Bulletin of the Royal Entomological Society Volume 42 (3) 2018

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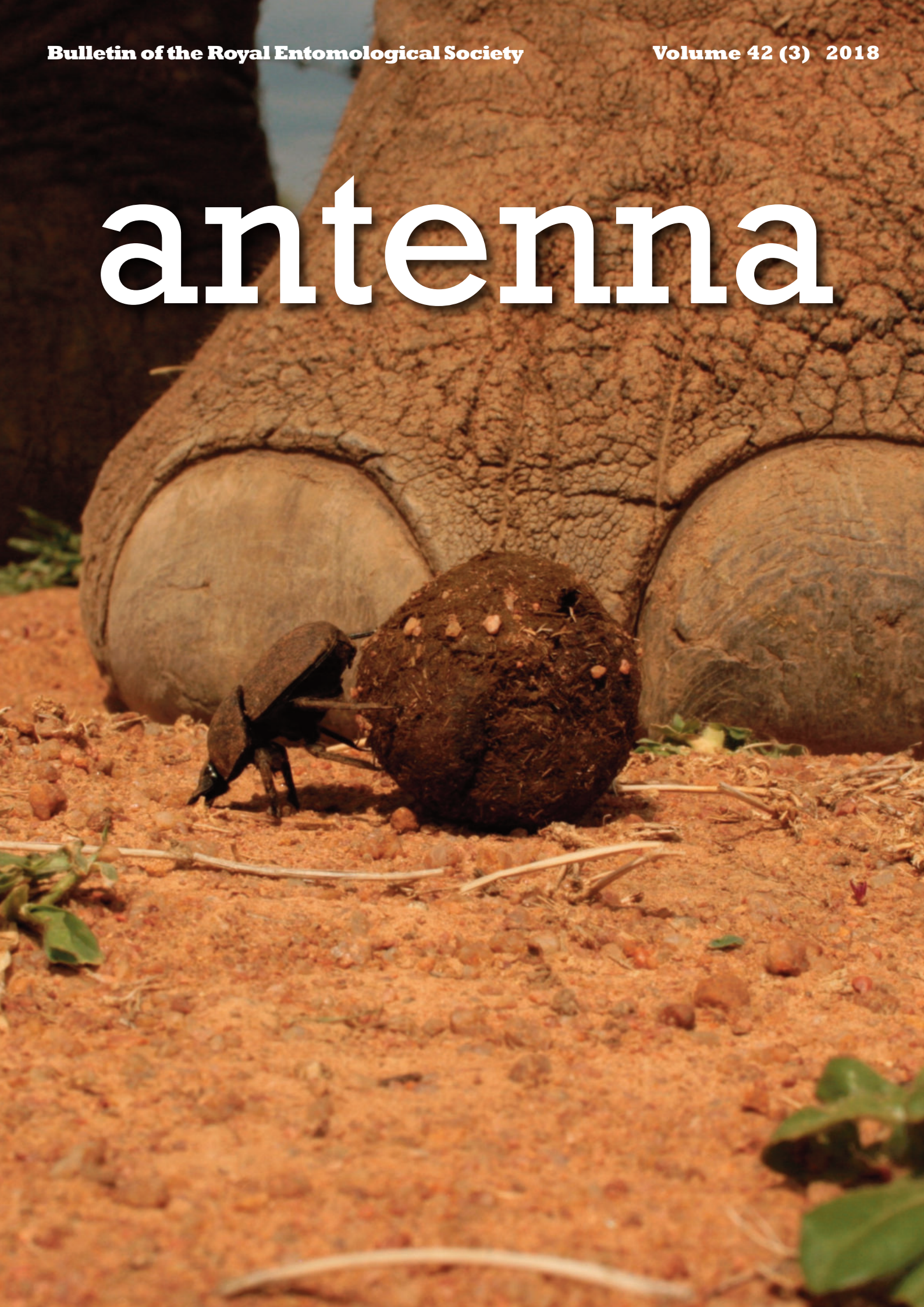

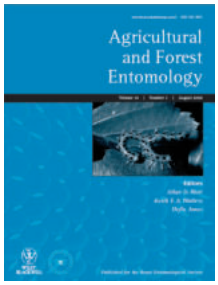


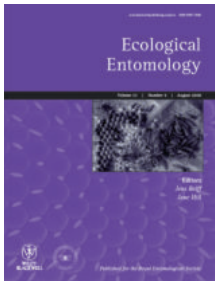


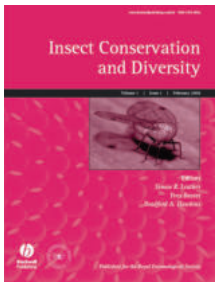


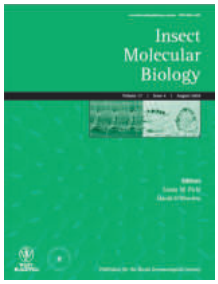


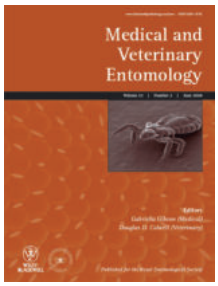


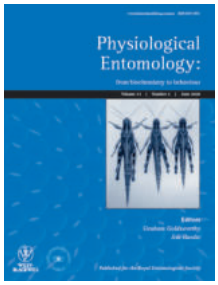


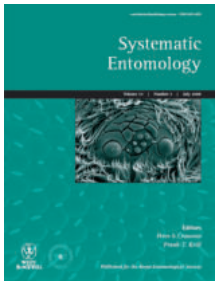


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**COVER PICTURE**

Elephant and Dung Beetle. Photo: Marcus Byrne


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**Bulletin of the Royal Entomological Society**

**The Royal Entomological Society**
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# EDITORIAL

First and foremost, huge thanks to Peter Smithers, from whom I have taken over as editor of issues 1 and 3 each year. Pete has made his mark not only as an editor but as a prolific contributor of articles and reviews and I am pleased to say that he will continue to delight us in this way. Thanks also to fellow editor David George and to editorial assistant Jen Banfield-Zanin who have guided me through my first tentative steps in the role. And, yes, thanks to Lin Field, Publications Committee Chair, for getting me into this – I'm already enjoying it and it sits neatly alongside my role as Special Interest Group (SIG) Coordinator. The SIGs show off cutting edge entomology and are a potential rich vein of material for *Antenna*. The two roles combined are a marvellous way to keep up to date with entomology and entomologists in retirement, after spending the whole of my career with the Rothamsted Insect Survey working on aphids.

For me this issue has been mainly about learning the ropes. You will hence not spot any immediate change in style or content, but I do have some ideas, particularly around highlighting progress towards dealing with the "grand challenges" in entomology identified by the world's major entomological societies as: i) public health related to vector-borne diseases, ii) feeding the world in a sustainable manner and iii) dealing with invasive species. I will always very much welcome your ideas and, of course, your articles. It would be great, for example, to have a few more robust exchanges on topical and controversial issues. The day after my arm had been twisted I received an email from a potential contributor, greatly boosting my optimism for the role. This related to grand challenge ii) and was from Heather Poxon, whose father, Paul Latham, is leading a project in the Democratic Republic of Congo aimed at encouraging the use of lepidopteran larvae as food. This has been a strong theme for the Society over the last few years and one with huge potential for improving food security. Indeed, there are two further articles on edible insects herein, one on termites and one on the work of the UK's largest insect farm which nourishes, in this case, amphibian, reptilian and mammalian pets. Read also about the extraordinary behaviour of Europe's longest insect.

There has been a changing of the guard. Professor Chris Thomas has taken over the Presidency from Professor Mike Hassell and, after 19 years as Registrar and Chief Executive, Bill Blakemore has handed over those roles to Kirsty Whiteford and Dr Luke Tilley, respectively. I am sure that all members would wish to join me in thanking Mike and Bill and in wishing Chris, Luke and Kirsty successful and enjoyable tenures.

Richard Harrington

## Guidelines for submitting photographs

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

Electronic images can be embedded in the Word document but we will also require separate electronic images. These images should be at least 300dpi at an image size that is either equal to, or greater than the expected final published size.

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

Photos taken on film should ideally be submitted as reasonable sized prints for us to scan or alternatively they can be scanned in by authors provided the scanner is capable of scanning at up to 1200dpi.

If an image is intended for the front cover then the photograph should be in portrait format and at least 300dpi at final size or a good quality print.

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

300dpi

72dpi

Fig. 1. *Cirina forda* feeding on *Crossopteryx febrifuga* at Kasangulu in DR Congo.

# An edible caterpillar-rearing project in the Democratic Republic of Congo

## Editor's Introduction

Within a few days of agreeing to become an Editor, I received an email from the Salvation Army's International Development Officer, Heather Poxon, suggesting that an article from her father, Paul Latham, on edible caterpillars in the Democratic Republic of Congo, might be of interest. *Antenna* has published much on edible insects recently and has an Entomophagy (insects as food) Special Interest Group. Paul, though, was ahead of the game, having first published an article on the subject in Issue 23(3), July 1999. Clearly this is a long-term interest of his. Paul and Heather are, incidentally, related to Eleanor Ormerod (1828 to 1901), the well-known entomologist instrumental in the early days of studying pests of farm crops. In 1887 she moved to 47 Holywell Hill, St Albans, where there is a commemorative blue plaque. Eleanor was the granddaughter of John Latham (who was President of the Royal College of Physicians). John was Paul's great-grandmother's uncle, making Eleanor Paul's second cousin twice removed (so Paul tells me – I don't claim to have worked that out for myself!).

***Paul Latham***
Salvation Army
(paullatham36@btinternet.com)

## Introduction

The larvae of the Saturniid moth, *Cirina forda* (Westwood, 1849) (Fig.1), known as Ngala in the Kikongo language, are important edible caterpillars in Kongo Central province, in the Democratic Republic of Congo. Elsewhere, like other moth larvae, they are considered a pest, causing serious defoliation of the Wild syringa tree, *Burkea africana*, which is valuable as timber. Forty years ago, the larvae were plentiful within the province but now they are imported from Bandundu and elsewhere and sold dried in the markets. In Kongo Central they used to be found on the savanna shrub *Crossopteryx febrifuga* and were available at the beginning of the rain season in October and November.

The Salvation Army has worked in the province since 1934 establishing churches, schools and health centres, and operating an agricultural development programme. A bee-keeping programme has enabled approximately 11,000 farmers to benefit from the sale of honey. In 2016 a project to reintroduce *Cirina forda* was started at Kilueka, approximately 135 km southwest of Kinshasa. This is not the first time the Salvation Army has been involved in the rearing of various Lepidoptera species. A project to collect, mount and send butterflies from French Guiana helped many of the prisoners on Devil's Island to earn their passage back to France after completing their sentence. An earlier project in Kongo Central, previously Bas-Congo province, and referred to in

Fig. 2. Eggs of *Cirina forda* collected in Bandundu.

Fig. 3. Young *Burkea africana* trees grown from root cuttings.

Latham (1999), was aimed at conservation of various caterpillars then fairly common in the province. It was also linked to a bee-keeping and tree-planting project. Unfortunately, the project came to an end in 2007 with very little to show for it, as far as the caterpillars were concerned.

Since then, due to over-collection and loss of habitat, the variety and quantity of edible caterpillars has decreased steadily. The present project represents a completely new start in a different location with different staff. The current project is entirely focussed on edible caterpillars.

In charge of the project is Augustin Konda, a biologist who has, for many years, worked with Anamed, a health programme based on the use of plants with healing properties.

## The project so far

The initial aim of the project was to reintroduce and maintain a sustainable population of *Cirina forda* in 30 villages around Kilueka. In 2016, 43 batches of eggs (Fig. 2) were collected from African blackwood, *Erythrophleum africanum*, trees in Bandundu, and transported to Kilueka, a distance of approximately 400 km. Most of these were then fastened to twigs of *Crossopteryx febrifuga*. Unfortunately, after hatching the larvae refused to eat the foliage, even though trees had been burned beforehand to encourage them to sprout new leaves. A trial planting of *Erythrophleum africanum* had produced a good crop of seedlings but they grew very slowly and the majority died off while they were still small. Sufficient eggs had been brought, however, to make trials on other tree species, but only two trees were accepted, a *Bridelia* species and *Burkea africana* (Fig. 3). Neither tree is particularly common in Kongo Central, but it was decided to find a method of propagating the latter species. Although the tree flowers and produces seed elsewhere, it doesn't appear to do so in the area around Kilueka; however, it can be propagated from root cuttings and, whilst this is very labour intensive, it has successfully been used to produce a reasonable number of new plants.

In Bandundu the rain season runs from September to May and the *Cirina forda* eggs hatch out in August, this being during the dry season in Kongo Central. Forcing the food trees to produce fresh leaves for the young

Fig. 4. *Lobobunaea phaedusa*.

Fig. 5. *Imbrasia epimethea* on the trunk of *Ricinodendron heudelotii*.

larvae provided a feast for every other leaf-eating insect in the area. Last year a larger batch of 87 groups of eggs was imported from Bandundu and placed on newly established *Burkea africana* trees prepared for the caterpillars as they hatched out. We wait to see if the chrysalises produce adults this July. A total of 115 chrysalises were collected and, so far, three have hatched out; all females so no mating has taken place. *Cirina forda* only produces one generation per year so it would be very helpful if a simple method of breaking the diapause could be developed. Alternatively, there are plans to import eggs from an area with the same rainfall pattern, such as from northern Angola.

Other Saturniid and Sphingid species are, however, present at Kilueka; a total of 35 different Saturniids and 19 Sphingids were caught at a light trap during December alone. These were identified from photos by Dr Thierry Bouyer in Belgium. Of the Saturniids, six are known locally as Kaba in Kikongo. The larvae are large, edible and are generally found singly in amongst the foliage where they are often difficult to locate because of their colour. People find them by looking for their droppings on the forest floor and then searching the branches overhead. *Lobobunaea phaedusa* (Fig. 4) and another, so far unidentified species, are currently being reared at Kilueka.

Other Saturniids include *Imbrasia epimethea*, *Bunaea alcinoe* and *Nudaurelia petiveri*. *Imbrasia epimethea* is a valuable, and much appreciated, species which feeds gregariously. It has the useful habit of descending the trunk of the host tree during the day and returning to the foliage to feed at night (Fig. 5). When in their final instar, the caterpillars are easily collected from the trunk of the tree which is often marked in some way to show that the person finding the colony has claimed it. In December and January last year, several colonies were found on trees growing in the villages around Kilueka and, instead of being collected and eaten, they were divided into groups of between 40 and 100 and placed on other trees where they could be monitored. These colonies have produced an abundance of new colonies this present season and have again been divided and distributed to other villages. Traditionally people in Kongo Central planted the fast growing *Ricinodendron heudelotii* near their homes to attract this species. For this reason, tree nurseries, to produce food trees for *Imbrasia epimethea* and other species, were started at five schools last

year and the trees are now being planted out in the villages to provide sufficient food for future generations. There are two major challenges facing tree planting. One is that it is not customary for trees to be planted other than fruit trees, the other is Kinshasa's insatiable appetite for charcoal. Over the past 40 years the countryside has been almost completely denuded of tree cover; however, it has been found this year that because a valuable species of caterpillar has returned in good quantities to existing trees and that *Ricinodendron heudelotti* is useless for making charcoal, there has been a big demand for planting this tree. The only other problem with *Imbrasia epimethea* is that safari ants attack and destroy the colonies. They are the major pest of this species.

Although not part of the caterpillar rearing project, the Army worm, *Achaea catacaloides*, known locally as Minsangula (Kongo) is an important, though rather irregular edible species. When it does appear, normally in great numbers, it is dried, packed in sacks and transported to Kinshasa for sale in the markets. Its last appearance occurred in May 2017.

## Conclusion

The caterpillar project is still in its early stages. There is much to learn and some difficult problems to solve, namely for *Cirina forda* to break the diapause so that the larval stage coincides with the rain season and, for *Imbrasia epimethea*, to find an effective way of dealing with safari ants. Despite these challenges, indications are that the project has the potential to sustainably meet an important, nutritional need for a high protein food in a very needy country. Furthermore, it promises to be a means of re-afforestation of a badly denuded landscape.

I would particularly like to thank Augustin Konda, who manages the project, for all the photos and most of the information, and Daniel Ambühl for his expertise and for the considerable help he has provided to the project.

## Further reading

A series of videos, available on YouTube, has been produced to illustrate various aspects of the project. These can be found at: https://www.songanzila.info/linkstovideos.htm

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Soldier caste of the Northern harvester termite, family Hodotermitidae. Photo courtesy of JMK via Wikimedia Commons

# Termites: Global pest and a tasty treat

***Rudi Verspoor and Katie Powell***

Rudi Verspoor and Katie Powell are based at the University of Liverpool. Their work aims to understand more about the value of termites as food in northern Benin, focussing on the community use of termites and the study of the nutritional value of termites. This work is funded by BBSRC GCRF support (BB/P022545/1).

## Termites: Small but mighty

*Reaching towards the skies, earth cathedrals rise majestically from the ground, throwing a blind society into a sheltered darkness.*

Take one look at a giant termite mound, and it is easy to see why they are considered wonders of the natural world. A thousand times taller than their occupants, these towering creations offer termites protection from predators of all shapes and sizes. Protection, however, is not the only service the mounds offer. Remarkably, they also maintain stable temperature and humidity levels and protect against abiotic extremes of the surrounding climate, like a self-regulating building. These constant environments even allow some species to support their own agriculture, with workers culturing fungus farms to feed their vast societies.

*"Trees growing on termite mounds had higher concentrations of all nutrients except sodium and crude protein, and were subjected to more intense feeding by elephants."*[1]

The engineering feats of termites, however, are not limited to these towering cathedrals of earth. Widely distributed and hyper-abundant across the tropics, termites provide important biological functions by breaking down both live and dead plant material. Distinct groups of termites, breaking down different types of organic material, are vital for decomposition in many tropical, sub-tropical and warm temperate ecosystems. By mound building and subterranean tunnelling, termites also redistribute nutrients, structure soils and raise soil moisture levels, earning them the well-deserved status of 'ecosystem engineers'.

*"Termites are a serious menace to both plants and structures. They are the most problematic pest threatening agriculture and the urban environment."*[2]

'Reviled' and 'hated', however, may be more common associations for termites in many parts of the world. Damage to structural timber can vastly reduce the life span of buildings where termites occur. In the US alone, damage from termites to buildings is estimated to cost billions of dollars for house owners every year. Subterranean tunnelling by termites can also undermine crop plants and interfere with agriculture. As pests of agriculture and construction, termites continue to be the focus of expensive control measures in many countries around the world.

The chimneys of a *Macrotermes* mound stretch towards the sky, providing the ideal home for the termite society inside. Photo credit Rudi Verspoor and Katie Powell

A fresh batch of winged termites is cooked over the fire until dry. Afterwards, the wings are blown away, while the tasty bodies are distributed within the community.
Photo credit Rudi Verspoor and Katie Powell

## Termites: A cultural food

*"Termite foraging by chimpanzees and present-day modern humans is a well-documented phenomenon, making it a plausible hypothesis that early hominins were also utilizing this resource"*[3]

'Delicious' may be a more surprising descriptor of termites, but there is growing interest in termites as a food resource. Yet in many parts of the world, eating insects such as termites is nothing new, and may have even been important for the evolution of a larger brain size in the ancestors of modern humans. As observed in the behaviour of chimpanzees, early hominids potentially used tools, such as bones, to fish termites out of mounds to eat. To this day, termites continue to provide a nutritious food source in many countries around the world. Some communities still fish for termites directly from the mound. However, a particular phenomenon occurring in the rainy season means a different caste of termites is readily available in the thousands.

*"From every chink, every crevice, a cloud of vapour formed of millions of wings mounting to the blue, in the doubtful and nearly always frustrated search for love"*[4]

In many parts of the world, the wet season brings relief to lands parched by the stifling heat of the dry season. New life begins to thrive in the rehydrated landscape, and termites are no exception to this. Long-awaited rains trigger a mass release of flying termites - known as alates – from their mounds. These alates are the members of the colony selected to mate when they swarm during their nuptial flight. Once the lucky ones have found a match, they shed their wings and mate, burrowing underground to become the king and queen of their new colony. However, only a very small percentage of the swarm rise to royalty; most fall prey to a suite of waiting predators including birds, reptiles, amphibians and even people.

*"Termites are considered to be very nutritive and they were compared with the first milk given by a cow after delivery."*[5]

Across Africa, winged termites are one of the most widely consumed insects. Revered for their good flavour, this flying insect bonanza forms a part of the diet in many countries across the

Left: Termite mounds like this, which can easily host three men, are made by insects smaller than a fingernail. Incidentally, a hollowed out old mound makes a great shelter from heavy rains while out working in the fields. Right: Storage granaries are often made out of the strong, compact soil of old termite mounds. Photo credit Rudi Verspoor and Katie Powell

continent. Termites offer quality nutrition, being rich in protein and important minerals like iron. Their little bodies are high in fat, and can provide equivalent or greater calories per gram than other forms of meat, such as beef. Tackling malnutrition and achieving food security remains a potent challenge in many parts of Africa. Thanks to their large quantity, nutritional value and popularity amongst the locals, termites and other insects can contribute to regional food security.

*"All, except very small children and some older relatives who remain to look after them, leave home in the evening armed with baskets…"* [5]

We travelled to West Africa to learn more about eating termites with the Waama in the Atakora region of Northern Benin. Here, once the season arrives, the wild swarms of alates are seen as free food for all in the villages. Collected by hand, villagers use lights (or fire) in their households to attract them, and trap them in basins of water. Roasted in a pan the next day, sizzling in their own body fat, these insects are shared with both the family and the neighbours. This contrasts with other types of meat, which are often reserved for older members of the household or special occasions. When there's a bowl of termites around, everyone - from the smallest child to the oldest family member - grabs a handful.

*"The best strategy would be to find techniques to process and preserve the termites to make them continuously available."* [5]

Do edible termites help to provide vital nutrition to people living in rural areas? The alates do emerge at the beginning of the rainy season, which is a crucial and challenging period of the year in northern Benin, when food is both expensive and in short supply. Working with local communities, we are estimating the quantity of termites collected each year. Furthermore, we will determine the nutritional content of termites to understand their importance in local diets. However, one problem with this resource is that it is only available for a short period of time. To overcome this, we are trialling simple preservation and storage methods, which could allow termites to be available for longer periods.

