (Ward, 1994; Ratcliffe, 2006). Some archaeologists even believe that the pupal stage in beetle development inspired human mummification in Egypt (Ward, 1994; Ratcliffe, 2006)! Along with their connection to mummies, scarabs were also associated with good fortune and health. Stone scarab amulets, seals and jewellery were all the rage (Ward, 1994; Ratcliffe, 2006). Their popularity as good luck charms were so great that it expanded into other cultures. These included the Romans, Persians and Macedonians (Ward, 1994; Ratcliffe, 2006). It was truly a great time to be an insect god.

Why do you think insects aren't as popular today as they were in the past?

Khepri: Societies conquer other societies, and the belief of the dominant society wins out. Unfortunately for insects, this meant demonisation and has resulted in many of my fellow insect god-kin being mostly forgotten. A great example would be fly gods. Most people only see flies as creatures of disease, death and filth (Hogue, 2009). Yet, if they got to meet my buddy Big Fly of the Navajo, they would have a more nuanced view of flies (Capinera, 1993). He is literally a giant fly that acts as the mediator between humans and gods as well as the instructor and helper of heroes (Capinera, 1993). Sadly, due to colonisation and the spread of Christianity, the only people who really know of him are scholars like yourself.

In your opinion, how do we change people's mindset on insects from a negative to a positive one?

Khepri: More positive representation. Most movies that either feature or reference insects associate them with villainy, horror or destruction (Hogue, 2009; Simaika and Samways, 2018; Duffus et al., 2021). For example, my good friend Itzpapalotl, the Aztec moth mother deity and goddess of war and death was recently featured in a Netflix horror movie called 'No One Gets Out Alive' (Gunning, 2021). Itzpapalotl had mixed feelings about her portrayal. She was upset that the movie only characterised her as a monster of death and completely ignored her representation as the mother deity (Gunning, 2021). If popular culture had a more nuanced representation of insects, I believe insects and beings associated with them would be viewed in a far better light (Simaika and Samways, 2018).

I can personally attest to that. I'm currently featured in a popular video game called SMITE (Kinney, 2021). In the game, people play as gods and mythical beings and compete in a battle royal. I'm quite a popular playable character. I'm characterised as a guardian and protector, which is very empowering (Kinney, 2021; The Portal, 2023). It brings back memories of my influence in ancient times. To be seen as a hero again, in such a popular game, gives me hope for the future of insects and insect-god kin.

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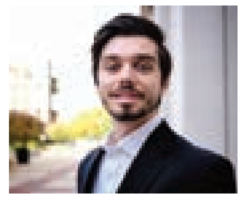
3rd

Altrim Mamuti



From Freedom to Boxes: A Journey Unchecked

I came across a pinned exotic beetle I had never seen before – a Titan Beetle (Smithsonian Snapshot, 2011). Pinned insects often have a scientific label indicating where they were collected (Walker and Crosby, 1988). This one did not. I could not determine where its home was. It left me with a growing suspicion that this beetle's journey had been unchecked, like many other insects that end up in the illegal trade. Insects remain the peripheral group in conservation efforts compared to charismatic megafauna. Even though authorities attempt to halt wildlife smuggling, it is insects like beetles that are still shown in collection exhibitions regardless of how they were obtained.

At the invitation of a friend, I attended an event called 'Beetles: An Interspecies Gathering' in Brooklyn. I expected a gathering where scientists and hobbyists discuss insects, conservation efforts, and educating the next generation. It was the opposite. A beetle collector (who preferred to remain anonymous) proudly presented his collection, drawers without any accompanying scientific labels to provide insights into the distribution, habitat, and biodiversity – which I

Figure 1. Unlabelled exotic beetles showcased by the collector at the 'Beetles: An Interspecies Gathering' in Brooklyn. The Titan Beetle is on the bottom right.

learned in class is fundamental to the field of entomology.