## Termites: A changing future?

*"When harvesting a popular, high-priced insect from nature, one of the dangers is overexploitation, which can endanger future harvests."* [6]

As is the case with termites, many edible insects are harvested from the wild, raising questions about the sustainability of the food source. The sheer size of alate swarms and the number of mounds across the landscape suggest a large resource. In addition, opportunistic and low intensity harvesting has occurred for generations, suggesting some collecting is sustainable. Through quantifying the catch taken by some households, we hope to estimate the quantity currently collected by whole communities. From this baseline information, additional questions emerge. Is it possible to collect more termites in a sustainable way? How does the availability of termites vary throughout the season and between years? When answering these questions, it is important to consider the part they play in the food chain. Alates are food for many other predators in the wild, so harvesting them could have wider consequences in the ecosystem.

*"Their staggering diversity and abundance should not lead us to think they are indestructible."* [7]

We live in an era of unprecedented global change, which is driven primarily by humans. Deserts are expanding, deforestation is ongoing, and natural habitats continue to be degraded. How will this affect termites, and insects more widely, as a harvested food resource? In Benin, it has been suggested that edible termites, of the genus *Macrotermes*, may be declining. Habitat degradation, changing rain patterns, and pesticide use have all been speculatively suggested as causes. Termites are spread vastly across the grasslands of Africa, representing a huge biomass and they are intrinsically linked to the functioning of those ecosystems. Range expansions or contractions caused by environmental change could dramatically affect the availability of edible termites.

*"Nature provides a free lunch, but only if we control our appetites."* [8]

The uses of edible insects worldwide are changing. Some countries are experiencing a rapid expansion in edible insects, for example the thriving insect markets of Thailand. The nutritional quality and sustainability benefits of eating insects could further fuel this expansion. On the other hand, traditional uses of edible insects may be declining through cultural erosion and the homogenisation of food habits. In

Benin, a number of insect species are rarely eaten nowadays compared to only fifty years ago. Expanding urbanisation could also mean the traditional, rural practice of eating termites is being lost. These cultural shifts present challenges for developing termites, and insects more widely, as food. While termites remain a popular insect to eat in northern Benin today, it remains to be seen if this popularity will expand or decline in the future.

Although considered pests in many countries where they damage infrastructure, termites are clearly viewed more positively elsewhere and regarded as a delicious food. Studying the quality, quantity and attitude towards edible termites in northern Benin, we hope to find out more about these fascinating insects. It is, however, important to consider the sustainability of this resource, in order to guard against environmental damage and the possibility of over-harvesting. The question remains, how much can termites contribute to food security in this region of Africa? We certainly look forward to finding out more about these tasty edible insects over the course of the project.

Reproductive Termite (*Macrotermes mossambicus*) after shedding its wings.



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# Life on a bug farm: Opportunities for developing insects as food and feed

## Introduction to Monkfield Nutrition

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Amongst the flat wheat and sugar beet fields on the Cambridgeshire-Hertfordshire border is the endearingly named hamlet of Shingay cum Wendy, and here sits a farm unlike any other in the UK. From the outside the large wooden-clad barn, once a potato store, looks distinctly normal in this agricultural setting and nothing suggests anything out of the ordinary. However, this barn is home to Monkfield Nutrition, the UK's largest insect farm, housing millions upon millions of mini-livestock: crickets, locusts, cockroaches and mealworms, all destined to be dinner for someone's pet chameleon, salamander, bearded dragon, hedgehog or bushbaby.

As you step through the door into one of the many culture rooms you are immediately hit by a wall of heat and humidity, maintained to replicate the tropical conditions the insects require. Most rooms are silent aside from the hum of fans circulating air, nothing indicates that you are in the midst of an insect horde. Take a walk between rows of boxes, stacked floor to ceiling and you can hear the rustle of legs on carapaces as the insects shift and shuffle, going about their lives and growing fast.

In the cricket breeding rooms, however, the silence is gone. Even before entering you can hear the constant chirruping of the males stridulating; close your eyes and you can almost imagine yourself somewhere tropical... almost. Inside these rooms the relaxing sound of a holiday evening is amplified by thousands of voices and absorbed into a ceaseless wall of noise, like shifting pebbles on a beach.

Once you get used to the strangeness of the animals which you are rearing, and the occasional cricket crawling up your leg or down your neck, then

farming settles down into a calm rhythm of feeding, watering and feeding again. This constant cycle of care nurtures our livestock as they grow a thousand times in size over a few short weeks until they are ready for harvest.

With the growing popularity of reptilian pets in recent years, Monkfield Nutrition has also expanded to meet the demand for their live food. Growth has been so great that the company has reached the capacity of its current site and change is now just around the corner. Early in 2018 the company moved to a new, state of the art facility near Ely, affording it space to expand and flexibility to develop as new opportunities arise.

## Edible Insects

One opportunity which Monkfield Nutrition is keen to take advantage of is the emerging edible insect market: developing insects as a sustainable source of protein. While eating insects, or entomophagy, is a bizarre concept for many of us, it is normal for approximately two billion people, from 3,000 ethnic groups in 113 countries, who regularly consume over 2,000 insect species. Even in the UK we unknowingly eat around half a kilo of insects every year as almost all processed foods contain some insects. These are either deliberately added such as carmine, the red food colouring E120 made from cochineal bugs, or accidentally harvested with plants because insects are so abundant in nature that it is impossible to remove them all. These insect fragments make it into coffee, peanut butter, chocolate and much more. Now an enterprising group of entrepreneurs, scientists, foodies and farmers are working to bring insect protein to our supermarket shelves in a big way.

The United Nations Food and Agriculture Organisation released a report in 2013 championing insects as a vital source of protein which will help to ensure global food security. This position is founded on a number of factors including the low environmental impact of insect farming and their nutritional profile. Although the diversity of insect species makes generalisations difficult, the larvae of seven insect species have been shown to have equivalent nutritional value to meat: the honeybee, domesticated silkworm, mopane caterpillar, house cricket, African palm weevil larvae and yellow mealworm. For example the house cricket (*Acheta domesticus*) has comparable protein content and digestibility to beef and egg, providing all nine essential amino acids; it is also a richer source of polyunsaturated fats than beef, delivered in the ideal ratio of 3:1 omega-6 to omega-3.

## Sustainability of Insect Farming

Another major benefit of insects as food, and the main reason that I chose to work with these foods of the future, is their sustainability credentials. You will be well aware of the challenges we face: by 2050 the global population will have grown to 9.6 billion people and the demand for high quality animal protein will have risen by 57%. We will need to meet these demands in the face of climatic uncertainty and water shortages, while preserving our remaining precious wild spaces and the biodiversity which they harbour (80% of new farm land replaces forests). Current livestock production uses 78% of all agricultural land (grazing = 68%, cropland for animal feed = 10%) and global livestock emit more greenhouse gasses than the global transport system. In the face of these facts it must be obvious that improving production as we have done historically is no longer a viable option. So why eat insects? They have a tiny footprint in many ways which will help address all of the above challenges: kilo-for-kilo edible insect protein requires 500 × less water, 12 × less feed and 10 × less land than beef, while producing 613 × less greenhouse gases.

## The Yuck Factor: a Major Challenge to Entomophagy

So how would you like to eat insects? Given these benefits there must be a reason why we are not all tucking in. The biggest challenge entomophagy faces in the western world is the, scientifically accurate, "yuck factor": an immediate negative reaction, which you might be feeling now as you read this, leaning away from the page, recalling scenes from "I'm A Celebrity". This repulsion is a learnt psychological aversion, which can easily be overcome by getting people to taste a delicious, highly nutritious food, which happens to be made using crickets. The positive experience rapidly overwhelms the immediate knee jerk resistance. Forty years ago the thought of eating raw fish turned the stomachs of most westerners, but today there are packs of sushi in every garage forecourt and a YO! Sushi on most high streets. Apart from a few novelty foods like insect lollipops, the majority of the effort to use insect protein focuses on disguising the 'insect character' within easily recognisable foods, like burger patties and protein bars. Here the challenge lies with chefs and food technologists to develop appealing, tasty dishes, and with psychologists, advertisers and marketers to make entomophagy acceptable to the general public.

With this in mind I am currently leading a project at Monkfield Nutrition to prepare the company to diversify production and enter the edible insects market. Working with food technologists, and researchers at the University of Nottingham, we have assessed the suitability of different insect species for use in food, based on taste, ease of processing and production cost. Having assessed the various different processes, from slaughter and cleaning to washing, drying and milling the insects, we have chosen a production system which will allow us to manufacture high quality insect powders which can be incorporated into foods. We are now upscaling these processes for application at an industrial scale and will be placing products on the market in the summer of 2018.

## Insects as Feed

If the idea of eating insects really doesn't whet your appetite then how would you feel about your food eating them? Insects are a more natural part of a British chicken's diet than some of the ingredients currently used, such as Chilean fish meal or soybeans grown in what was once the Amazon rainforest. Spiraling cost of these protein sources is driving a demand to develop suitable alternatives for animal feed in order to improve protein security in Europe. Insects offer just such an opportunity. Species suitable for use for animal feeds are also very efficient, but are considered unsuitable for human consumption for various reasons, including their general unpalatability. It is unsurprisingly difficult to persuade people to eat cockroaches or maggots, regardless of their benefits!

In May 2017 BSE era laws, which prevent livestock being fed animal proteins, were amended to allow the use of insects in aquaculture. With further developments anticipated to follow regarding the use of insects in other livestock feeds, it appears that the

market for insects as animal feed is primed for very rapid expansion. Insects suitable for use as animal feeds, such as the house fly and black soldier fly, offer an efficient way to recapture nitrogen, phosphorous, potassium, carbon and energy which would otherwise be lost from the 1.3 billion tons of food waste produced annually. This is approximately one third of global annual food production, with a value of US$750 billion. If this waste could be recycled it would be establishing a circular rather than linear food economy which would mirror natural cycles where almost nothing is wasted.

### Developing the Industry

I started working at Monkfield Nutrition in February 2016, on an Innovate UK Knowledge Transfer Partnership with the University of Nottingham. The University has a wealth of experience and expertise in animal breeding, genetics, husbandry, nutrition and veterinary science, a set of talents which has allowed massive improvements in the productivity of traditional livestock. Under optimal conditions a broiler chicken in 1985 could reach 1.40kg in 35 days using 3.22 kg of feed, but by 2000, broilers could reach 2.44kg on 3.66 kg of feed in the same amount of time. By drawing on the University's resources, this project aims to begin replicating the improvements in production efficiency seen in traditional agriculture to the insect farming industry. If we are successful, and learn from the mistakes which have led to past ethical and disease crises, there is great potential for rapid improvement.

A great proportion of the improvements made in traditional livestock, as demonstrated in the poultry industry, is due to the genetic improvement of livestock through selective breeding programmes. Although Monkfield Nutrition has been rearing insects for more than 25 years, these insects are essentially wild animals. It is now very exciting to see researchers and companies working on selective breeding of improved insect varieties.

My current research focusses on nutrition: what can we feed the insects? Specifically, fresh brassicas made up a large proportion of our crickets' and locusts' diets: cabbage, kale or savoy were consumed by the tonne. I began by exploring cheaper alternatives such as lettuce, beet, celery and wheat. Unfortunately these crops had many of the same inherent issues as brassicas: seasonal variability in supply and differing nutrition between varieties affected insect growth and moisture introduced by the plants makes humidity control difficult and can cause moulds to establish within the cultures. These alternatives also imported new issues: beet and lettuce's delicate leaves quickly wilt and degrade in the high temperatures making a dense slush which encourages mould, while wheat provided insufficient nutrition. It turns out that the brassicas, with their waxy leaves, are best able to retain structural integrity in the insect rearing environment while providing suitable nutrition. Unable to find viable alternatives I turned my focus to assessing the nutritional composition of the insects' diets. After investigating a number of avenues I have identified nutrients which can be added to the dry feed, completely eliminating vegetables in three of our insect's diets. What are they? At the moment I am unable to tell you, but watch this space.

## Challenges to Insect Farming

My research is yielding significant insights but despite entomology's rich history of research, from pest control to ecosystem service provision and conservation, I have encountered the important fact that mass rearing of insects is a relatively new and underdeveloped research area and we are still establishing first principles. One example of where this lack of knowledge is impinging on the development of insects as food and feed is in the use of low-quality waste streams such as byproducts from the food and drink industry in their feed. This is an area where integrating insects into the human food chain has huge potential benefits. However, research using crickets to recycle these products has not yet been able to achieve consistent results. Given our lack of basic knowledge on the nutritional requirements of these insects, is it all that surprising that poor results were obtained? Therefore I am currently working to identify the nutritional requirements of the insects, laying down the groundwork to allow better tailoring of experimental diets to meet the insects' needs in future research.

Rearing any species in captivity has the potential to cause inbreeding depression. There is currently no indication that inbreeding depression is occurring and this is almost certainly due to the fact that within a cubic metre of an insect rearing culture you can house thousands of adult insects maintaining a large and diverse genepool. That's not to say inbreeding depression will not develop and the industry as a whole needs to begin monitoring stocks for this.

High densities of animals provide the opportunity for diseases to develop. Unfortunately this has already happened in *Acheta domesticus*, a highly productive cricket species favoured for human food applications in many parts of the world. In the 1970s a highly contagious and lethal densovirus appeared in commercial stocks causing periodic catastrophic crashes in the subsequent decades and which still makes rearing this species tricky today. We have a responsibility to both the animals in our care and wild populations, which may be susceptible to these emergent diseases, to develop a veterinary industry linked to insect farming.

## Conclusion

I know that entomophagy is very much in vogue at the moment while large scale acceptance and deployment feels a long way off. However, I genuinely believe that industrial insect farming has the potential to increase future global food security, I wouldn't be working here if I didn't. Although there is a very long way to go to realise this, requiring work across a wide range of disciplines, that is exactly what makes this such an exciting and invigorating time: there is so much space to work in!

Combining the wealth of experience Monkfield Nutrition has gained from operating an insect farm for over 25 years, with the opportunity for expansion afforded by the move to a new, highly efficient facility, means that the company is poised to take full advantage of the current interest in entomophagy. This makes it a very exciting and stimulating time to be working on the farm. Furthermore, with NASA considering insects as suitable extra-terrestrial livestock for future missions for the exact same reasons which make them a fantastically sustainable food source on Earth, then the stars really are the limit.

# *Saga pedo* (Orthoptera, Tettigoniidae) outpreys the praying mantis

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I moved to Trieste in the north-east corner of Italy in 2003. In 2006 I moved out of the city to a small village on what is called the 'carso Triestino', or Triestine karst – a thin sliver of land bordered by Slovenia on one side and the northern shores of the Adriatic Sea on the other. Little did I know what entomological wonders were awaiting me.

Perhaps my biggest delight relates to an insect that has intrigued me since I first heard about it. *Saga pedo* (Pallas, 1771) (Orthoptera, Tettigoniidae) is unusual in many ways. First, despite belonging to an order that is predominantly vegetarian, it is a predator. It is also considered to be Europe's longest insect, measuring 15cm from the tips of its thread-like antennae to the point of its sword-like ovipositor (Fig. 1a). All *S. pedo* individuals possess an ovipositor. In other words, it exists only as females that reproduce parthenogenetically. Males have been reported, but definitive evidence of their true identity is lacking (Van Helsdingen *et al.*, 1996).

It seems as though *S. pedo* was revered by Bronze Age people. A small, bronze statuette was found on Sardinia in 1873 (La Greca, 1996) that appears to represent this remarkable insect. Unfortunately, the original effigy has gone missing, but one can get an idea of what it looked like from La Greca (1996), or from the banner of the website of the Forum Entomologi Italiani (www.entomologiitaliani.net), which uses an image of the statuette as its 'logo'.

*Saga pedo* has a wide distribution – from the Iberian peninsula in the west to Kazakhstan and Kyrgyzstan in the east, with Sicily as its southernmost outpost, and reaching as far as Slovakia and Hungary in the north (Krištín and Kaňuch, 2007). Within that range, however, it is scarce, classed as 'vulnerable' by the IUCN on its Red List of Threatened Species (Orthopteroid Specialist Group, 1996). This is particularly due to changes in



Figure 1. (a) Side view of *Saga pedo* individual showing full length of around 15cm, from tips of antennae to end of ovipositor. (b) Frontal view showing spines for gripping prey on inside of forelimbs. The plant is *Eryngium amethystinum*.


Figure 2. Sequence of the attack: (a) The *S. pedo* begins moving towards a green male praying mantis; (b) The male mantis flies up, attracted by a brown female mantis; (c) The *S. pedo* approaches the amorous mantises to within touching distance of her antennae; (d) The *S. pedo* grabs the mantises. At this point the male is still present; (e) The *S. pedo* begins devouring the female mantis, the male having escaped.

land use and the diminishing area of its preferred habitat, unimproved grassland and rough grazing. It is, however, present on Triestine karst (Fontana and Cussigh, 1996). Knowing it is there and finding a specimen, however, are two different things.

I must have almost stepped on the first one I came across. I was out walking and looked back during a conversation with someone behind me. She was about to tread on it. It was there – my first *S. pedo* – sitting, unmoving, in a clump of grass, right on the edge of the path. That must have been September 2008.

The second one I found, another adult, was a year or two later. It too was just sitting, motionless. I took a few photos, carried on with my walk, but returned along the same path about 30 minutes later. It was still there, apparently not having moved a muscle.

This cameo demonstrates perfectly *S. pedo*'s predatory tactics. It sits and waits, somewhat in the style of a praying mantis. Indeed, it even has fierce spines along the inner edge of the tibiae of its forelegs that are used exactly like those on a praying mantis' trigger-fast grasping forelimbs (Fig 1b).

Praying mantises, however, have fairly eclectic tastes in prey, targeting more or less anything that comes within range. *Saga pedo*, in contrast, specialises on crickets and grasshoppers.

On 11 September 2016, on another walk along the lanes and fields behind the house, I got extra lucky. The *Eryngium amethystinum* (Fig 1) were standing proud above the rough sward. I was checking each plant when I saw it – or should I say 'her'? I took my time firing off a series of photos trying not to disturb her too much. She remained stationary. Sitting and waiting. After a few minutes, I moved on, as I had a nearby pond to inspect.

On the way back, I cautiously approached the area where the *E. amethystinum* were growing. There she was, still on the same plant, but having moved a little. In fact, she was moving still – slowly, but with apparent determination – the first time I'd seen one actually move. I got down on my knees and elbows, camera at the ready, and started shooting. Not until I looked through the viewfinder did I notice her intended target – a male praying mantis, *Mantis religiosa* (Fig 2a). At this point I hadn't noticed the third protagonist in the theatre that was unfolding before my eyes. Look again in the top left corner of Fig 2a and you'll see a brown female mantis. Apparently, the male had spotted her and was making his way towards her. Seconds later, he fluttered up to grasp her in a would-be loving embrace (Fig 2b). With the pair of mantises otherwise occupied, the *S. pedo* made her approach. She advanced to within touching distance with her antennae (Fig 2c). and then made a lightening-quick lunge. She grabbed the female mantis while the male managed miraculously to slip free (Fig 2d).

For male praying mantises, as the story goes, mating is often the last thing they do: female mantises turn their heads during the act of copulation and begin eating the males who sacrifice their bodies to help nourish the eggs they are fertilising. This one got lucky and lived to mate another day. The female, however, had no such luck as the *S. pedo* started tucking in to its meal – starting with the head (Fig 2e) and eventually working its way down the body.

Not only did I witness a very rare insect in the act of catching its prey, but the fact that the victim was not the usual orthopteran prey of *S. pedo* made the encounter especially interesting.

I posted a sequence of the attack on the *entomologiitaliani* website, where one of the people posting a comment mentioned that he had fed *M. religiosa* and another, smaller mantis species (*Ameles spallanzania*) to *S. pedo* he had reared[1].

So what happened next? I went back following day to see if I could find my *S. pedo* again. I did find one, but checking closely the photographs and comparing various markings, I concluded that this was a different individual.

A year later, I was back in the field checking again – but without any luck. Indeed, during a second check some time later it was clear that the field had been sprayed with slurry. Everything was coated (it hadn't rained for some time), and there was not much life anywhere. This treatment could be considered disruptive. However, it is worth bearing in mind that one of the conservation issues facing the Triestine karst is 'rewilding'. Many grassy fields are being neglected and bushes and trees are encroaching into open areas. The fact that a farmer was planning, presumably, to take another crop of hay from this field means that future mowing will help maintain the sward – and the habitat for this rare and unique creature.

The fact that *S. pedo* eggs, laid in the ground via that sword-like ovipositor, can often take three or more years to hatch, leaves me optimistic that I will get lucky again and meet more *S. pedo* in the coming years.

[1] http://www.entomologiitaliani.net/public/forum/phpBB3/viewtopic.php?f=122&t=70891

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# Society News



## Council Matters

Council met on the first Wednesday of December, March and May. Council meetings were chaired by the President, Prof. Mike Hassell and held at the Mansion House, St Albans. The December meeting was concerned with initial overviews of the annual reports from the sub-committees, including Meetings, Library and Finance, and a report from the Director of Science, Prof. Hardie, outlining his many activities. The Deputy Registrar and Deputy Chief Executive gave a report on their visit to the Entomological Society of America conference in Denver. Ms Whiteford (Deputy Registrar) commented on the ESA approach to conferences and how they differed from ours; in particular, how they deal with the much larger number of delegates. An advantage of our smaller meetings is that it is easier to network around tea/coffee and lunch breaks. Dr Tilley (Deputy CEO) explained about the Grand Challenges initiative, which has the purpose of addressing the issues of vector-borne diseases, invasive species and sustainable food production. As before, Council voiced their support for this initiative. Mr Willans (RES solicitor) spoke about the Gardens of the Rose, which had now become the Society's sole responsibility following the closure of the Royal National Rose Society. Mr Willans mentioned two parcels of land that the Registrar had the foresight to request pre-emption rights on. This means that the Society has first right of refusal if the land is sold. Council debated the issues about purchasing these pockets of land, as they would strengthen our boundaries and safeguard against inappropriate development. Dr Tilley also mentioned about the location of a borehole on one of the pre-emption plots. The Registrar informed Council that the Society holds the licence for the borehole, should the need arise. Council agreed that the Society should purchase the pre-emption plots and requested that the Registrar and Mr Willans take the matter forward.

The issue of the Rose Gardens continued for the March Council. The Registrar reported on progress with purchase of the two pre-emption plots. There were some hiccups but progress is being made. Prof. Hassell raised the issue of what to do with the gardens once we have completed all necessary legal arrangements and have access. After discussion, Council were unanimous that it should be an 'insect garden'. Prof. Thomas (President-elect) suggested that the Membership be consulted as to the design and nature of such a garden. He agreed to produce a paper on the approach for next Council.

The paper prepared by Prof. Thomas was presented at the May Council meeting. There was some debate about the extent of the 'insect garden'. Council agreed that it should be limited to the former Rose Gardens and that the gardens surrounding the House be maintained as at present. Council agreed to set up a working party to take forward this project with Prof. Thomas as Chair. The Registrar reported that the Society was about to complete on the purchase of the pre-emption plots. Council also considered the sub-committee annual reports and the RES Marsh awards, details of which are on the website. Dr Tilley reported on EntoSci'18, which had been held at Harper Adams and been very successful. This is a conference for students in the 14-18 age bracket, which is a demographic often overlooked in our traditional outreach activities. Dr Murchie reported that his term of office as Honorary Secretary was due to finish at the 2019 AGM. He proposed Dr Jenni Stockan as his successor. Dr Stockan is Honorary Regional Secretary for Scotland and past winner of the Marsh Christian Trust Early Career Entomologist. After a general discussion, Council unanimously agreed that Dr Stockan would make an ideal Honorary Secretary and in accordance with the Bye-Laws Dr Stockan is considered Council's nominated candidate.

# SW Region Report 2016 – 2018

***Peter Smithers***

As it has been a while since I last reported from the SW, I thought an update was in order.

Two years ago I moved from Plymouth to Bristol, so I was concerned that there may be some disruption of SW meetings. As it turns out the reverse has been true.

The annual autumn meeting at Plymouth University continues to run and attract a good audience. This is due to help from my resident colleagues David Bilton and Jane Akerman, who now ensure the smooth running of this meeting. We always have had a good variety of talks which range from hard science to natural history:

**2016**

John Thorpe-Dixon, Plymouth University: *"Biogeography of Water Beetles in the Western Ghats, India"*.

Richard Fox, Head of Recording, Butterfly Conservation: *"The Secret Lives of Butterflies"*.

Dr Rosalind Shaw, University of Exeter: *"Biodiversity and ecosystem services: Beneficial invertebrates in crops"*.

**2017**

Stephen Carol (Buglife): *"A narrow escape – back from the brink of extinction"*.

Catherine Mitson (Buglife): *"Conserving the unknown – The Bog hoverfly on Dartmoor"*.

Katy Potts (NHM): *"An inordinate fondness for Longhorns"*.

This is always a very convivial evening, with entomologists travelling from across Devon to attend. Once the talks are over the audience reconvenes to the local but now legendary Nowhere Inn, just a stone's throw from the university.

Since arriving in Bristol I have set up a spring meeting at Bristol University with the help of Richard Wall. We have had three meetings so far. These have also proven popular, attracting a wide cross-section of the local community.

**2016**

Ulrike Bauer, University of Bristol: *"Friend or Foe? The complicated relationship between insects and carnivorous pitcher plants"*.

Michelle Bales, Buglife: *"Urban Buzz"*.

Gregory Sutton, University of Bristol: *"Gears and springs, lessons in mechanical design from the insect world"*.

**2017**

John Walters: *"Oil Beetles in the SW"*.

Peter Smithers, Plymouth University: *"Invaders from another hemisphere – The natural history of the land hopper* Arcitalitrus dorrieni*"*.

Bryony Sands, University of Bristol: *"Dung beetles in an African agricultural ecosystem"*.

**2018**

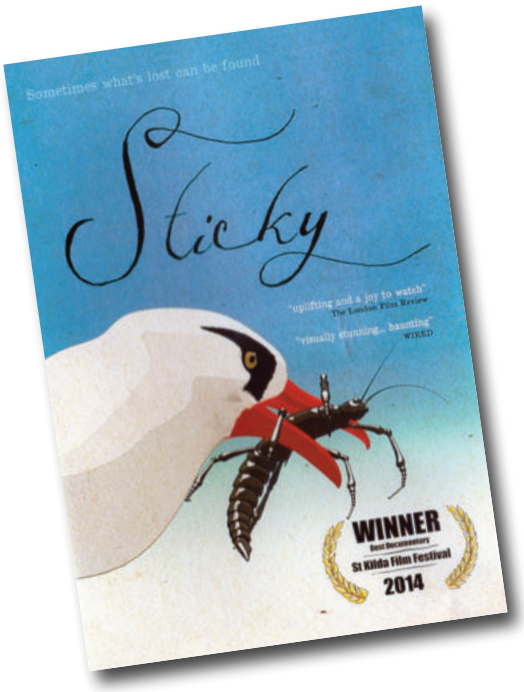
Tim Bray (Bristol Zoo): *"Lazy Lycidae. Tropical forest beetle assemblages and fine scale speciation"*.

Josh Phangurha: *"The biology of spider webs"*.

Lucia Chmurova: *"Farming Lepidoptera in Madagascar"*.

We are also exploring the possibility of a South Wales meeting base at the Pontypridd campus of Cardiff University. Lucia Chmurova and Tim Cockerill are driving this and I look forward to our first South Wales meeting.

Bristol has also offered a number of other opportunities, such as the Bristol Festival of Nature. This is a massive event that takes over the Millennium Square, attracting tens of thousands of people and acts as a showcase for many environmentally-based organisations. The RES had a stand in the Square in 2016, offering a chance to view local insects under a USB microscope, sorting insects into groups based on legs and wings and offering a range of the Society's publications. We then took part in the extended festival in 2017, as it travelled down the River Avon, holding events in both Keynsham and Bath where we reverted to the ever-popular 'Build-A-Bug', which went down a storm. In fact, a storm was a little too literal as halfway through the afternoon at Bath a gust of wind took the RES gazebo and hurled it across the




park, bringing a sudden end to our activities! Up to that point all had been going well.

We have also formed links with Bristol Zoo, which hosted an insect film evening. This was a great success, and we screened the animated film *Sticky* (which had its UK premier at Ento'15) to a packed house. *Sticky* deals with the discovery, loss and rediscovery of the Lord Howe Island stick insect and its subsequent conservation. This was supported by the contemporary film *Last Dream of the Butterflies* and a short animation *Small Talk Diaries* (with kind permission from Ammonite Productions). There are plans to repeat the event this year.

I have also given a number of talks to local groups that include the Bristol Naturalist Society, the Royal Bath Science and Literature Society, plus several 5th & 6th forms at local schools via the organisation Speakers for Schools (set up by Robert Peston). If you wish to gain access to a school audience this organisation is highly recommended.

The most exciting development has been the replication of the Insect Festival that the Society holds biennially in York. As this was such a success, the Outreach group decided to run a second such event in Bristol. The City Museum jumped at the chance to host the event and a September date


Festival of Nature, Bristol.


Festival of Nature, Keynsham.

Insect Festival, Bristol.

was finally agreed. As it was the first time this was to run, we decided to have a one-day event, so the Insect Festival, Bristol (IFB) ran on a Saturday. However, we organised a public talk on the Friday evening in order to kickstart the event. This was given by Dr Tim Cockerill, who talked on the history and biology of the flea circus. All 120 tickets were taken and the audience was treated to Tim's wonderful scientific showmanship as he told the story of his journey from a fascination with fleas to becoming the Professor of Pulicoidea.

The Saturday saw 17 stands in the main atrium of the museum. These ranged from local entomology groups to insect-inspired artists, while at intervals over the day Luke Tilley and I ran a series of bug hunts on a nearby nature reserve (just a 5 minute walk away). The Natural History curators Rhian Rowson and Ray Barnett also offered tours of the insect collections deep in the museum vaults. The day was a great success, with just under 2,000 people coming through the doors. It was agreed that we would repeat the festival, but like the York event it would be a biennial affair.

The SW has now begun to move into the 21st century, with a Facebook page (Bristol Invertebrate Group) and a Twitter account (@InvertsBristol). These are run by Charlotte Chivers from Bristol University, to whom I am extremely grateful.

So, despite the reservations following my move, entomology is alive and well in the SW.

Bristol Inverts

# Changing of the Guard

Professor Chris Thomas FRS, incoming President (left) with Professor Mike Hassell FRS, outgoing President (right), outside the Mansion House on AGM day, 6th June. Presidents are in office for two years.

Professor Thomas signs the Obligations Book at the AGM (possibly for a second time!).

2018 is a significant year in the development of our Society. It's 185 years since the Entomological Society of London was founded, 85 years since we became the Royal Entomological Society and 10 years since the official opening of the new Headquarters at Mansion House. At the AGM on 6th June, Professor Chris Thomas succeeded Professor Mike Hassell as President, and Bill Blakemore, the Registrar and CEO, retired after 19 years' service. Luke Tilley became Chief Executive and Kirsty Whiteford became Registrar.

Bill's largest undertaking by far was the move to St Albans. He not only secured the sale of Queen's Gate at a very satisfactory sum, and the purchase of The Mansion House, but also acted as project manager for the full restoration. More recently Bill oversaw the purchase of the National Rose Gardens and land around them to consolidate our curtilage, as well as a share of Daneway Banks Reserve. Many other notable changes have been supported by Bill's guiding hand. The biennial National Insect Week was introduced in 2004, alternating with the Insect Festival in York in odd-number years since 2007. Bill also oversaw the introduction of the Marsh Awards and we took on the Lesley Goodman Awards from the original trustees in 2004, and the Wigglesworth Medal and Lecture in 2008. The annual Science Meetings began in 1997 but continue to excite UK and international entomologists and led to us hosting the European Congress of Entomology in 2014. The Special Interest Groups continued to grow in number, there are now 23, and Insect Conservation and Diversity was added to the stable of refereed journals. Bill's big talent has been putting the Society on a very sound financial footing and without that none of the above activities could take place. The Society was Bill's baby and at times even appeared more important to him than Aston Villa! So, thank you, Bill, for all you have done for the Society over the last 19 years. We are fortunate that this is only a partial retirement as Bill will continue to sit on, and offer wise counsel to, the Finance committee.

Dr Luke Tilley is the new Chief Executive Officer (formerly Deputy CEO and Director of Outreach and

Outgoing Registrar and Chief Executive of 19 years, Bill Blakemore (centre) with incoming Registrar, Kirsty Whiteford (left) and Chief Executive, Luke Tilley (right).

Bill Blakemore receives his certificate of Honorary Fellowship from Professor Mike Hassell.

Mike Hassell presents Bill Blakemore with a President's Medal for his service to the Society.

Development). Luke grew up in Manchester, Paris and Cheshire. He did his undergraduate degree in the Department of Animal and Plant Sciences at the University of Sheffield, which firmly established his fascination with insect science. His PhD on biological control in protected horticulture was based at the University of York and it was at this stage that his association with the Society began as its Postgraduate Representative and one of the organisers of Insect Festival. After York, Luke worked as a Project Manager at Stockbridge Technology Centre (STC) in North Yorkshire, where he managed projects on crop protection, horticultural biodiversity and education. Alongside his job at STC, he worked within the editorial office of the RES journal *Ecological Entomology*. Before his employment at the Society, he was elected a Fellow and served as a trustee. In 2012, Luke became National Insect Week Coordinator and worked with the media and a wide range of stakeholders. As Chief Executive, Luke works with Council and the Officers to oversee the outward facing profile of the Society, its strategic development and policy implementation. Further, he manages the collaborative relationships, communications and outreach and is line manager for the RES science and outreach staff. He shares his life with wife Jennifer and their two whippets. During free time, he enjoys cookery, music and finding time for as much personal entomology as possible.

Kirsty Whiteford, our new Registrar (formerly Deputy Registrar and Senior Administrator) grew up in St Albans. She was Senior Auditor at a firm of accountants before joining the Society in 2008. Her role is to manage all aspects of RES administration and particularly the Society's finances, over which she has sole charge. She is line manager for all Mansion House staff, supervises the website and pre-authorizes all expense claims besides overseeing the Society's internal accounting and preparing Annual Accounts. Further, she manages the Society's property assets and is responsible for our regulatory compliance, ranging from data to health and safety plus much more. She has two teenage daughters and, if free time becomes available, enjoys reading, walking and going to the cinema, theatre and music concerts.

# Insect Behaviour Special Interest Group Meeting

## Rothamsted Research, Harpenden
## 14th March 2018

*Richard Harrington*

Insect behaviour is, of course, a very broad topic and that was reflected in the wide range of presentations at this exciting meeting. It impinges on pretty much all of entomology as, if we don't understand how insects behave and what influences that behaviour, we can forget about the practical application of entomology to issues such as control and conservation.

Two keynote presentations were followed by eight further talks and a rich crop of posters. Space prohibits a detailed account of each, and I have picked on just a few of my personal fascinating facts (**FF**), pertinent points (**PP**) or quality questions (**QQ**) arising from the presentations and ensuing discussions.

For me as chair of the morning session, introducing the first speaker was a somewhat surreal experience: Professor John Pickett FRS CBE etc. from Cardiff University. Yes, Cardiff University. Most readers will know that John, a pioneer of the fundamentals of insect chemical ecology and its practical application, has been a key player in Rothamsted's science and lore throughout his career. John presented a series of vignettes to explain his views on how we might make use of odour responses in relation to food security and disease control.

**FF:** Waterbuck are not attacked by tsetse. Relevant chemicals have been identified and a "push-pull" strategy is being developed which it is hoped will reduce trypanosome infections in humans.

**PP:** To achieve sustainable food production we must become champions of GM in all its forms.

**QQ:** In evolutionary terms why does *Desmodium* protect maize through producing an odour that deters stemborers?

A few days before the meeting I had watched a programme in Sir David Attenborough's (an Honorary Fellow of the Society) series "Natural Curiosities" on straight-line navigation by dung beetles. Now we could hear it first hand from Marie Dacke (Lund University, Sweden) in the second keynote. With terrific videos of elegant experiments involving mirrors, polarising filters, different spectra and planetariums, she explained the range of cues available to day-active and night-active beetles and how they are used in variable hierarchies according to circumstances.

**FF:** Night-active dung beetles can detect the milky way and use it in navigation.

**FF:** Dung beetles are not scared of elephants, but elephants are scared of dung beetles.

**PP:** Messy or disruptive experiments are easier to do in South Africa, where they "don't worry about things that are not lethal".

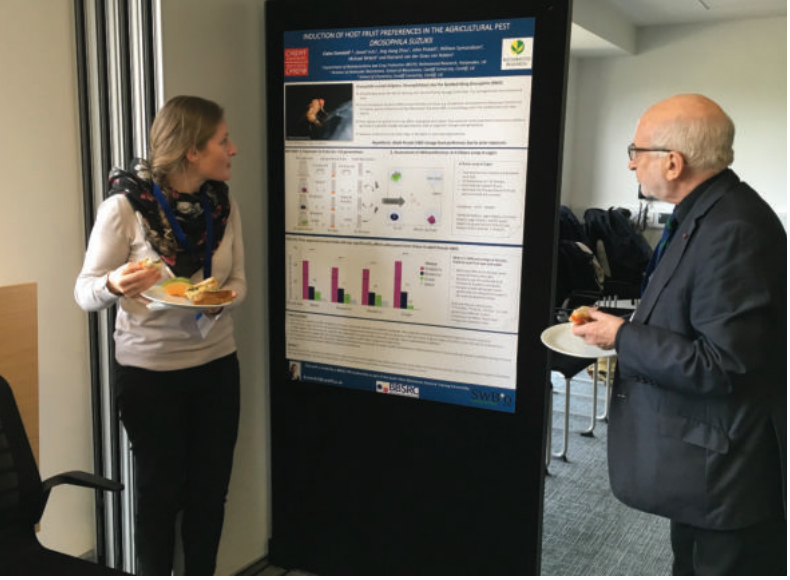
**QQ:** Dung beetles have four eyes. Nobody knows what the ventral ones are for.

Mike Harrap and Clara Montgomery (University of Bristol) and Joe Woodgate (Queen Mary University of London) spoke about behaviour in bees as relevant to pollination. Mike showed features of flowers, used as cues by bees, that are hidden to the human eye but revealed by techniques such scanning electron microscopy and thermal imaging. Clara demonstrated how electrostatic interactions between bees and plants are important in pollination. Joe used harmonic radar to track free-flying bees and show that they learn to fly the shortest distances between pairs of multiple feeders, rather than finding the most efficient route to cover all the feeders. Laura James (Rothamsted Research, and chair of the afternoon session) presented a poster demonstrating the early stages of work to assess the sublethal effects of a range of insecticides on bumblebee mobility, navigation, memory and learning.

**FF:** *Bombus terrestris audax* uses temperature patterns of flowers, as well as texture patterns and humidity gradients to determine good sources of nectar and pollen.

**FF:** Pollen is "sucked" to and from bees as a result of bees having a positive

Elephant and Dung Beetle.




Insect Behaviour SIG

charge and flowers a negative charge. Bees gain this charge whilst flying and are much better at keeping it than are other insects.

**QQ:** How do pollinators respond to the array of signals from flowers and does the hierarchy of cues vary with circumstance?

**QQ:** Can bees learn routes that take into account the volume of nectar as well as its distribution?

Staying with social Hymenoptera, Chris Pull (Royal Holloway, University of London) gave a fascinating account of how ants detect, disinfect and destroy sick individuals and hence prevent pathogens from spreading horizontally and vertically in a densely-packed community with overlapping generations.

**FF:** Lactic acid is used to sterilise infected ants.

**QQ:** Is this metabolically-expensive generalist disinfectant used because it is had already evolved for defence?

**FF:** If pupae are infected with spores, workers bite the pupae out of their cocoons and dismember them. There is a chemical signal for detection of disease.

Coming three days after Mothering Sunday, Jennifer Slater's (James Hutton Institute) talk on how the host choice of mothers influences offspring fitness in multitrophic systems was well timed. In the case of pea and potato aphids and their parasitoids, it was revealed that multitrophic host environments have subtle effects on fitness: wasp fitness differed more when the plant and aphid combinations were changed than when only the plant was changed.

**QQ**: Bigger aphids are more attractive to natural enemies. How does this play out in terms of plant damage, bearing in mind that bigger aphids could cause more damage but are more likely to attract parasitoids?

A range of talks and posters covered behavioural aspects of control of outdoor crop pests. Michelle Fountain (NIAB EMR) gave several examples of the successful application of conservation biocontrol and augmentation biocontrol. Claire Duménil (Rothamsted Research and Cardiff University) showed that spotted-winged drosophila (*Drosophila suzukii*) prefers raspberry, followed by blueberry and grape, the order of preference being maintained irrespective of prior exposure. Kelly Jowett (Rothamsted Research and Reading University) explored methods of enhancing control of pests by carabids at farm scale. Stephanie Schlaeger (Rothamsted Research and Cardiff University) evaluated bioassays testing volatile repellents against whiteflies. Ariane Soares (Federal University of Alagoas, Brazil) investigated the semiochemistry of sexual signalling in a lepidopteran pest (*Anthistarcha binocularis*) of early dwarf cashew with the aim of identifying pheromones that might be used in environmentally-friendly control methods.

**FF:** The serrated ovipositor of the recent UK invader *Drosophila suzukii* allows it to lay in unripe fruit, unlike other drosophilids.

Melissa Minter (University of York) described work done whilst at Rothamsted on the use of flight-mill technology for studying the genetics of insect flight. Eighty-eight studies were reviewed, covering insects from the size of aphids to Monarch butterflies.

**FF:** Some odorant-binding proteins are upregulated during flight.

**QQ:** Could this be because, as well as being important in capturing and transporting odours, they facilitate energy release through lipid mobilisation?

Lisa Reimer (Liverpool School of Tropical Medicine, and convenor of the Medical and Veterinary Entomology SIG) modelled the impact of "behavioural resilience" in *Anopheles farautii* on malaria incidence in Papua New Guinea, and her poster with Katherine Gleave and others showcased work that should ultimately lead to determining how mosquito behaviour is affected by insecticide resistance.

**FF:** After bed nets had been in place for a while, mosquitos changed their behaviour to fly earlier, hence partially avoiding the bed nets and compromising control. The number of bites per person per night rose with time after bed net deployment (600 with no bed nets; 200 after a year of bed nets; 400 after 2 years, 500 after 3 years).

**QQ:** Could this be an artefact of a changing age-structure in mosquito populations, as younger mosquitos tend to feed earlier and hence fare better under a bed net regime?

**PP:** The "protective efficiency" of bed nets is 80% in children under 5 and 33% in adults over 20, reducing to only 32% and 16% respectively as a result of behavioural resilience.

Many thanks to Jason Lim and Jozsef Vuts (Rothamsted Research) for organising an excellent and memorable meeting.

# Interactions of Insects with Microbes: Everything from Symbiosis to Pathogenesis

## Joint meeting of the Endosymbiont and Infection and Immunity Special Interest Groups, University of Liverpool, Wednesday-Thursday 21-22 March 2018

***Stuart Reynolds***

It is increasingly evident that it's a mistake to think that we can understand the biology of insects without taking into account their associated microbiota. It's been known for ages that microbes contribute to the success of insects in no small way through mutualistic associations with beneficial symbionts that enable the exploitation of "difficult" foodstuffs and confer the ability to resist parasites and pathogens; on the other hand other associated microbes are definitely deleterious, often distorting sex ratios of offspring, and potentially capable of driving populations or even whole species to extinction. Only now, however, are we starting to realise that these microbes (viruses, bacteria, Archaea, fungi, etc) are much more diverse than previously thought, that individual insects may harbour several different microbial associates, and that between-microbe interactions are likely to have significant impacts on the outcome of the association for the insect. These associations challenge traditional ideas on what constitutes a symbiosis. Research on insects is at the forefront in developing an understanding of how associated organisms evolve to live together.