Over the years, this collector had accumulated thousands of beetles from all over the world but mentioned that the Titan Beetle was becoming increasingly hard to find, and I couldn't resist asking, "why?" He explained "There are fewer beetles in the wild, especially the colourful and larger species due to weather and habitat changes". Additionally, "authorities are restricting collectors by making permits expensive and difficult to acquire" because of biodiversity issues, decreasing threats and banning collection of certain species (Wyler and Sheikh, 2008). "If you're interested" he said, "there are ways to obtain them. Would you like to buy any?"

I did not buy anything. Instead, I was left puzzled by vast numbers of beetles with unknown origins. Sellers were clearly willing to cut corners and buyers from around the world are willing to pay hundreds, even thousands of dollars apiece for the rarest, flashiest insects to display in their collections or frame in their living rooms... but how much of a problem is the illegal invertebrate trade?

Each year, local poachers in Bolivia aim to make $30 for each live Rhino beetle (*Dynastes satanas*) captured in the forests (Berton, 2021). These live adults are illegally transported to major markets all over the world. Among other insects, beetles are predominantly used as toy pets and collectible ornaments. You might recall Heracross (Bulbapedia, 2010) – a bipedal, coleopteran insect robot collected in the Pokémon trading card game. This is among several examples of how pop culture leads to mass interest in beautiful insects for collecting, ornamenting, displaying and artisan jewelry.

Beetles and other insects are purchased online on Etsy, eBay and InsectNet, a network for insect collectors. Most wanted specimens are from tropical regions of Indo-Asia, Southeastern Africa, and Northern South America and specific countries like Australia, Papua New Guinea, and Madagascar (Work *et al.*, 2005; Hale, 2010). The tropical climates, niche ecosystems and isolated habitats contain biodiversity hotspots that these marvellous critters call home.

Invertebrates, including insects, are smuggled into the United States, and are often detected. Just recently $200,000 worth of smuggled insects, including butterflies, were caught by U.S Fish and Wildlife in Long Island (Shanahan, 2023; U.S. Attorney's Office, 2023). Insects are often overlooked in conservation efforts and removing rare species from their ecosystem niches further reduces the genetic diversity of that population. With single collectors hoarding thousands of specimens for personal use, and the trade remaining unchecked, we could easily lose the precious insect biodiversity that keeps our ecosystems intact.

After having gazed at so many unlabelled beetle drawers, I wondered if the guests at the event would feel disturbed by looking at taxidermised charismatic megafauna presented without labelling and a story. Audiences pay a lot of money to visit museums and view scientifically labelled megafauna exhibitions, otherwise those exhibitions could be shut down. Loss of genetic diversity and species is the same whether it be elephants, tigers or small beetles or butterflies. We are the audience. We have a say in the matter.

By uniting in our effort to increase awareness around insect handling, labelling and conservation, we can send a powerful message that insect smuggling is unacceptable. Let's be the voice for those who cannot communicate for themselves – at least in human tongue – and work towards a future where our ecosystems thrive, so the beauty of diverse insect life continues to inspire generations to come. Act now, boycott events where 'unchecked' insects are displayed and report smuggling no matter how small it is. Let's create a world where insects can flourish without the shadow of extinction and those that have already been collected, labelled properly with an origin and a story.

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Meetings

Monthly Online Meeting

The Ecology and Conservation of Urban Insects

10th April 2024

Report by Richard Harrington
Photo by Jan Skriver

This was the first in the revamped series of monthly online meetings. Signs were good that the move to 4 pm, alignment with a journal, and the crisp one-hour-max format were popular, with 50 joining from around the world to find out about the special issue of *Insect Conservation and Diversity* on The Ecology and Conservation of Urban Insects. Tilly Collins, one of the editors of the special issue, chaired the meeting and introduced seven short videos from contributors.

The first main presenter was Cecile Svenningen (Natural History Museum of Denmark), who spoke about her PhD project studying changes in insect biomass and species richness along urban gradients. Using data from Denmark collected by citizen scientists in June 2018 and June 2019 using car nets, Cecile found that increasing urban landcover decreased insect biomass by 93% and species richness by 61%. Environmental heterogeneity did not mitigate this negative effect.