So what are the microbes that interact with insects? These much smaller organisms may live externally on the cuticle surface (like the actinomycetes that enable leaf-cutting ants to protect the fungal gardens that they cultivate in their tropical nests from being overrun by the "wrong" kind of fungus), or internally – for example within the insect's gut (like the *Pantoea* spp. bacteria that inhabit special crypts of the midgut in pentatomid bugs) or even trapped in special cells inside the insect's body (like the proteobacteria that are found only in the specialised bacteriomes of *Sitophilus* grain beetles). In both the latter cases, associated microbes enable the insect to live on plants that attempt to deter specialist herbivores by cunningly withholding certain essential micronutrients. The common feature of the biology of these associated microbial species is that they are always (or almost always) found only with their hosts (i.e. they are obligate symbionts) and they are usually transmitted maternally (i.e. by vertical descent), which means these microbes have little opportunity to recombine genetic material during replications, and are thus likely to evolve exceptionally quickly, often through genome reduction.

But of course there is also a spectrum of associations with microbes that can only be described as detrimental to their insect hosts. In some cases, the insect is subject to invasion by frankly pathogenic microbes with lethal potential. Specialist free-living insect pathogens exist among both bacteria (e.g. *B. thuringiensis*) and fungi (e.g. *Metarhizium* spp.), while other insect-pathogenic species have themselves entered into obligatory associations with vector species (e.g. the bacterium *Photorhabdus* is transmitted between insect hosts by heterorhabditid nematodes). But other parasitic microbes "steal" resources from the host, reducing its fitness but not usually killing it, and often persisting within the host for long periods (some parasites of insects, like the mollicute bacteria *Spiroplasma* spp., can be vertically transmitted through many generations). This lack of lethality is evolutionarily interesting in itself. It implies on the one hand that it has not been evolutionarily beneficial to the parasite to acquire (or at least to deploy) lethal force in robbing its host of fitness, and on the other hand that a successful evolutionary response to such parasites has been to tolerate their presence.

Thinking about the immune defences of insects in this way illustrates the difference between resilience (in which a host defends itself directly by attempting to prevent the proliferation of a potential parasite) and tolerance (in which the host attempts to reduce the harm done by the parasite). These two defensive strategies aren't necessarily mutually exclusive, of course. This way of looking at the evolution of antagonistic relations between hosts and parasites has been initiated and developed in recent years by David Schneider and his associates at Stanford University, and it is of increasing interest to those involved in insect-microbe associations.

In fact, when the chips are down, it isn't always easy to distinguish friends and foes. Looking for typical "virulence genes" in the microbe, or checking on the deployment of "immune" genes by the host doesn't necessarily help. In my view, the difference between a parasitic or even a pathogenic interaction on the one hand and a mutualistic association on the other is more to do with how the fitness gains associated with evolution are distributed between the members of these co-evolving communities, than it is about the identities of the genes that evolve as a result of the interaction. Whether they are parasites/pathogens or mutualists, bacteria that are closely associated with insects will always have a strong interest in avoiding the immune responses of their hosts, while host insects will benefit if they are able to identify and regulate the proliferation of "their" bacteria. Moreover, all obligately-associated microbes will tend to lose those parts of their genomes that once conferred benefits during free-living stages of their life-cycles. Degenerate genomes characterise all these microbial groups, whether beneficial or harmful.

So far I have been talking only about bilateral relations between insects and associated microbes. But actually, the interest doesn't end there: because all microbes associated with a particular host effectively occupy the same niche space, we may predict there will be strong interactions between them, and that this is likely to have fitness consequences for the host insect, sometimes favourable, sometimes unfavourable, according to the context in which they occur. The host is not necessarily disinterested in the subdivision of the niche by its various occupants, and how the host's fitness is affected may well depend on which niche occupants are present, and in what order they colonize it. Moreover, environmental conditions (like temperature) may well influence the outcome.

From what has been said so far, it's thus no surprise that insect biologists should be very interested in the interactions of insects and microbes, both from the point of view of understanding how biotic interactions have evolutionary consequences, and also from the standpoint of using that knowledge to applied ends. For example, what if an insect that transmits a human disease could be rendered less effective as a vector by association with another microbe? The present burgeoning of interest in insect-associated microbes stems not only from these intrinsic interests, however, but also from the fact that with DNA sequencing easier and less costly than ever before, it is now much easier to study the microbes that are associated with insects. Since many of the former are "unculturable" on Petri dishes or in test tubes, such technical advances were in fact absolutely essential to permit this area of study to get off the ground at all. Moreover, easy DNA sequencing also allows the study of population structure, epidemiology and phylogeography in ways that were simply impossible before.

With all the above in mind, the Royal Entomological Society recently sponsored two linked day-long meetings on two aspects of insect-microbe interactions as indicated in the title of this article. For most of those attending, the two meetings ran as one. The two days of talks turned out to be a memorable occasion, well-attended with lots of excellent talks, well-constructed posters and thought-provoking discussion. The two SIGs have previously been convened only separately; but this meeting showed that there is a great deal of intellectual shared space between the two overlapping research communities. My guess is that this won't be the last time that meetings of these two SIGs are arranged to occur back-to-back.

As you'd guess, of course, the opportunity to bring the two groups together was seized by **Professor Greg Hurst** and other members of the Evolution, Ecology and Behaviour Section of the Institute of Integrative Biology at the University of Liverpool, in which there is active interest in both of these SIG areas. Of the several people involved in the practical organization of the meeting, two Liverpool PhD students **Joanne Griffin** and **Georgia Drew** deserve special mention. Thanks to them and their colleagues, the meeting ran exceptionally smoothly, and was altogether both an inspiring and a happy experience for everyone.

There were 31 talks on the two days of the meeting (this figure actually excludes a number of "lightning" presentations designed to arouse interest in posters – I particularly enjoyed these talks). Because of the popularity of the occasion, it was necessary to timetable most of the "full" talks as short presentations (a fifteen-minute slot for both talk and questions). But four talks were longer keynote lectures and deserve note.

In Wednesday's first keynote, **Ailsa McClean** (Oxford) discussed variation and specificity in the protective symbionts of aphids, reminding us that the fitness gains (or losses) from particular associated microbes may depend on the ecological circumstances (different host plants make for different outcomes for particular host-symbiont pairings). Later on in the same day, **Martin Kaltenpoth** (Mainz, Germany) gave a wide-ranging lecture in which he talked (among other topics) about symbiont-provided defence in herbivorous beetles of the subfamily Lagriinae associated with bacteria of the genus *Burkholderia* that appear to have evolved from free-living plant pathogens. The bacteria are held in extracellular cuticle-lined chambers and can be transmitted both vertically and horizontally; they appear to be currently undergoing a remarkable genomic evolution, with different clades differing in genome size by a factor of at least four. These microbes produce novel chemicals defending the insects against fungal attack, and may in the long run yield useful new chemicals for plant protection.

On Thursday, **Katherine Roberts** (Exeter) considered in the first keynote how temperature influences the potential for pathogen host-shifts, a topic that was echoed on several occasions by other contributors to the meeting. Katherine examined the case of the *Drosophila* C-virus experimentally using a number of different fruit fly species, exposing them to different temperatures; she concluded that temperature was important not so much in affecting which host species could be used, but that high temperatures did affect the probability of a host-switch occurring. Later on the same day, **Lena Wilfert** (Exeter) was impressive in portraying the evolutionary ecology of multi-host bee pathogens as a man-made epidemic. Her talk focused particularly on the deformed wing virus complex (DWV) and its interaction not only with host honey bees, but also the parasitic mite *Varroa*. Genomic methods to study virus evolution combined with epidemiological data and studies of island populations have yielded an exceptionally interesting picture of how a parasite and a pathogen can simultaneously co-evolve during multiple sequential geographic invasions, with evolutionary changes in virulence following on from this; spill-over of the virus into other pollinators then ensues as domesticated and wild bees interact indirectly on the flowers that they both pollinate. This work has obvious potential for application, but the exceptional complexity of the interactions reminds us that every story of host-parasite evolution may in the end turn out to be different.

All four keynotes were cleverly chosen, with issues raised in them being frequently re-encountered during the meeting: thus, plenty of other talks were concerned with issues of host-specificity and host-switching; with host tolerance *versus* resilience; with the evolutionary consequences of co-occurrence of multiple parasite species in the same host; and with environmental (especially temperature) effects on microbial associations.

The tight scheduling of all other talks required strong speaker self-discipline, which was admirably enforced by the threat of an enforced exit at time-up to the tune of Rimsky-Korsakov's *Flight of the Bumblebee*. With so many talks it's invidious to mention only a few of these presented, but with limitations on space I'll try here to pick out a few of the ones that (for me) achieved particularly high impact.

(a) Maltin Kaltenpoth's excellent keynote lecture; (b) at the poster session; (c ) dinner at Mowgli's restaurant.

Scientifically, the meeting was a reminder that close associations between insects and microbes are manifold and important. Just to give one example of this, **Jane Charlesworth** (Cambridge) was able to remind us of the astonishing fact that in excess of 60% of insect species have been found to be infected with *Wolbachia*, vertically-transmitted intracellular bacteria that frequently distort the sex ratio in their hosts. But what governs which species are affected? Jane's talk set out to test whether there are temperature-related trends in infestation with the sex-ratio-distorting bacteria *Cardinium* and *Wolbachia*. It turns out that although the prevalence of *Cardinium* in Mandibulata is strongly temperature-dependent, there's no such effect in Chelicerata. *Wolbachia* is also more prevalent in Mandibulata at higher temperatures, although this effect is almost all due to its presence in Lepidoptera. What on earth governs effects like this? We don't know; there's a lot to learn.

Previous meetings of these two SIGs have often looked carefully at genes underlying evasion by parasites and pathogens of host immunity, or those responsible for sex-distorting effects. This was true here also, and I'll call

## Full list of presentations

### Insect Symbionts Special Interest Group, Thursday 22nd March 2018

**Protective symbionts in aphids: variation and specificity.**
**Ailsa McLean**, Jan Hrček, Ben Parker and Charles Godfray
Department of Zoology, University of Oxford, UK

**A versatile model of endosymbiosis grounded in multilevel selection and energy flow.**
**Mathé-Hubert H.**, Kaech, H. and Vorburger, C.
Swiss Federal Institute of Aquatic Science and Technology (EAWAG), Dübendorf, Switzerland

**Variation in *Wolbachia* effects on *Aedes* mosquitoes is a key determinant of invasiveness and vectorial capacity.**
**Gabriela Gomes**
School of Tropical Medicine, Liverpool, UK

**Is *Wolbachia* infection influenced by climate? An analysis of global data.**
**Jane Charlesworth**
Department of Genetics, University of Cambridge, UK

**Male-killing toxin produced by a bacterial symbiont.**
**Toshiyuki Harumoto** and Bruno Lemaitre
École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland

***Aphis fabae* pays for protection against parasitoids – but how?**
**Heidi Kaech**
Swiss Federal Institute of Aquatic Science and Technology (EAWAG), Dübendorf, Switzerland

attention to three particularly impressive mechanistic talks. One was by **Toshiyuki Harumoto** (Lausanne, Switzerland) who showed that a vertically transmitted male-killing *Spiroplasma* symbiont associated with *Drosophila* fruit flies interferes with dosage-compensation in the sex chromosome of male embryos, thus inducing apoptosis. The effect appears to be associated with a single gene, whose product acts by an as yet unknown mechanism, perhaps involving the host's ubiquitin system, on the male-specific lethal complex of the unpaired X-chromosome of male embryos. Another talk of this mechanistic kind was given by **William Palmer** (Edinburgh) who reported the isolation from *Drosophila melanogaster* of Kallithea virus, the first DNA virus found in wild populations of flies. Unlike *Drosophila* RNA viruses (but like the pox viruses of birds and mammals), this is a large double-stranded DNA virus, whose genome encodes many genes. By analogy, many of these genes are likely to encode proteins that suppress host immunity. The virus is costly to the host and modulates expression of host genes encoding immune genes of various sorts. There is genetic variance among hosts for virus-induced mortality and viral titre, and candidate host genes that may underlie this variation have been identified. Kallithea looks to be a potentially important model for insect DNA viruses and (like poxviruses) may allow the identification of previously unknown host immune pathways. Another mechanistic talk that I found very interesting was that by **Gianmarco Raddi** (Sanger Institute, Cambridge), who has been using single cell transcriptomics along with cell sorting to catalogue the hemocytes of the malaria mosquito *Anopheles gambiae*. It's evident from his work that there are many more types of hemocyte in this insect than have previously been recognised by simple microscopic inspection. I predict that work of this kind will have important outcomes on our understanding of mosquito immunity and of *Plasmodium* host-parasite interactions.

One talk that I particularly enjoyed was not about insects at all, but about ticks, those blood-sucking ectoparasites of vertebrate animals that so often masquerade as "insects" at meetings like this. This was given by **Alaa Al-Khafaji** (Liverpool) who talked about the vertically transmitted intracellular endosymbiont *Midichloria*, which occupies a highly defined intracellular niche located within the host's own mitochondria. In the UK *Midichloria* is

**Multi-locus sequence typing of the sheep tick *Ixodes ricinus* and its symbiont *Candidatus* Midichloria mitochondrii across Europe reveals evidence of local coevolution in Scotland**
**Alaa M. Al-Khafaji** [1] , Simon R. Clegg [1] , Alice C. Pinder [1] , Kayleigh M. Hansford [2] , Frederik Seelig [3] , Gabriele Margos [3] , Jolyon M. Medlock [2] , Edward J. Feil [3] , Alistair C. Darby [1] , John W. McGarry [1] , Lucy Gilbert [4] , Olivier Plantard [5] , Davide Sassera [6] , Benjamin L. Makepeace [1]
(1) University of Liverpool, Liverpool, UK; (2) Public Health England, Porton Down, UK; (3) University of Bath, Bath, UK; (4) The James Hutton Institute, Aberdeen, UK; (5) ONIRIS, Nantes, France; (6) University of Pavia, Pavia, Italy.

**Antibiotic-producing symbionts in attine ant microbiomes.**
**Tabitha Innocent**[1], Panagiotis Sapountzis[1], Mariya Zhukova[1], Morten Schiøtt[1], Neil Holmes[2], Michael Poulsen[1], Douglas Yu[2], Matthew Hutchings[2], Jacobus J. Boomsma[1]
(1) Centre for Social Evolution, Department of Biology, University of Copenhagen, Denmark (2) School of Biological Science, University of East Anglia, UK

**Symbiont-provided defence and nutrition in herbivorous beetles.**
**Martin Kaltenpoth**
University of Mainz, Germany

**Specificity and stability of the squid-*Vibrio* symbiosis.**
**Natacha Kremer** [1, 2] and Margaret McFall-Ngai [2, 3]
(1) Laboratory of Biometry and Evolutionary Biology, CNRS, University Lyon 1, France.
(2) Medical Microbiology and Immunology, University of Wisconsin-Madison, USA.
(3) Pacific Biosciences Research Center, University of Hawaii at Manoa, Honolulu, USA.

**Environmental sensitivity of symbiont-mediated protection.**
**Greg Hurst**
Institute of Integrative Biology, University of Liverpool

**Investigating the genomic features of a midgut bacterial symbiont of the phytophagous stink bug *Acrosternum arabicum.***
**A.M. Floriano**[1] , M. Kashkouli[2], Y. Fathipour[2], C. Carnevale[1], C. Bandi[3], M. Mehrabadi[2] and D. Sassera[1]
(1) Department of Biology and Biotechnology, University of Pavia, Italy
(2) Department of Entomology, University of Tarbiat Modares, Tehran, Iran
(3) Department of Biosciences, University of Milan, Italy

**Effects of natural temperature regimes on different *Wolbachia* infections in *Ae. aegypti.***
**Maria V. Mancini**, Christie S. Herd, Thomas H. Ant and Steven P. Sinkins
MRC Institute of Infection, Immunity & Inflammation, University of Glasgow, UK

**Tn5 analysis of the insect endosymbiont *Arsenophonus nasoniae.***
**Pol Nadal**
Institute of Integrative Biology, University of Liverpool

**Did the success of leaf-cutting ants depend on the sequential domestication of Mollicute endosymbionts?**
**Panagiotis Sapountzis**, Mariya Zhukova, Jonathan Z. Shik, David R. Nash, Morten Schiøtt and Jacobus J. Boomsma
Centre for Social Evolution, Department of Biology, University of Copenhagen, Denmark

## Infection & Immunity Special Interest Group, Thursday 22nd March 2018

**How does temperature influence the potential for pathogen host shifts?**
**Katherine Roberts** and Ben Longdon
Centre for Ecology & Conservation, University of Exeter, Penryn Campus, Cornwall, UK

**Genomic insights into trans-generational immune priming in *B. terrestris*.**
**Seth Barribeau**
Institute of Integrative Biology, University of Liverpool

found in 100% of female *Ixodes ricinus* ticks (but only 50% of males) but the endosymbiont is lost in lab colonies of ticks. What on earth is going on here? A distribution like this strongly implies that the endosymbiont confers a selective advantage in the wild. But what can the advantage be? Alaa has used MLST (MultiLocus Sequence Typing of housekeeping genes) to examine the population structures of both ticks and *Midichloria* in samples from across the UK and finds that both ticks and endosymbionts from upland sites in Scotland and Wales differ markedly in these DNA markers from those in England. Evidently, genetic exchange between the two clades is limited or non-existent. But how did this separation come about in the first place? Does it represent adaptation to a distinct niche? We don't know. Watch this space!

But as is shown by the full programme, there was much more than this; I am sorry not to mention by name the many other enthusiastic and skilled student and postdoc presenters who gave so many good talks. And yes, I enjoyed those given by older presenters too (like me?) but there just isn't space to do justice to this excellent meeting here.

An innovation (for me anyway) was that considerable effort was put into making the meeting visible on social media. During the two days, more than 100 tweets were made using the hashtag **#insectinfect18**. I have to admit that I'm not yet sure of the value of this mode of communication. I suppose that for the *twitterati* it's useful to know what others in their own locality of the twittersphere think of the meeting; but as long as almost all of the tweets are made only by those actually present, it's hard to know how much additional exposure to the crowd this mode of communication achieves. Nevertheless, I expect to see cultural evolution in action and that there will in future be more and more tweeting from RES meetings.

Being in Liverpool, of course, the occasion was also extremely enjoyable from a cultural point of view. The organisers had arranged for us all to have lunch and dinner together at two local restaurants, *Frederick's* on Hope Street, and *Mowgli* on Water Street, both of which were very good. On Thursday evening after the meeting had ended, many of us just hadn't had enough insect microbiology, and so we all went off to a remarkable pub, the architecturally stunning *Philharmonic Dining Rooms* ("The Phil") at the corner of Hope Street and Hardman Street, a pub which just isn't like anywhere else.

**Comparative genomics of Lyme Disease spirochetes (*Borrelia* spp.).**
**Gabriele Margos**[1], Volker Fingerle[1] and Stuart Reynolds[2]
(1) Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit (LGL), Oberschleissheim, Germany (2) Department of Biology and Biochemistry, University of Bath, UK

***Borrelia bavariensis* – recent switch of tick vector and invasion of Europe.**
**Stuart Reynolds**[1], Volker Fingerle[2] and Gabriele Margos[2]
(1) Department of Biology and Biochemistry, University of Bath, UK
(2) Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit (LGL), Oberschleissheim, Germany

**Infection of *Drosophila melanogaster* with trypanosomatid *Herpetomonas muscarum.***
**Megan A. Sloan**[1], Lihui Wang[1], James Cotton[2] and Petros Ligoxygakis[1]
(1) Department of Biochemistry, University of Oxford, UK
(2) Sanger Institute, Cambridge, UK

**Selection by pathogens increases genetic variation in susceptibility to infectious disease in natural populations.**
**Elizabeth Duxbury**[1], Ben Longdon[2] and Francis Jiggins[1]
(1) University of Cambridge, UK (2) Centre for Ecology & Conservation, University of Exeter, Penryn Campus, Cornwall, UK

**Characterisation of the response of *Galleria mellonella* to the development of invasive aspergillosis.**
**Gerard Sheehan**
Department of Biology, Maynooth University, Ireland

**Understanding the impact of cordycepin on the insect immune system.**
**Victoria Woolley**, Graham Teakle and Dave Chandler
Warwick Crop Centre, University of Warwick, Wellesbourne, UK

**Arthropod cell line resources in the Tick Cell Biobank.**
**Lesley Bell-Sakyi**[1], Alistair Darby[2], Matthew Baylis[3] and Ben Makepeace[1]
(1) Department of Infection Biology, University of Liverpool, UK
(2) Department of Functional and Comparative Genomics, University of Liverpool, UK (3) Department of Epidemiology and Population Health, University of Liverpool, UK

**Immune priming decreases resistance to an early-stage infection.**
**Megan Kutzer**[1] , Joachim Kurtz[2] and Sophie A.O. Armitage[3]
(1) Institute of Science and Technology, Klosterneuburg, Austria; (2) Institut für Evolution und Biodiversität, Universität Münster, Germany; (3) Institute of Biology, Freie Univerisität, Berlin, Germany

**Man-made epidemics: the evolutionary biology of multi-host bee pathogens**
**Lena Wilfert**
Centre for Ecology & Conservation, University of Exeter, Penryn Campus, Cornwall, UK

**The viruses and immunity of *Drosophila suzukii.***
**Nathan Medd**, Jerry Cross, Simon Fellous, Fergal Waldron, Madoka Nakai, Anne Xuereb and Darren Obbard
Ashworth Laboratories, University of Edinburgh, UK

**Induction and inhibition of host immune responses to Kallithea Virus, a natural dsDNA virus of *D. melanogaster.***
**William H Palmer**, Nathan Medd, Gijs Overheul, Ronald Van Rij and Darren J Obbard
Ashworth Laboratories, University of Edinburgh, UK

**An atlas of the mosquito immune system with scRNA-seq.**
**Gianmarco Raddi**[1, 2, 3], Carolina Barillas-Mury[2], Oliver Billker[1]
(1) Wellcome Trust Sanger Institute (WTSI), University of Cambridge, UK
(2) Mosquito Immunity and Vector Competence Section, NIAID, NIH, USA
(3) David Geffen School of Medicine, University of California Los Angeles, USA

**Exploring the genetic basis of resistance to parasitoid wasps in *D. melanogaster.***
**Alexandre Leitão**
Department of Genetics, University of Cambridge, UK

All this reminds us that Liverpool is a city that has invented its own culture, often quite separately from the rest of the UK. Greg Hurst reminded us more than once that we could rely on Liverpudlians to be friendly and helpful. And they were; I really like this city!

Who would have thought only a few years ago that there would be so much cross-talk between entomologists and microbiologists? There were 64 registrations for the Endosymbiont session and 70 for the next day's Infection & Immunity session. 49 delegates attended both parts of the meeting (by my calculation that makes a total of 85 people who were present at some point or other). It was particularly good to see that 13 of these people came from outside of the UK (oh dear, what will happen after Brexit…?). As always with SIG meetings, this meeting was particularly well-attended by research students, who showed just how much it is the twenty-somethings who drive research along.

SIG meetings are (for me anyway) rapidly gaining importance as the key outputs for the research communication mission of the RES. The meeting reported here was a very substantial meeting, involving quite as much scientific content and probably almost as many attendees, as one of the justly famous biennial RES Symposia. Continuing a trend in recent years, it attracted many non-UK participants who were thereby brought into the RES-based community of insect research. The main difference between SIG and Symposium in my view is that whereas RES symposia tend to involve mostly "top-down" transmission of a settled consensus view from a few scientific grandees, the SIG meetings are very much "bottom-up" with lots of talks about research in progress by those hewers at the scientific coal-face, the research students and postdocs. Both approaches to meeting organization are good, of course, but I confess to liking the cheerful camaraderie of the SIG meeting very much!

But the SIG concept also poses an organizational challenge, where (as here) the subject of the meetings is inherently interdisciplinary. I got the impression that rather few of those attending the meeting thought of themselves first and foremost as entomologists; I wonder how many of them will go on to join the Society? And yet, the RES is most definitely important to them in its championship of this particular area of research. Let's see where we go with this over the next few years.

**Gut, not immunity: how insects fight sexually-transmitted infection.**
**Nicholas Priest**
Department of Biology and Biochemistry, University of Bath, UK

## Posters

**Endosymbionts in winter wheat: spiders don't walk alone.**
**Alastair T. Gibbons**
School of Life Sciences, University of Nottingham, UK

**Within-host selection for faster replicating bacterial symbionts.**
**Ewa Chrostek**[1,2] and Luis Teixeira[1,3]
(1) Instituto Gulbenkian de Ciência, Oeiras, Portugal (2) Max Planck Institute for Infection Biology, Berlin, Germany (3) Faculdade de Medicina da Universidade de Lisboa, Portugal

**Isolation and propagation of *Spiroplasma* spp. from European ticks.**
**Lesley Bell-Sakyi**[1], Ana Palomar[2] , Pilar Alberdi[3] and Maria Kazimirova[4]
(1) Department of Infection Biology, University of Liverpool, UK (2) Centre of Rickettsiosis and Arthropod-borne Diseases, Centre for Biomedical Research of La Rioja (CIBIR), Spain (3) SaBio, Instituto de Investigación en Recursos Cinegéticos (IREC), Universidad de Castilla–La Mancha, Spain (4) Institute of Zoology, Slovak Academy of Sciences, Slovakia

**Immune responses of *Leptopilina boulardi* infection in *Drosophila melanogaster.***
**Esref Demir,** Alexandre B. Leitão, Arunkumar Ramesh, and Francis M. Jiggins
Department of Genetics, University of Cambridge, Cambridge, UK

**Examining the outcomes of viral coinfection across a diverse phylogeny of host species.**
**Ryan Imrie**
Centre for Ecology & Conservation, University of Exeter, Penryn Campus, Cornwall, UK

**Using contact networks and next-gen sequencing to understand the community dynamics of the pollinator virome.**
**Vincent Doublet** [1,2], Toby Doyle[2] , Mark J. F. Brown[3] and Lena Wilfert[2]
(1) Institute of Evolutionary Biology, University of Edinburgh, UK; (2) Centre for Ecology & Conservation, University of Exeter, Penryn Campus, Cornwall, UK; (3) School of Biological Sciences, Royal Holloway University of London, Egham, UK

**How does a butterfly embryo cope with immune challenges?**
**Nora Braak**
Oxford Brookes University, Oxford, UK

**Mitochondrial genome effects on humoral and cellular innate immune responses in *Drosophila melanogaster*.**
**Tiina S. Salminen,** Ryan Lucas and Pedro F. Vale
Institute of Evolutionary Biology, University of Edinburgh, UK.

**Characterising the dynamics of the wild *Drosophila* virosphere.**
**Megan Wallace**
Institute of Evolutionary Biology, University of Edinburgh, UK

**Phylogenetic signal and correlations in host susceptibility to different viruses.**
**Camila Souza Beraldo**
Centre for Ecology & Conservation, University of Exeter, Penryn Campus, Cornwall, UK



Left: Lisa Reimer (SIG convener) along with speakers Florian Brod, Karina Mondragon-Shem and George Dimopoulos; Right: Professor Domenico Otranto. Photos by Francisca Sconce

# Medical And Veterinary Entomology Special Interest Group Meeting

## In Conjunction With British Society Of Parasitology Meeting, Aberystwyth, 11th April 2018

***Lisa Reimer***

Research on vector–parasite interactions is crucial for understanding parasite epidemiology, and for the development and deployment of vector control interventions. Not only does infection with a parasite alter a vector's behaviour and physiology, but the vector's environment also shapes its ability to develop and transmit disease. To shed light on this expanding area of research, the Medical and Veterinary Entomology Special Interest Group sponsored a session at the British Society of Parasitology annual meeting in Aberystwyth, 9-11 April 2018. The BSP meeting attracted over 400 delegates from across the globe and it was an excellent opportunity to engage with experts from across the field of parasitology.

The keynote speaker for our session was Professor George Dimopoulos from Johns Hopkins University, Bloomberg School of Public Health, Baltimore. Mosquito larvae ingest microbes from nutrient-rich habitats, and adult mosquitoes take a sip upon emergence. A limited number of these microbes successfully colonise the midgut, and they can have direct and indirect effects on parasite development, for example by stimulating immune activity or with their own anti-microbial properties. His group has isolated and characterised bacteria from wild mosquitoes, and identified microbes present within the midgut that are capable of blocking the development of malaria parasites and the dissemination of dengue virus in their respective vectors. The team has also identified fungi in the midguts of wild *Aedes aegypti* which increase susceptibility to the malaria parasite and dengue virus. Understanding the complex interactions between parasites, vectors and microbiota may lead to the development of novel approaches to block vector-borne disease transmission.

Next up was Dr Florian Brod from the University of Oxford, presenting work from his PhD thesis with supervisors Professor Sumi Biswas and Professor Adrian Hill. He was interested in identifying specific targets used by malaria parasites to escape the midgut, which could possibly be used to block transmission. He utilised an avidity-based (antigen–antibody binding) extracellular interaction screening assay to explore 650 potential interactions between malaria ookinetes and the mosquito midgut. He identified one putative receptor for the well-characterised transmission-blocking antigen Pfs28, which was highly expressed in the midgut. RNAi knockdown of the putative receptor supported the findings that these proteins are necessary for successful midgut invasion.

Karina Mondragon-Shem, a PhD student working with Dr Alvaro Acosta-Serrano at the Liverpool School of Tropical Medicine, presented her work on salivary glycoproteins. Insect salivary components aid blood feeding, elicit immune responses which could affect disease pathology and are necessary for successful pathogen transmission. While salivary proteins have been well studied, less attention has been paid to the sugars that modify the proteins and influence the immunogenicity of saliva. Karina's work focused on the salivary glycome of ticks, tsetse flies, mosquitoes, sand flies and triatomine bugs. Her approach to characterise the glycome of the diverse array of vectors included high performance liquid chromatography with mass spectrometry. She found similarity in sugar structures which suggest a conserved pathway of salivary protein glycosylation.

The Society also had an exhibit stand throughout the meeting and the Garden Entomology booklet that BSP attendees received in their registration packs was a huge hit! The *Medical and Veterinary Entomology* Journal launched a virtual issue on Vector/Parasite Interactions. Journal editor and Head of Veterinary Parasitology at the University of Bari, Professor Domenico Otranto, was a keynote speaker in the session Arthropod Ectoparasites and Vectors.

# Electronic And Computing Technology Special Interest Group Meeting

## The Mansion House, Chiswell Green

### 11th April 2018

*Richard Harrington*

Whilst there is still a place for some "good old-fashioned entomology", pretty much everything we do can be enhanced, and new avenues can be opened-up, by keeping abreast of developments in electronic and computing technology. This SIG, however, aims not only to ask what technology can do for insect science but also what insect science can do for technology. I hear a famous JFK speech coming on.

This excellent meeting was organised by Mark O'Neill, co-founder of Tumbling Dice, a company which makes these objectives its own. Eighteen delegates heard six enlightening and well-presented talks and participated in lively discussion.

Electronic And Computing Technology Special Interest Group Meeting.

Li Yunpeng (University of Oxford) introduced mosquitoes as the most dangerous animals on the planet, killing 725,000 people a year, outdoing deaths at our own hands by 250,000. There are 3,500 mosquito species of which only 40 bite humans and hence can potentially transmit malaria. Current processes for identifying mosquitoes are slow and often bloody or even dangerous, but a project going by the perfect name HumBug (http://humbug.ac.uk) aims to identify species by the buzz of their wings using a simple app "MozzWear" suitable for budget smart phones. The buzz is recorded, its harmonic structure analysed and the insect identified using machine learning approaches. A citizen science project using the Zooniverse platform (http://zooniverse.org/projects/yli/humbug) is helping to gather data, 20,000 records being received from 600 people within two weeks of the launch. The mosquito has to be within about 10-30cm of the phone depending on microphone quality and background noise. The data will be used to map mosquito populations and model their interactions with vegetation and environmental variables. Discussion centred on issues around intraspecific variation and variation within individuals as they age.

Another taxonomically challenging and economically important group, the *Bemisia tabaci* whitefly complex of at least 35 cryptic species, was the subject of Roy Canty's (Natural History Museum, with Norman MacLeod and Andy Polaszek) talk. Ground-breaking morphological software is being trialled on the puparium (4$^{th}$ instar) to resolve the species and hence aid management decisions. A linear discriminant function analysis of pixel brightness in grey scale digital images leads to difference maps which show promise in separating species but a larger training dataset is needed in order to generate a fully validated statistical model.

I'd heard of Procrustes analysis. Indeed, I may even have used it in morphometric analysis of aphids in the dim and distant past. A thought-provoking talk by Neil Thacker (University of Manchester) pointed out some pitfalls of this methodology. These arise from its inability to cope with location error in "semi-landmarks": these are features which are on a shallow curve and hence highly unstable compared to landmarks at a sharply defined and hence easily identifiable locus. Given that Procrustes analysis (often falsely) assumes an isotropic noise distribution, an alternative is needed. A new method "Monte Carlo Evaluation of Estimated Location Uncertainties" transforms the observed noise pattern to make it isotropic and thus amenable to the Procrustes method. Notionally, this transformation is similar to the transformations we make (e.g. logarithmic scaling) prior to the standard statistical analyses that most of us are more used to. The amended method prevents semi-landmarks

Left: Dr Li Yunpeng; Right: Professor Richard Bomphrey.

behaving as outliers and has been used by Neil in applications ranging from medical (e.g. detecting changes in the brain that may be related to dementia) to analysing the surface of Mars. This is complicated stuff (to me, at least). If you want to follow it up, see Ragheb, H. *et al*. (2013) *Frontiers in Zoology* 10: 16.

Understanding the relationship between plants and their pollinators is essential in conservation and crop protection. Sarah Barlow (University of Utah) described the Rana automated monitoring system developed by Tumbling Dice. Cameras trained on individual plants provide condensed footage of pollinator visits, allowing their identification and quantification of behaviour. *Aconitum* is well known for its alkaloid-laden nectar, but why poison your reward? Could it be to deter nectar robbers – those short-tongued bees which cut into the nectaries rather than going via the corolla and collecting pollen in the process? The Rana system found that the behaviour of a pollinator (*Bombus hortorum*) and a robber (*B. terrestris*) were both negatively affected by increasing concentration of alkaloids, but bioassays found the robber to be ten times more sensitive to the alkaloids than was the pollinator. *Astragalus holmgreniorum* is a rare and declining plant endemic to Utah and its pollination is poorly understood. Eleven Rana units were trained on 58 plants for a total of 1351 hours and recorded 840 visits, 67% of them by pollinators and 23% by robbers (a nectar-robbing wasp was found for the first time). Of the pollinators, 79% were bees of the genus *Anthophora*, 11% were hawkmoths and 2% hummingbirds. The work is helping to determine the necessary size and features of a conservation area aimed at saving the plants in the face of surrounding development. For more on Rana see https://en.wikipedia.org/wiki/RanaVision. Sarah also outlined a prototype RFID-tagging system for tracking bumblebees.

The four talks so far have covered the first objective of the SIG: "What can technology do for insect science?". The final two met the obverse objective: bioinspired technology. Richard Bomphrey (Royal Veterinary College, University of London) described the measurement of pressure and acoustic surfaces around the beating wings of mosquitoes and showed changes when close to the ground. These changes might be detectable by mosquito antennae (Johnson's organ) and hence might act as cues to help avoid accidental contact with the ground. By applying a custom-made pressure sensory array to a quadcopter, the behaviour was mimicked in the machine, thus opening up the possibility that the technology might help prevent crashes in drones or helicopters. Fascinating fact 1: when two male mosquitoes fly close to each other, one modulates its acoustics up and one down so that they don't jam each other's signals. Fascinating fact 2: mosquitoes have the lowest wing stroke angle known in an insect: 44 degrees. This is possible because rapid rotations during pronation and supination generate sufficient lift. In addition to lift generated by leading and trailing edge vortices, rotational drag also aids lift in mosquitoes, a mechanism that has never previously been observed.

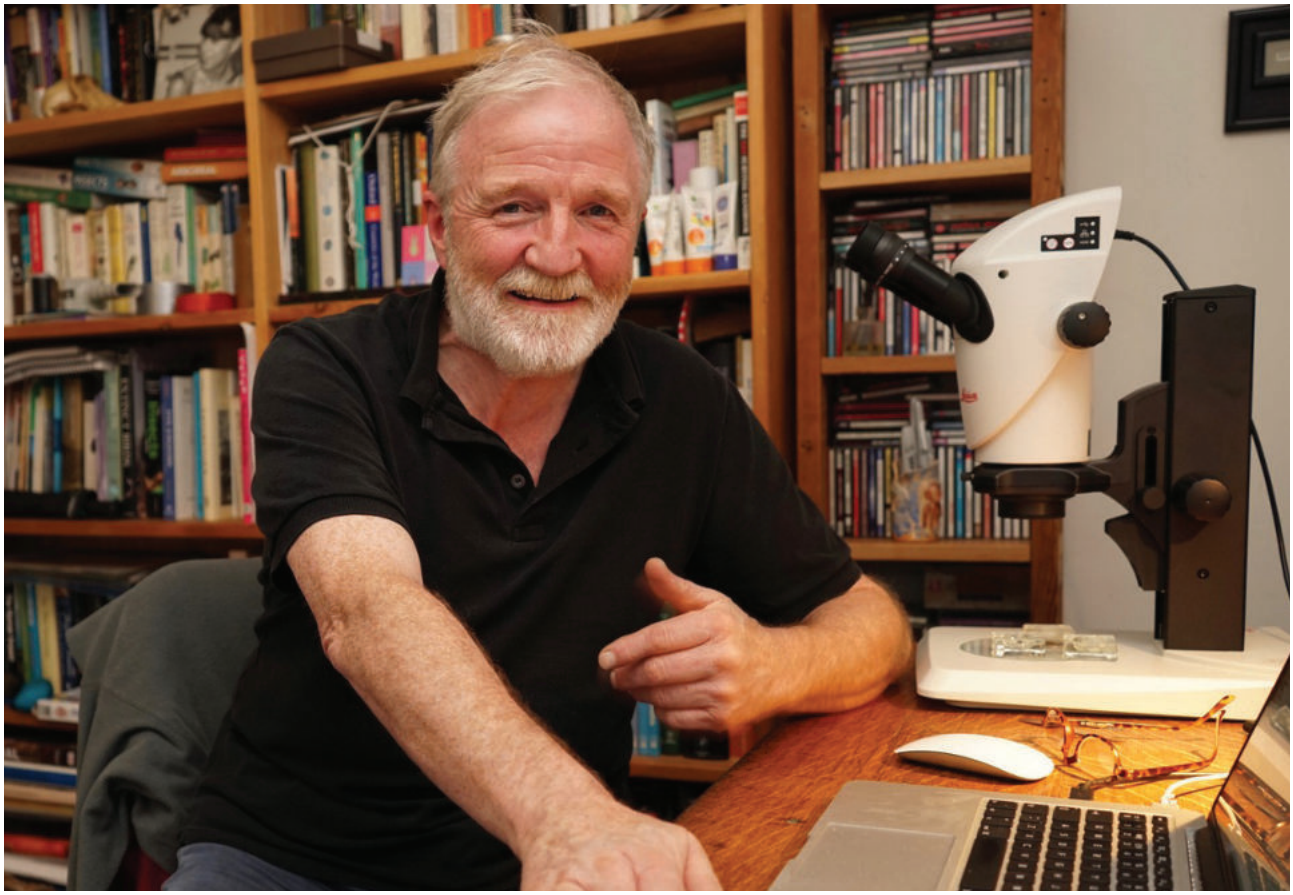
How and why do swarms, herds, flocks and shoals form and behave as they do? Dan Reed (University of Newcastle) used agent-based modelling to show how interaction between predator and prey individuals affects the behaviour of whole systems. Just four rules can generate any kind of aggregation behaviour. Dan studied the salient features of aggregations picked out by predators when selecting prey individuals. As a result of the agent-based modelling, artificial neural network models which act and react like predators were built. These can be used to explore how predator behaviour can influence the evolution of prey aggregations and this might lead, for example, to informing land-based and aerial robots of salient areas which are to be avoided or targeted.

To quote the late and great Steve Jobs, as Mark did at the start of the meeting: "I think that the biggest innovations of the 21st Century will be at the intersection of biology and technology. A new era is beginning." I hope that its aims will always be peaceful.

The abstracts and presentations from this SIG can be viewed via the link at:

https://www.royensoc.co.uk/special-interest-groups/electronic-computing-technology.

# Honorary Fellow Interviews



## George McGavin

### An unexpected journey

***by Peter Smithers***

My train is late, which means I now have only three minutes to cross the vast expanse of Reading station and catch my connection to Ascot. Jogging onto the platform I stop to get my breath and am just in time to see my train snaking out of the station, so I ring George to let him know I am on the next train. When I finally arrive at Ascot, George is waiting, "I am starving" he says, "It's been a long time since breakfast. Let's talk while we eat." We drive to Cafe Fego on the high street and grab a table. George recommends the scrambled eggs; he was not wrong, they were delicious. And so, amid the clamour of a busy lunch time we discuss his life and work.

"I had a stammer from a very early age and it was pretty bad. If someone had come back from the future and said to me at age 14, "you are going to be a lecturer at Oxford University for 25 years and once you have finished with that, you will be a TV presenter", I would have told them not to be ridiculous. Which just goes to show that you never know what is around the corner. As a kid I wanted to understand the world around me, I wanted to know all about plants and animals but quickly found the animals more interesting. On family holidays I would search rock pools, collect plants, bones and skulls and of course insects, making my own nets and other equipment from anything I could find. At school, biology was my best subject and I nearly always won the annual biology prize. I knew more biology than anyone in my class but then when I arrived at Edinburgh University to read Zoology, I realised that everyone there had been the best in their class at school, I was suddenly just another biologist. While I enjoyed my first year it was not until my second that I realised that insects were the most important things on Earth. We were on a field trip to the west of Scotland and the ground was covered in ants which none of my peers appeared to notice. It was then that I realised how fascinating insects were. If you want to understand how the world works you have to understand the role that the insects play. As a biologist if you don't have an appreciation of the insects, you are missing half the picture".

"After graduation the next obvious thing was a PhD. So, one day while walking past the careers office I wandered in to see if anything was going. After a few initial questions the man there said, "Ah hang on a moment I have these two positions for PhD's at the Natural History Museum in London, I'll give them a ring". He picked up the phone and waxed lyrical about the 'brilliant' young man he had in his office and closed the conversation saying, "yes he will be on the train tomorrow".

Jungle moth trapping. Photo: BBC

"What, now hold on" I said, this was all bit sudden!

"Yes" he said, "It's all arranged, your interview is tomorrow afternoon. Take the train in the morning" and so I did. I arrived at the NHM having navigated my way across the city and was interviewed for both posts. One was on ticks and was meticulously planned out, while the other was on plant bugs and was supervised by Sir Richard Southwood, who had a more relaxed approach. Studying mirids, he said, "would be great fun, you will have a lovely time". I was offered both posts but chose the more relaxed and flexible mirid project. On gaining my PhD I was looking for a job and Sir Richard found me a post as research technician at Silwood Park where I worked on a range of projects with Val Brown, Mike Hassell and of course Sir Richard. I was there for five years, but then in 1984 Mike Hassell informed me that the post of Assistant Curator of Entomology at Oxford Museum of Natural History had become available and that he thought I should apply. My application went in and I was invited for interview. I learnt afterwards that there had been 200 applicants so making it to interview was good going. The interview went well, and I left feeling confident but a few weeks later the letter arrived. It informed me extremely politely that I had not been successful. I had been second choice and Malcolm Scoble, who had previous experience of working in a national museum, had been offered the post. I continued in my post at Silwood Park but then as Christmas approached I received a phone call from the Oxford museum "Would [I] be interested in the role of Assistant Curator at Oxford on a temporary basis, for just one year?". I accepted and only later discovered why. The Curator of the Hope Entomological Collections, Martin Birch, had been involved in a very serious car accident and would be off work for at least a year. This meant that Malcolm Scoble had taken on his boss's role, leaving the original post vacant again. Life at the museum was wonderful and I began the long job of rehousing the large number of specimens that were then in temporary store boxes. After a year it was clear that Martin Birch was not going to return and then Malcolm Scoble was head hunted by the NHM in London, so my temporary post became permanent. As Assistant Curator and later, Acting Curator, I wanted to make the entomology collections accessible to whoever wanted to work on them. So, I set about re-organising the collections and the spaces around them to offer more convenient facilities for researchers who would visit the museum and as a result many more people came to work with the collections."