Felipe Walter Pereira (Universidade Federal de Goiás, Brazil) spoke about the potential of iNaturalist for bee conservation research in a Brazilian suburban landscape. His excellent presentation was his first in English. He compared spontaneous observations on iNaturalist (90 recorders, 496 bee individuals, 52 bee species) with a structured local survey of bees in Curitiba. He concluded that iNaturalist has great potential to provide useful information for the conservation of larger and eusocial bees but that there was a need for taxonomic specialists, especially as regards smaller and solitary bees.

Other authors of papers in the special issue joined the panel for a lively and informative Q&A session covering the motivations of citizen scientists, reasons for biodiversity loss and the future of the two projects outlined.

Many thanks to all speakers and their co-authors, and to Tilly Collins and Manu Saunders for editing the special issue, which forms *Insect Conservation and Diversity* **17**(2) pp E1–E3, 169–408. See full contents at: https://resjournals.onlinelibrary.wiley.com/toc/17524598/2024/17/2.

The Verrall Lecture and Young Verrall Lecture

Life After Death: Using burying beetles to determine how behaviour influences evolution

2nd March and 6th March 2024

Presented by Rebecca Kilner

Report by Richard Harrington and Francisca Sconce

The first Wednesday of March is always eagerly awaited by entomologists. The Verrall Supper, organised by the Entomological Club at the Rembrandt Hotel in South Kensington, is a social highlight and is preceded by a scientific highlight, the Verrall Lecture, this year held at Imperial College and presented by Professor Rebecca Kilner FRS, Head of the Department of Zoology at Cambridge, Fellow of Pembroke College and Honorary Fellow of the RES.

Rebecca's talk explained that the science of ethology began taking shape in the 1930s, led by Dutch scientist Niko Tinbergen (1907–1988) and Austrian Zoologist Konrad Lorenz (1903–1989). Some of their work resulted in the new discipline of behavioural ecology, which investigates how behaviour is adaptive in relation to current ecological conditions, and the evolutionary history of that behaviour. Working in parallel, the American Palaeontologist G.G. Simpson (1902–1984) asked explicitly how adaptive behaviour evolves and how it affects subsequent evolution. This is 'Simpson's question', and Rebecca and her team have been working to answer it using the burying (or sexton) beetle *Nicrophorus vespilloides* (Coleoptera: Silphidae) as their model.

The beetle has an extraordinary natural history. It reproduces on small dead mammals and birds, which it strips of fur or feathers before rolling the flesh into a ball, which it buries and uses to feed its larvae. Its abundance, elaborate parental care and short generation time make it an ideal study organism for work on evolutionary questions. Rebecca described her experiments looking at how behaviour affects environmental conditions, selection and genetic variation.

The beetle has to deal with competition for carrion by microbes and other insects such as blow flies. It does this by manipulating the carcass breeding resource as described above, removing the guts to prevent bloating and hence microbial activity, and by exuding lysozymes

Rebecca Kilner receiving the President's Medal from Jane Hill.

which can destroy bacterial cells. The beetle apparently actively modifies the bacterial community to its benefit. The carcass environment is also manipulated in favour of the beetle with the help of the mite *Poecilochirus carabi*. The mite depends on the beetle for transport to carrion, which it, too, breeds upon, and benefits the beetle by eating blow fly eggs. Blow flies pose a particular competitive threat to the beetle's breeding success at lower and higher temperatures. At lower temperatures, beetle nests are less spherical and blow flies do better for reasons that are not understood. At higher temperatures, blow flies develop more rapidly than the beetle's larvae and hence outcompete them. The beetle thus needs help at lower and higher temperatures to outcompete the blow flies and the mite provides this by eating blow fly eggs.