"Outreach became an important part of the curator's role in the 1980s. I have always felt that it's important to fire people up about the natural world. If you don't do this how can we expect to have students applying to study biology at our universities. The Education Dept at the Museum was set up in late 80s employing young people with enthusiasm and the ability to capture the imagination of their audience. Personally, I feel that outreach is very important. You want someone to come along after you have gone, it's vital to inspire the next generation. The great astro-biologist Carl Sagan once said "Not wanting to explain science is perverse. When you are in love you want to tell the world". As an example, back in 2000 I wrote a general book on insects for Dorling Kindersley, '*The DK Handbook of Insects*'. This was a global overview of all of the main orders and selected families of insects illustrated with photographs of a mixture of pinned and live animals. The book was bought by an eight-year-old boy in Athens who wrote to me saying how useful the book was and asking a few questions. Over the next year he wrote with more questions and finally persuaded his mother to bring him to Oxford to meet me. I arranged for him to explore the collections and gave him small tasks to do while he was here. As a result, he went on to take a degree at Imperial College, graduating with a First Class Honours degree and is now about to complete a DPhil at Oxford. He is going to be a much better entomologist than I ever was. So as a result of outreach I have replaced myself with someone better. "That is enough for me. I can go now"."

"My first major interaction with television was '*Life in the Undergrowth*'.

Some of my students were now at the BBC Natural History Unit which resulted in me being asked to be scientific advisor for the series. This entailed checking Sir David Attenborough's scripts for scientific accuracy and transferring them from his typed pages to a word processor. I did not manage to get into the field with Sir David but had established a connection. As a result, when another of my students now working for the BBC Natural History Unit proposed a new kind of natural history documentary they came to Oxford to see if I was interested in being involved. This would be an expedition to South-East Asia shot in real time, no set up shots, just go and see what could be found and record what was encountered and the reaction of the scientists. The programme would have a sense of immediacy and drama that traditional documentaries lacked. The programme would be called *Expedition Borneo* and would run over a week with a new episode each night. The programme was a great success and as a result we then went to Guyana and filmed *The Lost Land of the Jaguar* which also did very well."

"At the end of this series the team met with the president of Guyana, Dr Bharrat Jagdeo, to report our findings and discuss what could be done to conserve his rainforests. He agreed that something had to be done, then surprised us by offering to talk to the UK government to see if they could "work together to identify bold rainforest solutions". Dr Jagdeo had a series of talks with our Prime Minister, then Gordon Brown, who listened politely but felt it was not good fiscal policy. So 'thanks, but no thanks'. Fortunately, Norway stepped in the following year and took up the offer, thus protecting some of the most pristine tracts of rain forest in South America."

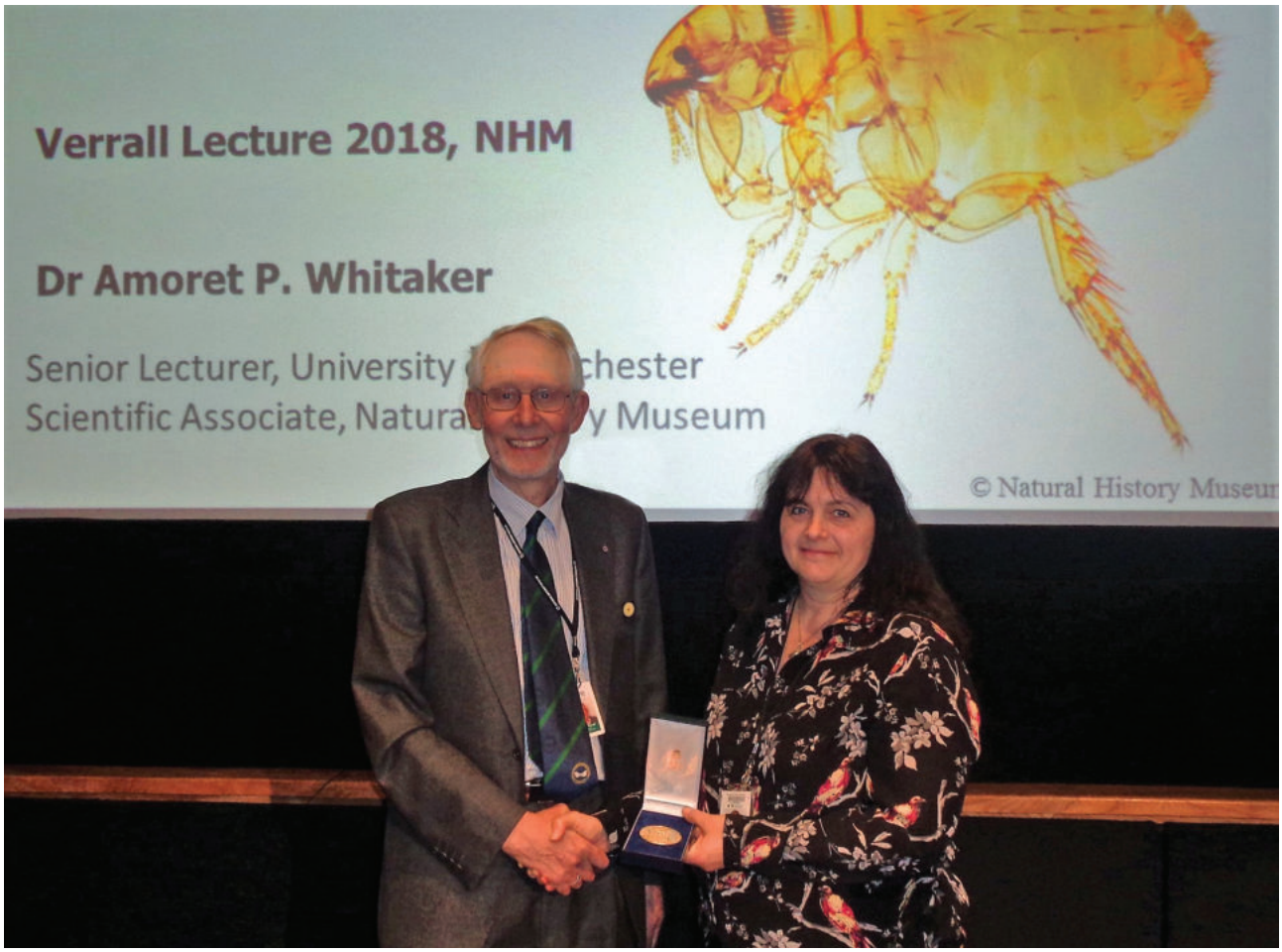
"At that time, I rode my Kawasaki motorcycle between my home in Abingdon and Oxford. It was the only way to beat the Oxford traffic. As I cruised home one Friday night, a thought struck me out of the blue. I had begun to question what I was doing. What did I enjoy doing? The answer was sharing my excitement and enthusiasm for the natural world with an audience. It was also becoming clear that I could not continue to work at the museum and make TV programmes; it was impossible to do both jobs well.

PNG filming and collecting ants. Photo: Tim Fogg

One would have to go. At that time, we were planning the next expedition to Papua New Guinea and *The One Show* had just agreed to produce a series of short films about invertebrates which I would present, so TV was looking attractive. I realised that as a lecturer I could reach a few hundred people at best, while on TV I could potentially reach millions. So, I went home and wrote out my resignation from the museum. I did not tell my wife for six weeks as I was sure she would talk me out of it. Since then I have made many TV programmes which deal with the natural world and I have made nearly a hundred short films for *The One Show*. I can now reach between four and five million viewers for a single programme so the switch from academia has been worth any uncertainty."

"Insects are not doing terribly well; when I was at Oxford we realised that the UK had experienced a 50% decline in abundance over the last 100 years, but recent work on a German nature reserve has shown a 70% decline over the last 30 years and that was in a protected area. When as a boy we drove from Edinburgh to the west coast for our summer holidays, a journey of about 4 hours, the front of the car would be plastered in insects. While now, I can drive a whole summer around the fields in Oxfordshire without having to wash off any insects and this change has happened over just 50 years. The use of agrochemicals and loss of habitat have had an enormous impact on insect populations and this in turn has knock-on effects up the food chain, impacting birds and mammals. We have to change the way we produce our food, focusing on sustainability and stability. The term sustainable growth is frequently used by politicians but it's an oxymoron. In a finite world, continued growth is not sustainable. As a TV presenter I can now make my audience aware of important issues like these and hopefully persuade them to change their behaviours and influence others to do the same."

George is an entomological ambassador at a crucial time, a time when we as humans need to gain a better appreciation of the natural world and alter our behaviour to improve the way we interact with it. As a result of his switch from academia George's wild enthusiasm now filters into living rooms across the land, widening horizons, shifting opinions and altering perceptions. While his films and programmes often have a sense of fun, they are also steeped in hard fact. As George says, "If it's not fun no one is going to pay attention". 'Edutainment' is the new media with which to challenge and alter public perceptions. The regular presence of George's passion and infectious enthusiasm in UK homes will ensure that fresh generations will be inspired to take up the challenge to enhance and protect a world that is becoming increasingly disturbed by human activities.




Dr Amoret Whitaker, 2018 Verrall Lecturer, receiving the RES President's Medal from Prof. Michael Hassell.

# 2018 Verrall Lecture by Dr Amoret Whitaker

***Hon Sec. Archie K. Murchie***

The 2018 Verrall lecture was delivered by Dr Amoret Whitaker and introduced by the RES President Prof. Michael Hassell, and Dr Gavin Broad from the NHM. Amoret is a Senior Lecturer at the University of Winchester whose main interest at the moment is forensic entomology. However, in consultation with a few colleagues she felt that her earlier work on fleas might not put people off their Verrall Supper as much as some of the forensics images. Amoret gave a little background info on herself, including her work at the NHM on tiger beetles (counting hairs) and parasitic Hymenoptera with Prof. Donald Quicke. She was then offered a three-year post writing the RES British Handbook of Fleas and then went on to complete a PhD in forensic entomology, still based at the NHM.

At the moment the NHM central hall is dominated by big, impressive animals. However, Amoret showed a picture from 1927, with lots of insect models in the hall. This was because the Museum had a remit to improve public health. The models on display were wax models of insects and unfortunately haven't survived but Amoret explained that she uses similar models to illustrate fleas to schoolchildren, jokingly telling them that the model is an elephant flea. Fleas are the order Siphonaptera, 'siphon' for pipe and 'aptera' for wingless. The order is most closely related to the true flies or perhaps the scorpion flies, as modern molecular phylogenetics are suggesting. There are comparatively few fossil fleas but their age suggests that they may have been associated with feathered dinosaurs. Amoret gave a typical flea lifecycle. The larvae feed on detritus in the host's nest and have the ability to stay dormant in the pupal stage, which is why if you purchase a vacant house with potential flea problems, Amoret recommends throwing a cat in first. The human flea (*Pulex irritans*) is becoming scarcer as public health measures have improved substantially, although they can also be found on foxes and pigs. A lot of flea species can live on multiple hosts but humans are the only primate that has fleas in the wild as we have a permanent 'nest'. The largest British flea is the mole flea, which can

parasitise one of our smallest mammals, the pygmy shrew. This equates to a size ratio of 1 to 10, equivalent to a human hosting a small litter of puppies.

Fleas have featured in early microscopy. Antoni van Leeuwenhoek studied fleas and produced very accurate drawings but was not particularly enamoured by his subjects. Robert Hooke, on the other hand, expressed more respect for the humble flea. The study of fleas in Britain has been much associated with the Rothschilds. Lionel 'Walter' Rothschild, who established the zoological museum at Tring, started off the Rothschild flea collection. Nathaniel 'Charles' Rothschild published over 150 papers on fleas and discovered the vector of bubonic plague. He did though object to a *Daily Mail* report that claimed he had spent £1000 for a flea specimen. Some curious specimens in the collection originate from Mexico and are termed *Pulgas vestidas*. These are fleas dressed in miniature clothes often depicting bridal couples and are given as wedding gifts. Miriam Rothschild, daughter of Charles, catalogued the Rothschild Collection of fleas (currently being digitised at the NHM) and discovered the link between myxoma virus and the rabbit flea *Spilopsilus cuniculi*. Myxoma virus is carried by the rabbit flea and the breeding cycle of this flea is intricately linked to the breeding cycle of the rabbit host. Feeding fleas take up the oestrogen of the pregnant rabbit, which stimulates the flea to synchronise egg production with the production of rabbit kittens. Miriam also filmed the jump of the flea using time-lapse photography and was the first person to document how fleas jump by the use of resilin in their legs.

Amoret also paid due homage to Bob George, the '*flea man of Bournemouth*', well known to Verrallers through Marris House nets. Bob identified thousands of fleas and produced maps of species' distributions throughout the British Isles. Frans Smit produced the first RES Handbook for the Identification of British fleas, which Amoret in due course updated. This included the addition of six new species, to bring the British list to 62 species, out of a worldwide estimate of 2,500 species.

Amoret went on to discuss the role of fleas in folklore and art. There was a belief, for example, that a fox would rid itself of fleas by holding a piece of wool in its mouth and submerging gradually in a river until all the fleas jumped onto the wool. Fleas are also depicted in Aztec stone sculptures from *c.* 1500 and in many paintings, often with semi-nudes, where the fleas themselves are not shown but rather the activity of flea catching. Queen Christina of Sweden had a flea gun crossbow, although quite how it worked was unclear, whereas there are historical designs for flea traps, which were ornate sticky traps worn as necklaces.

Fleas unfortunately spread a lot of diseases. *Tunga penetrans* known as the chigoe, jigger or sand flea, is an unusual species that burrows into peoples' feet, causing severe pain, itching and infection. Most notoriously bubonic plague, *Yersinia pestis*, is spread by fleas. Plague was originally a disease of rodents in Mongolia and spread to humans through black rats and their fleas. However, a recent 2018 paper suggests that the speed of transmission of the Black Death in medieval Europe models more closely to direct transmission from fleas or lice to humans, missing out the rats.

It is not therefore surprising that fleas have entered common vernacular, often with negative connotation: '*get a flea in your ear*', '*flea pit*', '*flea market*', '*flea bag*', etc. There are also quite a few poems or ditties related to fleas. One of the most quoted is by Augustus de Morgan paraphrasing Jonathan Swift:

*Great fleas have little fleas upon their backs to bite 'em,*

*And little fleas have lesser fleas, and so ad infinitum.*

One curious interaction with fleas is that of the flea circus. These came about originally by watchmakers making fine chains and other delicate artefacts that were so small that they could be manipulated by a flea, thus demonstrating the watchmaker's craft. From this, the flea circus developed into a form of entertainment, with the last permanent one in Manchester during the 1950s. There are also mechanical 'flea circuses', where the viewer is drawn into the illusion of seeing a flea perform through the clever movement of wires, powders and miniature apparatus.

Amoret finished her lecture by talking about the crossover between fleas and forensic entomology. Whilst not common, she mentioned one case where a carpet was suspiciously disposed of. The excuse for doing so was an infestation of fleas. However, when the vacuum cleaner contents were examined, there were a few fleas but not enough to justify an infestation and disposal of the carpet. Using this information, the police were able to question the suspects further and a confession was obtained admitting that the carpet was disposed of because it was blood-stained.

Prof. Hassell thanked Amoret for an entertaining and informative lecture. After a question about anything parasitising fleas, alluding to *little fleas have lesser fleas* (the answer was mites perhaps), Prof. Hassell presented Amoret with the RES President's Medal.


Nick (right) and Liam (left) celebrating the launch of Entocast.

# The Entocast Adventure: Lessons learnt from a year of podcasting

***Nick Howe and Liam Crowley***

*University of Birmingham*

A little over a year ago we found ourselves sitting one lunch-time, talking about honeybee sex. After an excitable discussion it suddenly dawned on us how bizarre this, and indeed most of our lunch-time conversations, were. So, what are entomologists to do when they find themselves talking about insects all the time? Get a new hobby? Certainly not! It seemed clear to us that the only rational course of action was to talk about insects with even more people. And that, in a nutshell, was how Entocast was born.

So, what is Entocast, and what are we hoping to achieve? Entocast is a podcast all about insects and the wonderful world of entomology, aimed at not only entomologists, but anyone with an interest in insects and the people who study, love (and sometimes loathe) them.

Podcasting began as a niche movement in the mid-noughties and is essentially recorded radio where audio is broadcast over the internet using 'RSS' web syndication. The key difference? You can download the programme and listen at your convenience. Ten or so years later, with advances in mobile phone technology, podcasts have millions of listeners! With the movement of audio entertainment onto the internet, it's meant that any Tom, Dick or Harry with an internet connection can make a podcast and send it out into the world - which is exactly what we did last year, launching '*Entocast: an insect podcast*'.

With a grant from the Royal Entomological Society, we bought some microphones and eagerly began recording in an echoey room. The idea was that we could spread our passion for entomology and create a repository for cool, and potentially useful, information about insects. In essence, we wanted to utilise podcasting as a tool for public engagement.

One year on we have recorded, edited and released 15 episodes (plus some bonus episodes) ranging from our own 'Insect Oscars' to spooky insect horror stories. We have also attempted to tackle some of the most common entomology questions such as 'What is the point of wasps?' and 'Where do insects go in the winter?' through interviews with entomologists. But what have we learnt during our Entocast journey so far?

## Engagement is hard to measure

Public engagement has always been something that has hugely interested us both, but in our previous experiences it was difficult to tell if we had actually 'engaged'. The beauty of making something like a podcast for public engagement is that we can get solid measurements on factors such as downloads, comments and subscribers. Whilst not perfect, some of the metrics associated with podcasting can give us an idea of how well we are engaging with our audience; importantly, we can see if we're on a trend to increasing downloads or subscribers and we can see what works well and what doesn't.

## Podcasting is an interactive medium

Podcasting can be a more interactive form of media than traditional forms such as radio. Comments and reviews from listeners will help us find out what people are interested in listening to. The entomology community is quite social media savvy, so we're able to interact with our listeners and interviewees over things like Twitter, which again helps us discover how best to make the show. This feedback loop


Left: Liam discussing Entocast with someone at the Bristol Insect Festival; Right: Liam representing Entocast at EntoSci 2018.

is something that we feel is very important to make useful material to engage with the public. For example, one of the major reasons people have told us that they like listening to the show is that it's fun, we don't take ourselves too seriously and we think that the laid-back nature of the show makes it more approachable. Whilst this might not be everyone's cup of tea, we have also learnt another important lesson: you can't please everyone!

### It's unpredictable

We've also learnt that making media can be very unpredictable, you never can quite tell what will take off and what won't. For example, the episodes which we have most enjoyed making don't necessarily have the highest number of downloads. In this field you have to be adaptable, as you can never tell what works and what doesn't until you put it out there. We are also beginning to get a better understanding of who our audience is, and that shows us what they might like listening to. Our audience seems to prefer interviews with entomologists rather than just us talking (unless it's about bees!), so this is something we're looking to include more in the future.

### It's hard work...

Given the relatively novel nature of this venture we were not sure what exactly to expect. One of the biggest surprises was exactly how much time it would end up taking. Recording the episodes themselves isn't overly time-consuming: after all, the length of the episode is as long as the time it takes to record it. What is less apparent is the time taken researching the subject beforehand (yes, believe it or not we do try to research what we're talking about) and the time required to edit the piece into the final format. We quickly find we become sick of hearing an episode after listening to it again and again during the editing process, and even the funniest insect joke grows tiresome on the twentieth time of hearing it!

### But worth it!

In the first year we've been working on Entocast we have achieved 358 downloads, on average, per month. We've also had over a thousand unique visitors to our website. Does this mean that we've convinced thousands of people that entomology is awesome? Possibly not, but we are growing our audience and we're honing our craft in podcasting. The episodes now require much less editing than they did initially, much less trailing off into nowhere.

On a personal level, Entocast has really enhanced our skills and confidence in many areas. For example, our interviews have been a fantastic opportunity to network with a whole range of fascinating people and allowed us to become more confident and efficient interviewers. We have even been recognised as '*the Entocast guys*'! Moreover, we have found the entomological community such a giving and willing one: if we weren't in love with the community before then we certainly are now.

So what next? Well, focusing on creating better quality podcasts is our priority, which we hope may also help to attract a bigger audience. With an increasing audience for our podcasts, we're hoping to move forward and make all sorts of media for the public interested in entomology, such as infographics, videos and blog posts. We also aim to continue addressing some of the most frequently asked questions in entomology with our end goal being for Entocast to become a one-stop shop for information about insects and the science of entomology. The recent successes of outreach such as *"Entomology Uncensored"* has shown that there is a desire from the public for factual insect information, it just needs to be packaged in the right way.

The biggest thing about podcasting, for us, is that you get to talk about something you love and pass on that passion to others, and in this way find an increased love of your hobby and your craft. What better way to spend your spare time?

If you're interested in hearing more about Entocast find us at:

www.entocast.com

or search for 'Entocast' on any podcast provider.

# Wallace Award 2017

2017 was a bumper year for applications for the RES's Wallace Award, with submissions nudging double-figures. This award is intended "For post-graduates who have been awarded a PhD, and whose work is considered by their supervisory team to be outstanding", and all applications ably met these criteria. After much deliberation, three finalists were selected to submit their theses in full and present their work at Mansion House in March 2018 before a panel of judges. Dr Charlotte H. C. Rowley, Dr Ailie Robinson and Dr Callum J. Macgregor all deserve significant credit for delivering excellent presentations and discussions around their topics, accompanied by equally impressive theses. Selecting an overall winner was a difficult task, requiring much debate and several cups of coffee, though by the end of the day members of the panel were all in agreement that the 2017 award go to Dr Callum J. Macgregor for his thesis entitled 'The role of moths as pollinators, and the effects of environmental change'. Our congratulations go to Callum, as well as to our two runners-up. Summaries of all three finalists' work are provided below.

Dave George (on behalf of the 2017 judging panel)

## FINALIST AND OVERALL WINNER:

### The role of moths as pollinators, and the effects of environmental change

***Dr Callum J. Macgregor***

Newcastle University

Supervisor: Dr Darren Evans

Pollination is important: a global assessment of pollinators and their contribution to food production recently formed the first output of the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES). An estimated 87.5% of plant species, and some 35% of global crop production, depend on pollination by animals (especially insects). The scientific study of pollination is generally well-developed, but the field has focused almost exclusively on diurnal pollinators, especially bees. By contrast, there has been very little study of nocturnal pollinators, which are largely moths. This is probably for practical reasons: it is hard to observe pollinator behaviour in the dark! As a consequence, the contribution of moths to pollination services is generally assumed to be minor, but there is little understanding of their place in pollination systems.