There is huge variation between *N. vespilloides* families in the degree of parental care, which Rebecca and her colleagues have simulated in separate experimental work, by establishing populations in the lab. In some populations ('no-care'), parents are removed soon after making the nest, whereas in other populations ('full-care'), parents stay to look after their larvae by providing a benign environment. Experiments on these evolving populations showed that they quickly and divergently adapt to these different regimes of parental care. No-care larvae evolved relatively larger mandibles for their body size, and cooperated more with each other, than did full-care larvae. No-care parents evolved to front-load their parental care, making rounder carrion nests, and more quickly, than those in the full-care populations.

Further experiments showed that in the benign environment fostered by parental care, relaxed selection allowed genetic variation to build up. In a harsh environment with no parental care, selection was stronger and weeded out mutations. Care causes genetic variation to accumulate, including mildly deleterious mutations, but further work revealed that care is the antidote to an increased mutation load. This positive feedback loop means that care is genetically self-reinforcing, which might explain the general observation that parental care has evolved across the animal kingdom many more times than it has been lost.

A lively question and answer session followed Rebecca's lecture, covering topics including whether the mites preferentially attach to male or female beetles, whether the beetles strip birds underground and mammals on the surface, whether there is competition between beetles, whether beetles can recognise their own kin and whether they show strategic infanticide. Rebecca was then presented with the President's Medal, and most of the 115-strong meeting adjourned to the Rembrandt Hotel.

The Young Verrall lecture took place at the Staffordshire Invertebrate Science Fair, where the RES had an interactive stand. Visitors could hear about RES activities and membership and meet some live exotic insects. The RES hosted the Young Verrall Lecture together with the Amateur Entomologists' Society, as part of the Fair's talk programme. Rebecca's lecture, aimed at 7- to 11-year-olds, provided an interactive journey into the evolutionary strategies of burying beetles. A particular highlight was a video of burying beetles on a treadmill with different weights of putty, to simulate different loads of phoretic mites and the different temperatures reached by the beetles. Eighty visitors attended the talk, and there were lots of questions from the young audience at the end.

Many thanks to Rebecca and her team for such inspiring and informative work, to Tilly Collins for procuring the Imperial College lecture theatre, to Lily Keyzor and Wilson Wall for crewing the RES stand in Staffordshire and to the RES team for excellent organisation at both events.

Student Forum 2024

25th March – 26th March 2024

Report by Ben Hawthorne, Ayman Asiri, Vera Kaunath

Playing the great board game 'Pond Dipping' byJoshua Sammy.

The Student Forum 2024, held at the University of Newcastle, was a dynamic showcase of student research from across the UK and beyond. We explored a range of fascinating topics, from coleopterans in the Lateglacial era to the future of biodiversity in the Anthropocene, and even delved into the world of flea circuses in cultural entomology. Throughout the event, we learned about subjects like pollinator pathogen spillover, the impact of viewing angles on hoverfly mimicry, and the evolution of genomes in plant-farming ants. These talks were just a few of the engaging discussions and insights shared by our talented presenters.

"The long and winding road that leads to your door will never disappear". With these lyrics from The Beatles in mind, we turned our minds to the prospects and directions of careers in entomology. Is the choice between industry and academia set in stone? Is experience outside the UK required? What are the burgeoning fields in entomology and what skills will be useful for an entomological career? These were just a few of the discussions we explored alongside our three amazing invited speakers – Larissa Collins, Kelly Jowett and

Proud winners of the Ento PubQuiz!

Vivek Nityananda – who shared their personal journeys. From working internationally, to navigating diverse professional roles before finding their footing in entomology, their brilliant stories highlighted two essential elements: an unwavering passion for their research and courage to pursue unanswered questions. These topics ranged from insect emotions to emerging crop pests, and engaging farmers with a love for carabids.

During the event, time was dedicated to skill-sharing through two insightful workshops. One focussed on public engagement through citizen science projects and another delved into cultivating a healthy research culture. Those joining us online had the opportunity to network with one another, making the most of virtual attendance.

No Student Forum would be complete without an EntoPub Quiz! The competition was fierce, but in the end, Team 'How Many Fleas Can You Fit In Your Mouth' won the quiz, answering a range of very tricky questions including the legendary Frankenstein's Bugs Round. The judging of this year's EntoFashion Contest took place during the poster sessions, with a glass of wine or lemonade to enjoy the pretty ensembles. The Natural History Museum X Joanie collection with its charming green insect patterns was very popular!

The standards were incredibly high for presentations, so congratulations to all the poster and talk prize winners! We'd like to say thank you to all the delegates for such a successful Student Forum, whether you joined us in person or online. We couldn't have pulled it off without the help from all the RES staff involved, so a huge thanks to you all! We hope to see many more of you next year!

Kelly Jowett sharing her research and passion for carabids and dung beetles.

Obituary

Paul Roy Seymour

10th April 1937 to 5th November 2023

Paul was born in 1937 and I in 1949, a time when Paul was fighting for life, being the only one of four young patients to survive from nephritis; a battle which lasted over a year causing a major setback to his education.

Paul's passion for insects and particularly Lepidoptera, pervaded my childhood with our home crammed with tins and muslin cages containing all stages of his butterfly 'farm'. He left school early having the opportunity to work at Maidstone Museum's Natural History Section. This was to stand him in good stead when, after National Service in the RAF, he started a career at the Natural History Museum, South Kensington, having acquired 'A' levels at evening classes at Regent Street Polytechnic. Further evening classes at Birkbeck College resulted in a degree in Zoology, and a Civil Service bursary enabled Paul to study for a year and gain a Master's Degree in Entomology, with Professor Reg Chapman, providing the necessary qualification to progress in the Lepidoptera Section.

Paul found much support and encouragement from the Keeper of Entomology, John Doncaster. He gained many skills and made numerous contacts around the world, especially while researching his revision of the genus *Masalia* for which he needed access to examine all the Type Specimens.

In 1972 Paul joined the Pest Identification Service of the Ministry of Agriculture, Fisheries and Food at their Central Sciences Laboratories in Harpenden. His work involved making accurate identifications for both the Inspectorate and general public. Those for the Inspectorate were often made under time constraints and with considerable economic impact, sometimes with national and international consequences such as when cargoes of ships and aeroplanes were at risk. Paul taught groups from the Commonwealth, and agricultural and horticulture producers. Although he always took this role seriously, he enjoyed introducing humour into these specialist talks and some of these on Colorado Beetle had the audience of potato farmers 'rolling in the aisles' with laughter. He also helped with talks and practical classes for the years when Greg Peakin and I took over from Reg Chapman in organising the ILEA summer-schools for the RES. Paul's earlier experience at the Museum and contacts with officials and politicians around the world proved invaluable in understanding the threats from imported produce and goods at a time when climate change was impacting upon the distribution of invertebrate pest species. As a consequence of communicating with a variety of scientists, producers, advisors and politicians, Paul became involved in the use of scientific and common names and his compilation of the common names of

invertebrates of economic importance, proved a valuable resource. Pressure was intensified with the emergence of a 'new' pest, the leaf miner *Liriomyza trifolii*. Paul tackled this problem of potentially enormous economic significance in a systematic manner, in all senses of the word. Starting by tracing the name back through two hundred years of literature and investigating the fate of type specimens, Paul was able to recognise a group of morphologically almost identical species, and in the days before DNA analysis became a practical alternative, set about finding those distinguishing features which might prevent interbreeding between otherwise indistinguishable individuals. This also had to be practical if accurate identification had to be achieved speedily when a cargo and passengers were held up at a port or airport. Paul developed a technique of dissecting and displaying features of the genitalia of male specimens (critically the distiphallus which acted as an isolating feature of closely related species) within little more than 15 minutes.

Paul achieved much of hugely practical and economic importance, but was deprived of the recognition he deserved, something I hope to belatedly rectify.