Throughout my thesis, I presented evidence that the role of moths as pollinators, both in the UK and globally, may be much greater than previously believed. On a global scale, I summarised the scattered existing knowledge, identifying 168 studies published in the scientific literature that described moths acting as pollinators. I highlighted the high diversity of interactions documented in these studies, with plants of 75 families pollinated by moths of 21 families. This was supported by the findings of my experimental work in the UK and Portugal. I used a range of methods to identify pollen, carried on the mouthparts of moths, of a range of plant species that were not previously known to interact with moths. This included some commercially-valuable crop species or their close relatives, suggesting for the first time that pollination by moths could perhaps be an economically-valuable 'ecosystem service'. Pollen carried by Portuguese moths represented some 83% of all flowering plants present at the study site.

However, pollination biologists do not simply quantify pollination interactions between communities of plants and their animal pollinators: they also try to understand the ways in which these interactions change under the influence of a changing environment. I investigated how two types of human-caused environmental change that may be particularly important to moths affect nocturnal pollen transport. I provided the first evidence that artificial light at night can directly impact nocturnal pollination interactions. I also showed that the effects of environmental change on nocturnal pollination cannot be assumed to be the same as the effects on diurnal pollination: wildfire had different effects on moth–plant pollination interactions compared to its comparatively well-understood effects on pollination by bees. My work was referred to by the recent IPBES report on pollination, evidencing that environmental change issues that might affect moths (e.g. artificial light at night and climate change) could therefore pose a threat to pollination services.

For every question my work answered, it raised several more. Very little is currently known about nocturnal pollination by moths. By unveiling the diversity of nocturnal moth–plant interactions, and the unexpected effects of a changing environment, I have revealed the potential for this area to form an exciting new branch of pollination biology.

## FINALIST:

### Aspects of the biology and ecology of saddle gall midge (*Haplodiplosis marginata*)

***Dr Charlotte H. C. Rowley***

Harper Adams University

Supervisor: Dr Tom Pope

Saddle gall midge (*Haplodiplosis marginata*) is a sporadic pest of cereals across Europe. This univoltine insect has a phytophagous larval stage that feeds on the stems of wheat and barley, causing the formation of saddle-shaped depressions (galls). This damage can result in yield losses due to underdeveloped grains, stem breakage or secondary infections.

The sporadic nature of saddle gall midge has meant that research into this pest has been, much like the outbreaks, patchy and intermittent, meaning that there is no cohesive strategy towards the management of this pest. This thesis therefore begins with a review of the existing literature on *H. marginata*, drawing together information from past studies done over many decades in several countries across Europe. Some of this information was previously unavailable in electronic format or required translation, making the consolidation of these studies an important part of increasing the availability of research and enabling easier identification of knowledge gaps (Rowley *et al.*, 2016).

One example is the lack of information surrounding the developmental biology of *H. marginata* resulting in an inability to predict when adult emergence will occur. In this thesis, the effect of soil temperatures and rainfall on *H. marginata* development are studied as a means of forecasting adult emergence. These data are then used to develop degree-day based models which can be used to predict the start of, or peaks in, *H. marginata* emergence as an early warning system for farmers (Rowley *et al.*, 2017a).

The next part of this thesis addresses the need to improve existing options for monitoring by investigating the chemical ecology of *H. marginata*. Electroantennography coupled to gas chromatography is used to record the male response to the female-produced sex pheromone and field experiments are used to determine the optimum formulation for a pheromone lure (Rowley *et al.*, 2017b). This lure is then tested in further field situations to define the optimal trap position to maximise catch rate (Rowley *et al.*, 2018, lure commercially available through Agralan). Such experiments give further insight into behavioural aspects of this insect as well as offering valuable monitoring solutions for farmers.

The natural enemies of *H. marginata* are another understudied area of research which the final section of this thesis attempts to improve upon through the development of a PCR-based assay for gut analysis of arthropod predators. Use of this assay in field trials demonstrates potential for the role of beneficial insects in the management of this pest through the identification of four carabid species that naturally predate *H. marginata* (Rowley et al., 2017c).

Finally, a summary chapter discusses how this thesis can be used in further research towards integrated pest management solutions for this insect. This thesis provides new information on *H. marginata* and tools for future research that are not only of practical benefit to the agricultural industry but are also relevant to the wider field of Cecidomyiidae research, which comprises a number of economically-important insects.

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Rowley, C., Pope, T.W., Cherrill, A., Leather, S.R., Fernández-Grandon, G.M. & Hall, D.R. (2017b) Development and optimisation of a sex pheromone lure for monitoring populations of saddle gall midge, *Haplodiplosis marginata*. *Entomologia Experimentalis et Applicata*, **163**, 82–92.

Rowley, C., Cherrill, A.J., Leather, S.R., McCormack, A.W., Skarp, J.E. & Pope, T.W. (2017c) PCR-based gut content analysis to identify arthropod predators of *Haplodiplosis marginata*. *Biological Control*, **115**, 112–118.

Rowley, C., Cherrill, A.J., Leather, S.R., Hall, D.R. & Pope, T.W. (2018) Factors affecting trap catch in pheromone-based monitoring of saddle gall midge *Haplodiplosis marginata* (Diptera: Cecidomyiidae). *Pest Management Science*, **74**, 406–412.


## FINALIST:

### An investigation into the effects of Plasmodium parasite infection on the human odour profile


***Dr Ailie Robinson***

London School of Hygiene & Tropical Medicine

Supervisor: Dr James Logan


Olfaction, or smell, is the primary sense used by insects to navigate their world. For many years, scientists have studied how blood-feeding insects use the smell of their hosts to locate their next blood-meal. Human odour is composed of a blend of chemical compounds, and we now know that certain compounds within that blend are very important to this host-seeking process: some are highly attractive, while others are repellent. Understanding and deciphering these cues can allow us to combat insect biting, or develop novel tools for monitoring or controlling insect populations.

The chemical cues that are used in host-seeking by the malaria mosquitoes, *Anopheles* species, have long been under scrutiny, because of the great burden caused by this disease worldwide. Around half a million people die from this disease every year. However, there is considerable evidence that when people are sick with some diseases their smell ('odour profile') is changed by the disease. Previously, no investigators had examined if such a change occurs in malaria patients, and whether that change could influence the mosquito response to their odour – their 'attractiveness'. This hypothesis is further supported when considering the benefit to the parasite of such a change: the lifecycle of the malaria parasite

involves two hosts, with different stages of the parasite existing and passing between a vertebrate host (e.g. humans) and the mosquito 'vector'. If some characteristic of the vertebrate host was changed in a way that made them more attractive to mosquitoes, the parasite would be more likely to complete its lifecycle. This is an example of parasite manipulation.

In this thesis, the odour profile of people who were infected with malaria parasites was sampled, and the odour composition was compared with that of individuals who were uninfected. This study was conducted for both individuals who had been experimentally infected with malaria, and those who harboured the disease naturally. For the first time, the response of *Anopheles gambiae* mosquitoes (the most important mosquito vector in sub-Saharan Africa) to odour samples from these groups was measured. Electroantennography, a technique that exploits the electrical signal generated when a nerve cell is stimulated in the antenna (the mosquito's 'nose'), was used to determine which compounds in those odour samples were detected by *Anopheles* mosquitoes. This work resulted in the identification of compounds that were both produced in greater amounts by infected people and induced a nervous response in the mosquito antennae.

This thesis therefore contributes a truly novel entomological finding, not only interesting biologically, but possibly with profound implications for human health and disease control – showing for the first time that malaria parasites change how we smell in a way that is detected by mosquitoes. Excitingly, these results paved the way for experiments that demonstrated that a blend of these infection-associated compounds, designed to represent 'infected' human odour, was indeed attractive to *Anopheles* mosquitoes. In the future, these compounds can be used to design attractive 'lures' for use in mosquito traps, or even as the basis of a non-invasive diagnostic tool for the detection of malaria in humans.

## HONORARY FELLOWS OF THE SOCIETY

## (HON. F.R.E.S.)

### as at June 2018

**1986**
Dr W J Knight – UK

**1999**
Professor H F van Emden – UK

**2000**
None

**2001**
Dr G L Bush – US
Professor J Crampton – UK
Professor T Jones – UK
Professor J H Lawton – UK
Professor A Minelli – Italy
Dr P Price – US
Professor G H Rothschild – Australia/UK
Dr G A Vale – Zimbabwe
Professor E O Wilson – US

**2002**
Professor A N Clements – UK

**2003**
None

**2004**
Professor T Lewis – UK
Dr R I Vane-Wright – UK
Professor K G Davey – Canada

**2005**
Mr B Marsh O.B.E. – UK

**2006**
Professor M F Claridge – UK

**2007**
Professor L Riddiford – USA

**2008**
Professor J B Whittaker – UK
Professor G J Goldsworthy – UK
Dr R Wootton – UK

**2009**
Dr R O Clements – UK
Mr J S Badmin – UK
Professor A J Mordue – UK
Dr G R Port – UK

**2010**
Professor C P Haines – UK
Professor J A Pickett – UK
Professor J Hemingway – UK
Professor P S Cranston – Australia
Professor G A Matthews – UK
Mr C P Farrell – UK
Professor D J Bellamy – UK
The Earl of Selborne – UK

**2011**
Professor B S Hansson – Germany
Mr P Smithers – UK

**2012**
Professor M Ashburner – UK
Professor M R Berenbaum – USA
Professor D L Denlinger – USA
Professor J G Hildebrand – USA
Professor J A Hoffmann – France
Dr P A Lawrence – UK
Professor B Lemaitre – Switzerland
Professor G A Parker – UK
Professor N E Pierce – USA
Professor J W Truman – USA
Dr P Barnard – UK

**2013**
Professor S J Simpson – Australia

**2014**
Professor C Wiklund – Sweden
Professor P R Ehrlich – USA
Professor B Hölldobler – USA
Dr R M Pyle – USA
Dr A J A Stewart – UK
Dr R Harrington – UK
Dr G McGavin – UK

**2015**
Professor W S Leal – USA
Professor Z R Khan – Kenya
Dr A D Watt – UK
Professor P Eggleston – UK
Professor S R Leather – UK

**2016**
Professor J K Hill – UK
Professor H D Loxdale – UK
Prof. Dame L Partridge – UK
Professor P G Mulder – USA
Sir Paul M Nurse – UK

**2017**
Sir David Attenborough – UK
Dr R S Key – UK
Mr T J Dillon – UK

**2018**
Mr W H F Blakemore – UK
Professor J Memmott – UK
Professor P Brakefield – UK
Dr T H Jones – UK
Dr H E Roy – UK

## SCHEDULE OF NEW FELLOWS AND MEMBERS

as at 2nd May 2018

New Honorary Fellows
None

New Fellows (1st Announcement)
None

Upgrade to Fellowship (1st Announcement)
None

New Fellows (2nd Announcement and Election)
Professor Laurence Packer (as at 7.3.18)
Dr Jagadish Sanmallappa Bentur (as at 7.3.18)
Professor Guy Smagghe
Professor David Maxwell Suckling
Dr Zhi-Shun Song
Dr Sunday Ekesi
Dr P G Padmaja

Upgrade to Fellowship (2nd Announcement and Election)
None

New Members Admitted
Mr Richard Wilson (as at 7.3.18)
Mr Sebastian Dixon (as at 7.3.18)
Dr Jessica Eleanor Stokes
Dr Adam Frew
Miss Morgan Hughes

New Student Members Admitted
None

Re-Instatements to Fellowship
Mr Martin Rapley

Re-Instatements to Membership
Dr V P Uniyal
Mr Craig Christopher Robert Munns

Re-Instatements to Student Membership
None

Deaths
Dr I J Wyatt, UK, 1959

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## SCHEDULE OF NEW FELLOWS AND MEMBERS

as at 6th June 2018

New Honorary Fellows
None

New Fellows (1st Announcement)
Dr Tariq Ahmad
Dr Camilo Ayra Pardo

Upgrade to Fellowship (1st Announcement)
Dr Nick Littlewood

New Fellows (2nd Announcement and Election)
Mr Vaughan Arthur Turland (as at 2.5.18)
Dr Kuppusamy Sivasankaran (as at 2.5.18)
Dr M Gabriel Paulraj (as at 2.5 18)
Dr Dharam Pal Abrol (as at 2.5.18)
Dr S Maria Packiam (as at 2.5.18)
Dr Sabtharishi Subramanian (as at 2.5.18)

Upgrade to Fellowship (2nd Announcement and Election)
None

New Members Admitted
Mrs M D Sakunthala Janaki (as at 2.5.18)
Mr Ben Martin Keywood (as at 2.5.18)
Mr James Rowland (as at 2.5.18)
Dr Heather Natalie Gibbard (as at 2.5.18)
Dr Roger Moore (as at 2.5.18)

New Student Members Admitted
Miss Tara O'Neill (as at 2.5.18)
Ms Juliet F R Turner (as at 2.5.18)
Miss Molly Rogers (as at 2.5.18)
Miss Ella Deutsch (as at 2.5.18)
Mr Matthew Peter Greenwell (as at 2.5.18)
Miss Melissa Minter

Re-Instatements to Fellowship
None

Re-Instatements to Membership
Dr Stephen James Venn

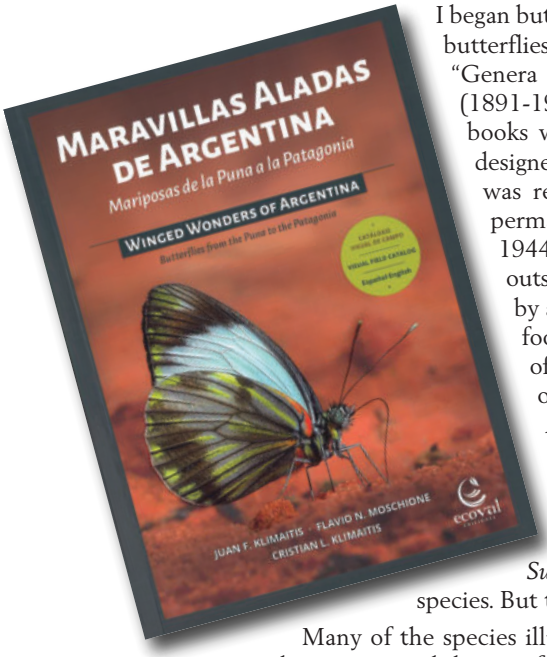
Re-Instatements to Student Membership
None

Deaths
Mr D S Burrows, UK, 1978
Professor Fotis C Kafatos Hon. Fellow, GR, 2012

# Book Reviews

## *Maravillas Aladas de Argentina/Mariposas de la Puna a la Patagonia (Winged Wonders of Argentina/Butterflies from the Puna to Patagonia)*

Juan F. Klimaitis, Flavio N. Moschione, and Cristian L. Klimaitis
Ediciones Ecoval, Cordoba, Argentina 2018
Paperback 17 x 23.5 cm, 259 pages
ISBN 978-987-4003-21-8




I began butterfly study in Argentina in 1977. Back then the only illustrated work on Argentine butterflies was the pretentious, oversized set of four volumes published under the series title "Genera et Species Animalium Argentinorum" by English expat Kenneth John Hayward (1891-1972) under the patronage of Juan Peron. Although the plates were beautiful, the books were about as unsuited for field use as could be imagined—indeed, they were designed to occupy a place of honour in a rare book room and never to leave it. Hayward was responsible for most of the literature on Argentine butterflies after he settled permanently in Tucuman in 1940 and joined the staff of the Instituto Miguel Lillo in 1944. I came along five years after his death and resumed the tradition of work by an outsider. There were a few attempts by Argentines to take up the many challenges posed by a fauna ranging from the tropics to the subantarctic and from the jungle to 20,000-foot Andean peaks, but only in the last few years have these local efforts really taken off. Much of the credit goes to Ezequiel Nunez Bustos, who has embarked on a series of regional, copiously-illustrated field guides. He is now joined by the Klimaitis crew. *Maravillas Aladas* is an attempt at a comprehensive national work and includes exactly 400 taxa. That, of course, falls very far short of completeness—there are almost 1500 species recorded in the country, and ones new not only to Argentina but to science, especially Lycaenids, are being described regularly now. It will be a long time before there is an Argentine work comparable to Jeffrey Glassberg's *Swift Guide to the Butterflies of Mexico and Central America*, which covers some 1700 species. But this is a decent start.

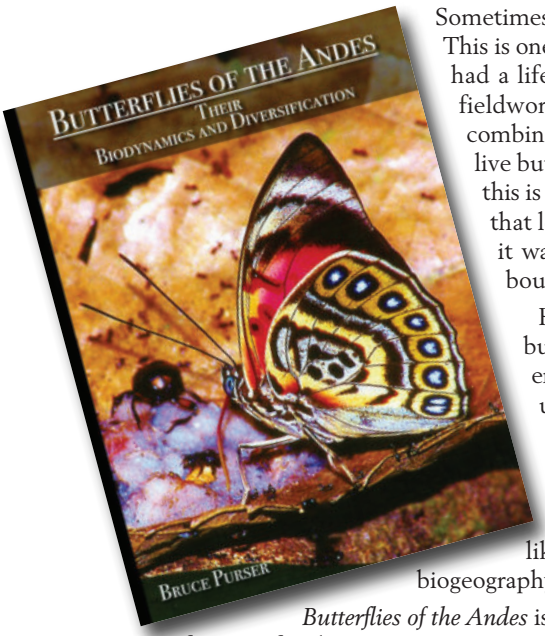
Many of the species illustrated here have never been photographed before. This applies equally to the numerous bizarre tropical skippers from the humid northeast and the high-Andean Satyrids and Pierids, some of which I have still not seen alive in Argentina even after 40 years of field work. The text is telegraphic and there is little biological information given. The species are grouped by geography and biome/biotope. The photographs are almost all superb, and all are from life. The text is completely bilingual. The English text is frequently clumsy and obviously not written by a native speaker, but it is always comprehensible and useful. Some common and widespread things from cooler and drier climates are unaccountably omitted – indeed, montane and Patagonian faunas are given very short shrift – while many very obscure but fascinating lowland tropical skippers are included. But the book is indispensable for the first-time visitor, especially in the north, and highly recommended. As of this writing there is no distributor in the US or the UK, but that will probably change. The publisher's on-line address is www.ecovalediciones.com.

One cautionary note: Foreign visitors need to investigate current regulations if they intend to collect in the country. This book does not instruct you how to do so, and the situation as usual is somewhat volatile and includes numerous ambiguities. Research the current situation by searching "Argentina wildlife regulations" on-line before planning your trip.

Arthur M. Shapiro

# *Butterflies of the Andes: Their Biodynamics and Diversification*

by Bruce Purser
Published by the International Biodiversity Foundation
Obtainable from BioQuip **www.BioQuip.com**
259 pages, colour photographs and maps throughout
Casebound 22.25 x 28.5 cm.
ISBN 978-0-9655370-0-1
£28.50 plus p/p




Sometimes it's obvious that a book was written as a labour of love, as soon as you pick it up. This is one such book. The author, Bruce Purser, was formally trained as a geologist, but has had a lifelong fascination with insects, especially butterflies, as well as a long record of fieldwork and publication on the butterflies of South America. These twin interests combine in this book, which is richly illustrated with impressive photography (of both live butterflies and habitats) and full-colour topographic and geologic maps. Simply put, this is a big, beautiful, and finely produced book. The sale price of less than £30 suggests that love for the subject rather than the prospect of profit was the primary reason why it was produced. What a bargain! Trust me when I say that similarly illustrated and bound books often sell for more than twice as much.

Part travelogue, part primer on the geology of South America, part guide to the butterfly fauna of the Andes, the text adeptly weaves these topics together into an enjoyable read. Purser's writing, in combination with the maps and photos, allows us to get a real sense of the topography, habitats, and butterfly fauna in different parts of the Andes, even for readers who have never visited the region. This makes it quite different from many other "butterfly books" that cover the Neotropics, which frequently focus on identification via species "mug shots", without giving much environmental context. If it isn't obvious already, let me be clear: I really like this book and the approach that it takes to understanding butterfly biogeography.

*Butterflies of the Andes* is not an identification guide. It makes no attempt to provide a comprehensive set of images for the 9000 or more Neotropical butterfly species. *Morphos* are particularly well represented in photos and in the text, but even for that group, this book would not be sufficient for specimen identification. Further, while the assistance of many taxonomic specialists is acknowledged, a number of the photographed species are misidentified. For example, the nymphalid *Junonia vestina* (photo V-18) is incorrectly identified as *J. evarete*, while *J. evarete* (photo VI-10) is incorrectly identified as *J. genoveva*. At one point in the text (p. 239), *J. vestina* is also referred to as *V*[*anessa*] *genoveva*. *Junonia* is an admittedly difficult genus, but Art Shapiro, in his review of Purser's book (2017, Quarterly Review of Biology 92: 207-208), provides some additional examples of identification errors from other genera. The book also lacks a proper index, and the photo index provided is incomplete. If you are interested in one particular taxon, you will need to read the entire book. The writing is engaging, so perhaps that will not be burdensome, but it will undoubtedly be slower than looking up the appropriate pages in an index.

Finally, Purser is particularly interested in the integration of geodynamics and taxonomy (thus the term "biodynamics" in the subtitle). Consequently the text focuses primarily on long-term processes of environmental change and vicariance speciation by habitat subdivision. Much less attention is devoted to processes such as speciation by dispersal or possible cases of rapid evolutionary change that have taken place in South America. A notable exception is Purser's hypothesis that much of the high elevation Andean butterfly fauna originates from a Pleistocene invasion of North American boreal butterfly taxa.

So, like all the great loves in literature, this book is imperfect, but that makes it no less fascinating. It presents a robust array of hypotheses just calling out for attention from the practitioners of evolutionary genomics, phylogenetics and biogeography among us. And even if you are none of those things, it is an excellent read and a pleasant means to escape to the tropics, if only for a few minutes at a time.