Clive Seymour

Obituary

Patrick Hugh Beresford Vyvyan

RES Representative in Chile

21st April 1959 to 27th May 2023

Born in the UK on December 21st, 1959, Patrick Vyvyan received a first in History of Art at East Anglia University after studying photography at Lincoln College of Art. A true adventurer, he travelled through Argentina and Chile teaching English at the British Council in Temuco, Santiago, and at numerous prestigious universities and language academies, while also writing about art and nature in numerous publications worldwide. In 1997, he settled in 'Putaendo' in the foothills of the Andes with his wife Alicia Galdames, where he also presided as the President of House of Culture. Inspired by the rich variety of Chilean endemic insects, Patrick's inquisitive intellect brought him to the international world of entomology with prominence. In 2022, the photograph of a small fly he put on his Instagram page created a stir; it was identified as the Dancer of Orellana by expert Rodrigo Barahon Segovia, thought to be extinct. This fruit fly was last seen in 1959 in the region stretching from Valparaiso to the Atacama, in which it lived.

I met Patrick and Alicia at the end of summer 2022 when they visited the open-air native bee exhibition organised by the Fundación MAB in the historic village of Vichuquén to which Patrick had kindly contributed with photographs of Chilean native bees, *Bombus dahlbomii*.

He arrived dressed in well-polished brogues, a worn tweed jacket and a crumpled straw hat, with the ubiquitous camera hanging from his shoulder. But what struck me most was his huge smile when in my ignorance I surmised that we were unlikely to see many winged insects in late summer. He said an outing was an adventure and every adventure came with the possibility of discovering an unknown insect.

For me, the adventure that day was my transformation in the way I looked at nature, and in particular its insects. Stealthily, with careful manoeuvring of his camera's huge lens, Patrick focused on tiny fast-moving wild bees, shining wasps, colourful pollinating flies, and clouds of transparent winged dragonflies circling above us, all of which were invisible to me a few minutes before.

Patrick sadly passed away May 27th, 2023, but his legacy continues. Generous with his art and his knowledge, he has left us with the determination to continue the fight to to protect Chile's rich winged insect fauna, as well as the world's insect population so vital in the preservation of our ecosystems.

Georgina Gubbins
MAB Fundación Museo de la Abeja, Chile

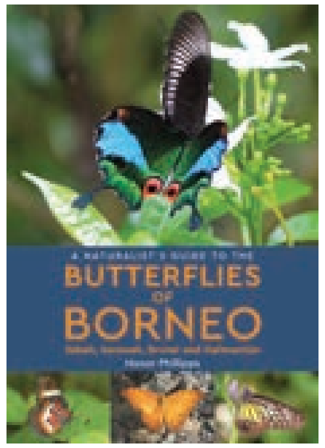
Bailarín de Orellana, photographed in Putaendo.

Royal Entomological Society

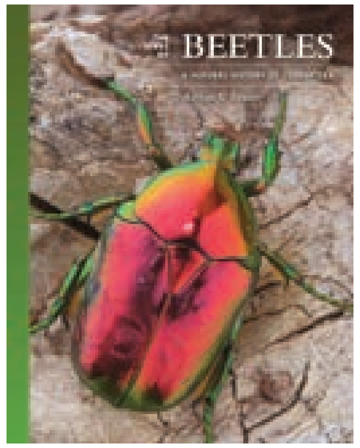
Antenna Reviews

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

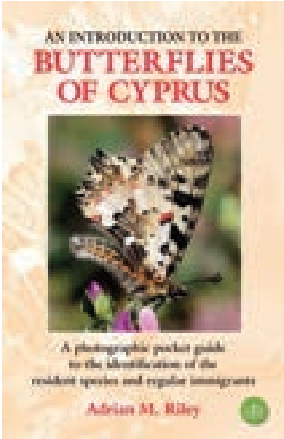
The following reviews have been added to the *Antenna* website:
www.royensoc.co.uk/publications/book-reviews/