Jeff Marcus

## *A Swift Guide to Butterflies of Mexico and Central America*

Second Edition

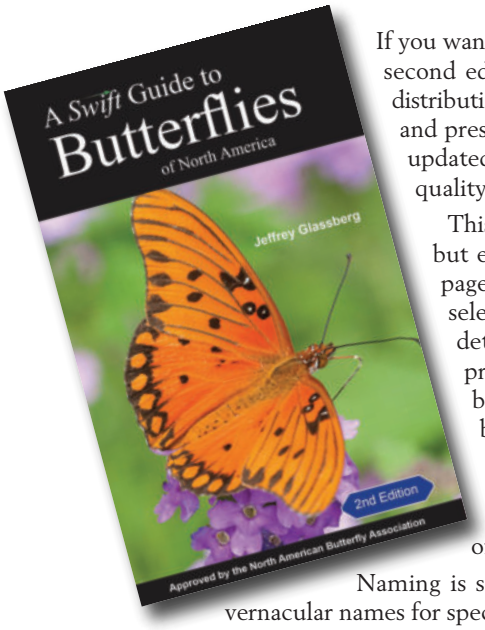
Jeffrey Glassberg

Princeton University Press, Princeton (NJ)

Paperback 2018, approx. 14 x 20 cm, 304 pp., 645 g, more than 3700 colour photos with maps

ISBN 9780691176482

£32.95




If you want a field guide to identify butterflies in Mexico or Central America, try this book. Now in its second edition, Jeffrey Glassberg's guide considers over 2,000 species, which are illustrated with distribution maps and clear photographs, annotated with distinctive features. The author is the founder and president of the North American Butterfly Association (NABA). His newly revised edition has updated names and maps, as well as better coverage of the species, with new photographs on good quality paper.

This guide helps the reader to identify butterflies quickly and easily. The introduction is short, but effective. I particularly like the efficiency with which this book packs information into its pages without getting cluttered. At the back of the book, there are some thumbnail photos of selected butterflies to get the reader to the right pages quickly. The excellent photographs are detailed, and are accompanied by a scale bar, the months when the species tends to fly, its preferred habitat, and the caterpillar's food plants (where known). The photos are accompanied by distribution maps for the region, with colour-coding to indicate local abundance. The background shading behind each species name shows its wider distribution pattern beyond the region. I have found this arrangement to work remarkably well. Lucidity often gets taken for granted when it is well done, and this book is a fine example. I suspect that most users will immediately relax into identifying their butterflies and overlook the careful crafting of the book they have in their hands. This is to the great credit of the author.

Naming is sensible, and mostly follows the NABA checklist. The author has thoughtfully invented vernacular names for species without them. Of course, the names and maps will drift as we learn more, but this book will help to drive that process forward by making butterfly identification easier—and setting a mark to work from.

Each year, I take a group of undergraduate conservation biology students for a two-week trip to the Yucatán Peninsula. Next time, we will have several copies of this book to pass round the group. In fact, this book is now firmly included in my pack list for any trip to Mexico or Central America.

Paul Ramsay

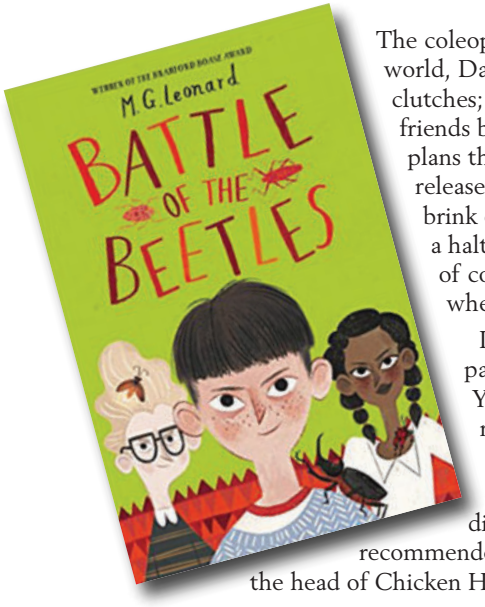
## *Battle of the Beetles*

M G Leonard

Published by Chicken House

ISBN 978-1-910002-78-0

£6.00




The coleopteran crew are back in this long-awaited finale of the 'Beetle Boy' trilogy. Back to save the world, Darkus's father (for the second time) and of course to rescue Novak from her mother's evil clutches; this is their most daring adventure yet, travelling deep into the Amazon rain forest with new friends but also with old enemies in the wings, in order to thwart Lucretia Cutter's dastardly plans: plans that quickly become all too clear as Lucretia holds governments to ransom by threatening to release millions of pest species of beetles to ravage the world's food supply. The world is on the brink of collapse so it's down to Darkus, Virginia, Bertolt plus Baxter and his beetle friends to put a halt to Lucretia's plans for world domination (with a little help from Uncle Max and his friends of course). The plot whisks the coleopteran crusaders up the Amazon to Lucretia's secret lair, where new dangers abound but where new allies are also waiting.

If you enjoyed the first two books this one is unmissable. The story roars through the forest, packed with humour, adventure and biology, reaching a conclusion that is totally unexpected. You cannot read this without gaining an appreciation of the beauty and importance of the rain forest and it is of course just like the previous two novels, packed with amazing facts about beetles.

*Battle of the Beetles* concludes the war between Darkus and Lucretia, but the only way to discover what happens, how it occurs and to whom, is to read the book. The *Battle* is highly recommended to coleopterophiles of all ages. If you have not read the other two, grab them now, and as the head of Chicken House says in the foreword, "Hang on to your beetles, it's a bumpy ride".

Peter Smithers

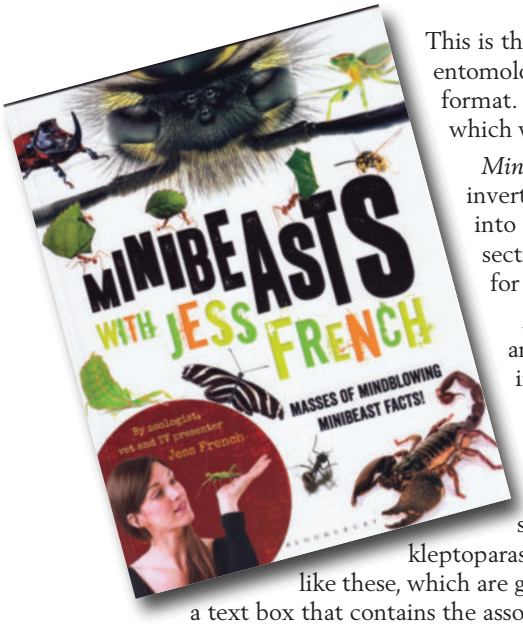
## *Minibeasts with Jess French*

Jess French

Published by Bloomsbury

ISBN 978-1-4729-3955-5

£12.99




This is the book that I wish I had when I was 10 years old. *Minibeasts* is an Aladdin's cave of entomological information, with so many exciting facts presented in an easy to read and absorb format. Jess has compiled a compendium of the bizarre, the amazing and the unexpected, which will be devoured by children who have even the slightest interest in the natural world.

*Minibeasts* opens with a clear and concise introduction to the taxonomy of the invertebrates; it's just two pages but it sets the scene. The remainder of the book is divided into five sections: 'Eat', 'Prey', 'Defence', 'Love' and 'Caring for Young'. Each of these sections contains short accounts of a range of adaptations, behaviours and other biologies for various invertebrates.

As an example, 'Feed' opens with a detailed exploration of invertebrate mouth parts and how they work. It then looks at the way that they find food, from the waggle dances in bees to the pheromone trails of ants. The arms race between caterpillars and plants is described, as is pollination and fungal ant farming. The blood-feeding habits of mosquitos and fleas are explained, along with descriptions of the Salticed spider that only feeds on female mosquitos that have recently had a blood meal, and the Dracula ant that consumes the blood of its own larvae. Other sections deal with net-casting spiders, mimicry in butterflies, camouflage in stick and leaf insects as well as kleptoparasites in spiders' webs. Each section of the book is crammed with amazing short stories like these, which are guaranteed to wow young readers. Each page features a colour photograph along with a text box that contains the associated facts. There is also a short glossary and an index at the rear of the book.

*Minibeasts* is a wonderful introduction to the amazing world of invertebrates and will ignite the curiosity of children everywhere, though not just children but anyone who wants an overview of the invertebrates in a user-friendly form should read this book. Jess French is to be congratulated on producing an attractive, informative and unputdownable volume that will inspire future generations to take a keen interest in the world around them.

Peter Smithers

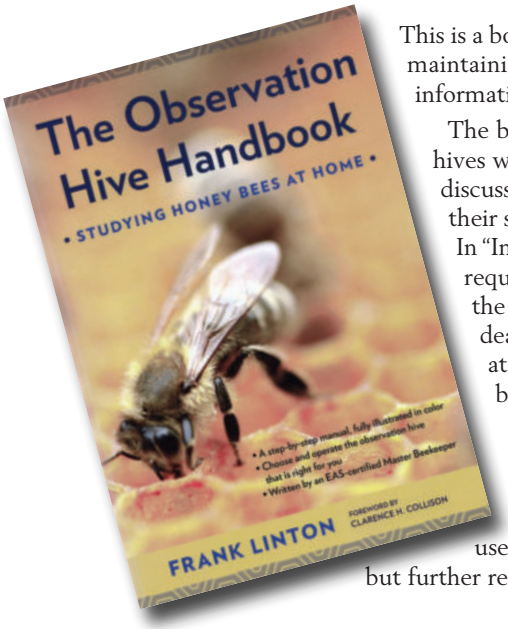
## *The Observation Hive Handbook: Studying Bees at Home*

Frank Linton

Cornell University Press

ISBN 978-1-5015-0726-1

$24.95




This is a book that is intended to guide beekeepers through the process of building, installing and maintaining an observation hive. While it is aimed at American beekeepers, much of the information can still be applied to the UK.

The book is divided into eight sections, the first of which is an introduction to observation hives with a brief account of their history. In the second section, "Hive Selection", the author discusses the pros and cons of eight observation hives that are available in the USA, outlining their size, portability, occupancy (temporary or permanent) quality, workmanship and price. In "Installing the Hive", he discusses the selection of the hive location and the modifications required to make it practical, while "Working with the Hive" outlines the introduction of the bees and the general hive maintenance with notes on parasites and pests. "Maintenance" deals with feeding methods and cleaning of the hive, while "Hives in Public Spaces" looks at how to manage public interaction with the hive. The last two chapters offer advice on bee photography and suggested studies to enhance your knowledge of bee behaviour.

While this book offers much common-sense, I found some of the advice sketchy and lacking in detail, and practical advice was missing. It could have offered more detailed advice on design features, especially ease of working with and cleaning of the hive. Having said that, the selection and installation checklist and the bibliography were useful. This is a book that will introduce the reader to the concept of observation hives, but further reading will be essential before taking one on.

David Maslan

President of the Avon Beekeepers Association (Bristol)

*Editor's note.* David Maslan maintains the observation hive at Bristol Zoo.

# Diary

Details of the Meetings programme can be viewed on the Society website (www.royensoc.co.uk/meetings) and include a registration form, which usually must be completed in advance so that refreshments can be organised. Day meetings typically begin with registration and refreshments at 10 am for a 10.30 am start and finish by 5 pm. Every meeting can differ though, so please refer to the details below and also check the website, which is updated regularly.

Offers to convene meetings on an entomological topic are very welcome and can be discussed with the Honorary Secretary.

## MEETINGS OF THE ROYAL ENTOMOLOGICAL SOCIETY

### Insect Genomics Special Interest Group
### 14 September, 2018

Venue: University of Leicester

Convenors: Hollie Marshall (hm257@leicester.ac.uk) and Katherine Beadle (k.beadle@exeter.ac.uk)

Keynote speaker: Yannick Wurm, Queen Mary University (https://wurmlab.github.io)

### Insect Data Special Interest Group
### 23 October, 2018

Venue: University of Hull

Confirmed speakers:

Dr David Roy (CEH)

Dr Peter Mayhew (University of York)

Convenor: James Gilbert (james.gilbert@hull.ac.uk)

### Orthoptera Special Interest Group
### 7 November, 2018

Venue: Neil Chalmers Room, Natural History Museum, London

Convenor: Björn Beckmann (orthoptera@ceh.ac.uk)

### Public Understanding of Entomology Special Interest Group
### 29 November, 2018

Venue: Bute Room, National Museum of Scotland, Edinburgh

Invited speakers:

Dr Helen Roy (CEH)

Maya Leonard - Author

Sally-Ann Spence

Dr Richard Harrington (Rothamsted Research)

Convenor: Ashleigh Whiffin (a.whiffin@nms.ac.uk)

### Verrall Lecture
### 6 March, 2019

Venue: The Flett Theatre, Natural History Museum, London, SW7 5BD

Speaker: Professor Marie Dacke (Lund University, Sweden)

### Aphid Special Interest Group
### 3-5 April, 2019

Venue: Rothamsted Research, Harpenden, AL5 2JQ

Convenor: Richard Harrington, RES SIG coordinator (richard@royensoc.co.uk)

This will be a joint meeting with the French Aphid Research Network, BAPOA.

### Arthropod Cuticle Special Interest Group

### 16 April, 2019

Venue: Flett Lecture Theatre, Natural History Museum, London
Convenor: Stuart Reynolds (s.e.reynolds@bath.ac.uk)

### Annual General Meeting

### 5 June, 2019

The Royal Entomological Society Annual General Meeting, open to Members & Fellows ONLY.
The Mansion House, Chiswell Green Lane, St Albans AL2 3NS

### Ento '19

### 20-22 August, 2019

International Symposium & Annual National Science Meeting
*'Vectors of diseases'*
Venue: London School of Hygiene & Tropical Medicine, Keppel Street, London, WC1E 7HT
Convenor: Prof Mary Cameron, LSHTM

## OTHER MEETINGS

### 2020

### 19-24 July XXVII International Congress of Entomology (ICE2020)

Entomology for our planet
Venue: Helsinki, Finland


# author guidelines

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

### AIMS AND SCOPE

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

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

### READERSHIP

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

### INSTRUCTIONS FOR AUTHORS

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

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

### PAGE CHARGES

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

### REVIEW AND PUBLICATION PROCESS

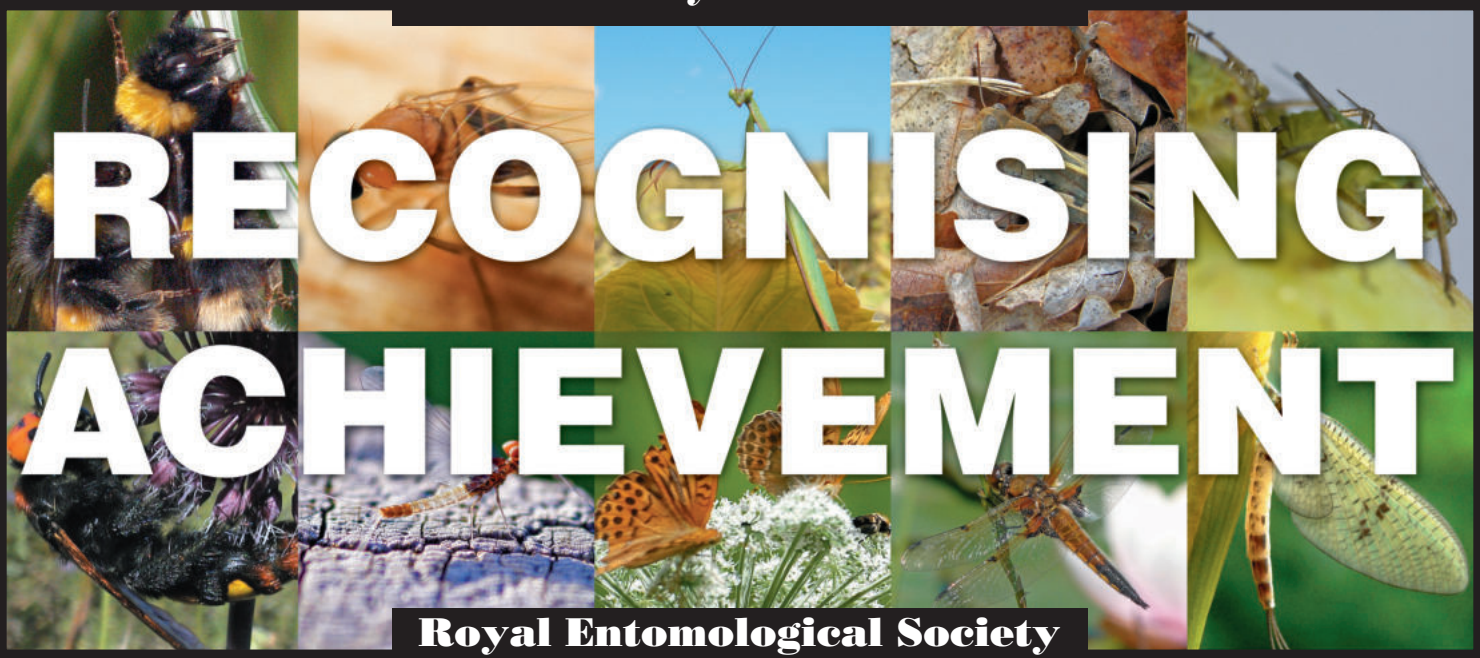
All submissions are reviewed and, where necessary, edited 'in-house' by the *Antenna* Editorial Board, though specialist external review may be sought in some cases (e.g. for submissions that fall outside the Editorial Board's expertise). Receipt of submissions will be provided by email, with submitting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

### SUBMISSION PROCESS

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

### EDITORIAL BOARD

www.royensoc.co.uk



# RECOGNISING ACHIEVEMENT

## Royal Entomological Society – Society Awards –

*For more details on these Society Awards please see www.royensoc.co.uk*

### THE ROYAL ENTOMOLOGICAL SOCIETY STUDENT AWARDS

**Award Criteria**: Any article about an Entomological topic that would be of interest to the general public. The article to be easy to read, in a popular style and no longer than 800 words.

**Prize**: Winner £400, runner up £300, third place £200, all three articles published in *Antenna*.

### THE L.J. GOODMAN AWARD FOR INSECT BIOLOGY

**Award Criteria:** For advancing the education of the public in the knowledge, understanding and appreciation of all aspects of insect physiology and behaviour, thereby promoting the control and conservation of insect species.

For promoting research into aspects of insect physiology and behaviour through online, digital or printed material.

For supporting exhibitions, meetings, lectures, classes, seminars and courses that widen the understanding of insect physiology and behaviour.

Grant: No individual award shall exceed £3,000 and not more than £6,000 shall be awarded each year.

### THE MARSH AWARD FOR INSECT CONSERVATION

**Award Criteria:** For an outstanding contribution to Insect Conservation; on the basis of 'Lifetime Achievement', or 'Considerable and Exemplary Contribution' to a significant project or undertakings. In exceptional circumstances two prizes may be awarded to reflect each criterion.

**Prize:** £1250 and Certificate.

### POSTGRADUATE AWARD: THE ALFRED RUSSEL WALLACE AWARD

**Award Criteria:** For post-graduates who have been awarded a PhD, whose work is considered by their Head of Department to be outstanding. The research involved should be a major contribution to the Science of Entomology.

**Prize:** £800 plus Certificate, plus one year's free Membership. The winner will also be invited to present their work at a Society Meeting.

### J.O. WESTWOOD MEDAL – AWARD FOR INSECT TAXONOMY

**Award Criteria:** The best comprehensive taxonomic work on a group of Insects, or, related Arthropods (including terrestrial and freshwater Hexapods, Myriapods, Arachnids and their relatives). Typically, this will be a taxonomic revision or monograph.

**Prize:** A specially struck silver gilt medal inscribed with the winners name. Also costs incurred in attending the International Congress of Entomology, European Congress of Entomology, or other major meeting (specified by the Adjudicators) to present his/her work.

### RES JOURNAL AWARDS SCHEME

**Award Criteria**: The best paper published in each Society Journal over a two year period. Each of the Society Journals participate biennially.

**Prize**: £750 and Certificate for each participating Journal.

### THE WIGGLESWORTH MEMORIAL LECTURE AND AWARD

**Award criteria:** The outstanding services to the science of Entomology. The award will be made to a researcher who has contributed outstanding work to the science and who best reflects Sir Vincent Wigglesworth's standards of personal involvement in every aspect of his/her research.

**Prize:** A specially struck gilt medal inscribed with the winner's name. Also the costs of attending the International Congress of Entomology to give the Wigglesworth Lecture.

### BOOK PURCHASE SCHEME FOR FELLOWS AND MEMBERS IN DEVELOPING COUNTRIES

**Award Criteria:** To provide assistance in purchasing specialist Taxonomic books, that will assist in the identification of Insect groups being studied in developing countries and their regions. Applicants will be required to demonstrate need and specify particular texts.

**Prize:** Any one applicant may be awarded up to £250 in a three year period. The Society will purchase the texts awarded and send them to the applicant. The applicants may, themselves, provide any additional funds in excess of the amount awarded.

### OUTREACH AND CONFERENCE PARTICIPATION FUNDS

**Award Criteria:** ORF: Grants to support activities which further the Society's aims. This may range from, help to purchase equipment, to help in funding expeditions/meetings. CPF: Grants to assist applicants who are participating in a meeting or conference in some way, e.g. presenting a paper/poster.

**Prize:** ORF: Monetary grant. CPF: Monetary grant.

### MARSH AWARD FOR EARLY CAREER ENTOMOLOGIST

**Award Criteria:** For an early career contribution to Entomological Science that is judged to be outstanding or exemplary with single or ongoing impact on the science. The Award is 'open' and not restricted to any particular discipline or specialised area of entomological science.

**Prize:** £1250 and Certificate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E-mail: info@royensoc.co.uk

# RES STUDENT AWARD 2018

## Write an entomological article and WIN!

www.royensoc.co.uk

### REQUIREMENT

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

### WHO CAN ENTER?

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

### PRIZES

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

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

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

### ENTRIES

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

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

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

For further information telephone: 01727 899387

Please include:

- Your name and address (including postcode)
- Your e-mail address
- The name and address (including postcode) of your academic institution
- Evidence of your student status

### THE JUDGES

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

### CLOSING DATE

The closing date for entries is 31 December 2018. The winner will be announced in the Spring 2019 edition of *Antenna* and on our website.



### PLEASE CUT AND RETURN THIS PORTION WITH YOUR ENTRY

Article title: _____

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Student name: _____

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Address: _____

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Telephone: _____

E-mail: _____

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Name of academic institution:

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