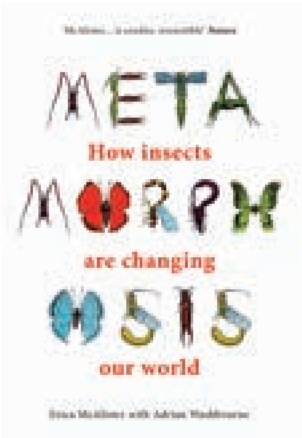
A Naturalist's Guide to the Butterflies of Borneo
Honor Phillipps
Published by
John Beaufoy Publishing
ISBN 9781906780692
Reviewed by Richard Harrington



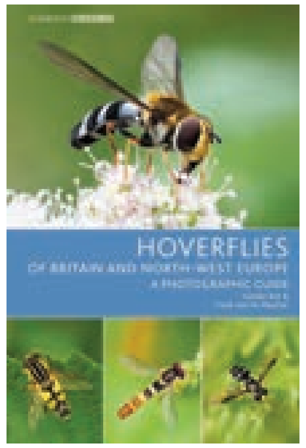
The Lives of Beetles: A natural history of Coleoptera
Arthur V. Evans
Published by
Princeton University Press
ISBN 9780691236513
Reviewed by Beulah Garner



An Introduction to the Butterflies of Cyprus
Adrian M. Riley
Published by Brambleby Books
ISBN 9781908241764
Reviewed by Richard Harrington



Metamorphosis: How insects are changing our world
Erica McAllister with Adrian Washbourne
Published by London Natural History Museum
ISBN 9780565095567
Reviewed by Peter Smithers



Hoverflies of Britain and North-West Europe: A photographic guide
Sander Bot & Frank Van de Meutter
Published by Bloomsbury Wildlife
ISBN 9781399402453
Reviewed by Richard Jones

Metamorphosis: How insects are changing our world

Erica McAllister with Adrian Washbourne
Published by London Natural History Museum
ISBN 9780565095567

Metamorphosis explores the many aspects of insect biology that have inspired new technologies and ideas. In each case the book outlines the biology of a particular group of insects, then examines how this has inspired a technological innovation and charts its development. These range from the jumping mechanism in fleas, via the fruit fly *Drosophila* as the Swiss army knife of biological research, to the origins of forensic entomology and the rise of the Black Soldier Fly (*Hermetia illucens*) as the ultimate up-cycler of organic wastes. But all of these stories meander across the entomological landscape introducing the reader to a rich cast of colourful characters and a diverse array of fascinating biology along the way.

Metamorphosis is not just about insect biology and innovation, it is also a series of mini biographies about the people who unravelled these complex biologies. Among these are the Rothschilds, to whom we are introduced as pioneers of flea biology, Charles Darwin and his fascination with the pollination of orchids, Thomas Hunt Morgan who pioneered the use of *Drosophila* as a model organism, Margaret Fountaine, the intrepid butterfly hunter and social rebel, plus Berta Scharrer who, with her husband, pioneered the field of neuroendocrinology using cockroaches but who as a woman was not allowed a salary. These life stories offer an insight into their determination, tenacity, self-belief and ultimate success.

Metamorphosis incorporates a larger dose of technical language than Erica's previous books and this could be challenging for some lay readers, but once engaged it is a fascinating composite of insect biology, technological innovation, entomological history and an introduction to a host of fascinating entomologists. It was also good to see small doses of the McAlister irreverence slip into the narrative now and then. *Metamorphosis* presents insects as incredibly complex and adaptable organisms, but also as a vast untapped resource that is set to inspire many new technologies. It also portrays the entomologists who research them as rebels and pioneers, biologists who think outside the box and who strive against a sometimes unreceptive world, heroes and heroines all. *Metamorphosis* is entertaining, informative and inspirational. It is a book that will be enjoyed by anyone with an interest in the natural world.

Reviewed by Peter Smithers

The Lives of Beetles: A natural history of Coleoptera

Arthur V. Evans
Published by Princeton University Press
ISBN 9780691236513

The Lives of Beetles: A natural history of Coleoptera, written by the eminent entomologist Arthur V. Evans substantially adds to the canon of useful reference books on Coleoptera. A book for the academic, the enthusiast, or the yet to be converted, it begs to be read. Today, so much is known about beetles, from the fun facts to the academic, and a new book on the subject must work hard to contribute something novel. This abundance of information, sourced increasingly from the internet, does require a synthesis and modernisation from the more traditional texts on beetles that were either regarding their taxonomy and identification or aspects of ecology and physiology. The Lives of Beetles ably synthesises our current understanding of the diversity and function of this enigmatic group of insects.

The book has an introduction, then sections including: Structure and Function; Evolution, Diversity and Distribution; Communication, Reproduction and Development; Feeding habits; Beetles in Medicine, Science and Technology; and Study and Conservation. These chapters stand alone as immersive primers into the much more complex topics they represent. Each chapter is divided into enticingly titled subchapters such as 'Adapted for success' in the chapter Structure and Function. The nine selected beetle species profiles at the end of this chapter demonstrate the extremes of structure and function that have contributed to the evolutionary success of the beetles as well as their ability to diversify and adapt to extreme environments. For example, the Blue Death-feigning Beetle, *Asbolus verrucosus* (LeConte, 1851) illustrates well how beetles can adapt to extreme desert environments. The contents page would benefit from indexing of these subchapters as each could be read as a stand-alone piece.

Each chapter follows this theme, featuring nine best-of-the-best beetles whose life history and morphology would be fascinating to any reader. The selection of beetle species highlighted to represent elements of each chapter could only have been made by an expert such as Art Evans. Given the immense diversity of the over 400,000 described species, how does one choose? Those beetles selected for special treatment provide just a glimpse of the multitude of beetle stories still waiting to be told but are representative of the diversity of families and their distribution throughout the world.

The final main chapter on Study and Conservation effectively gives the reader a sober insight into how beetles are surviving in our modern world. The message on how we need to act and conserve our species is highlighted by numerous examples of endangered and threatened, and geographically isolated beetles.

Further shorter chapters include further reading, a glossary of terms, and the currently accepted taxonomic classification of the described beetle families. Here the taxonomic classification would benefit from being linked to the chapter on Evolution, Diversity and Distribution. In Further Reading, given the author's deep dive into the most significant academic literature, a longer and more diverse list of suggested articles would help to steer the engaged reader to deeper learning. *The Lives of Beetles: A natural history of Coleoptera* is very clearly organised with lots of white space, allowing the easy digestion of so much information and really showcasing the outstanding photographic images. The photographs are further complemented by digital illustrations employed to help describe beetle morphology and behaviour, thoroughly modernising how we view beetles in print. This book is deeply engaging, so colourful, such fun and yet scientifically informative, with reliably sourced information from peer reviewed journals. It comes highly recommended.

Reviewed by Beulah Garner

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).

June 2024

Mon 24 — 24 June – 30 June
Insect Week 2024

July 2024

Wed 3 — 3 July
Computing & Technology and Data SIGs
AI in entomology **(hybrid event)**

Thu 18 — 18 July
Aphids SIG **(online event)**

August 2024

Sun 25 — 25 August – 30 August
International Congress of Entomology, Kyoto **(external event)**

September 2024

Tue 10 — 10 September – 12 September
Ento24 Liverpool **(hybrid event)**

October 2024

Wed 30 — 30 October
Feeding the Future: Using Insects as Food and Feed **(panel debate)**

Thu 31 — 31 October
Food & Feed, Insect Welfare & Ethics and Rearing SIGs
Insects as Food and Feed: Delivering insect proteins in the UK **(hybrid event)**

November 2024

Wed 6 — 6 November
Orthoptera SIG **(hybrid event)**

Fri 8 — 8 November
Sustainable Agriculture SIG
Sustainable Agriculture: Innovations in research and practice **(hybrid event)**

Online Talks

On the second Wednesday of the month, hear talks aligned to our seven journals. Free for members.

10 July: Insect Molecular Biology
9 October: Ecological Entomology
13 November: Agricultural and Forest Entomology
11 December: Medical and Veterinary Entomology

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