Laboratory of Apiculture and Social Insects

Annual Report January 2015

University of Sussex
Life Sciences

LASI
LABORATORY OF APICULTURE AND SOCIAL INSECTS

Fig. 1. Members of LASI, July 2014 (Photo: Francis Ratnieks).

Cover photo: A hover fly and honey bee on ivy flower (Photo: Francis Ratnieks).

Contents

LASI personnel

LASI Director

Prof. Francis L W Ratnieks

Postdoctoral researchers and research technicians

Dr Karin L Alton	Mr Norman L Carreck	Dr Margaret J Couvillon
Dr Mihail Garbuzov	Mr Luciano Scandian	Dr Martyn J Stenning

Doctoral students

Mr Nick Balfour	Dr Gianluigi Bigio	Mr Tom Butterfield
Mr Kyle Shackleton	Mr Hasan Al Toufailia	

Masters students

Mr Alan Gallagher

Temporary Technician

Felix Schrell

Volunteer

Ms Ellie Blows

Visitors

Ms Héloise Blanchard	Mr Ludovic Dubuisson	Mr Valentin Duflo

Mission statement and goals

Research

- To carry out basic and applied research on honey bees and social insects.
- To be a world-leading research group and a key component in UK science infrastructure and expertise.

Teaching

- To train the next generation of honey bee and social insect scientists.

Community

- To extend practical knowledge, informed by high quality research, about honey bees and social insects to beekeepers, industry and others.
- To play an active role in the public communication of science.

Contacts

Professor Francis Ratnieks: f.ratnieks@sussex.ac.uk
Dr Karin Alton: karin.alton@sussex.ac.uk
Sue Hepburn: s.j.hepburn@sussex.ac.uk (fundraising)

Website: http://www.sussex.ac.uk/research/researchgroups/lasi

Overview of 2014

The *Sussex Plan for Honey Bee Health & Well Being* started six years ago. The idea was to carry out research that addressed some of the most important challenges facing honey bees and beekeeping and that was suited to the LASI facilities and research skills. In consultation with beekeeper groups, and based on our experience studying honey bees and beekeeping, two areas were chosen: 1) honey bee pests and diseases; and 2) floral resources and foraging. Subsequently a third topic, neonicotinoid insecticides, was added.

The *Sussex Plan* became a major focus of LASI research. Thanks to the generosity of our many donors, funds were raised and we were able to hire the people to conduct the research. In total, approximately 40 people have worked on the Sussex Plan. These include 1 Masters student (Fiona Riddell), 4 PhD students (Gianluigi Bigio, Mihail Garbuzov, Hasan al Toufailia, Nick Balfour), 2 Research Technicians (Norman Carreck, Luciano Scandian), and 3 Postdoctoral Researchers (Dr Karin Alton, Dr Margaret Couvillon, Dr Roger Schürch). In addition, many undergraduate project students, undergraduate summer bursary students, visitors, and volunteers have also been part of the *Sussex Plan*.

How successful has the *Sussex Plan* been? One measure of success in the world of science is research output, which at LASI is prolific. As of January 2015 the *Sussex Plan* has produced 42 scientific papers including 25 published, 3 in press, 5 submitted, and 9 in the final stages of writing up. More than 10 other projects are also underway.

Arguably a more important measure of success when carrying out applied research is whether the results help solve the problems they were intended to tackle. The *Sussex Plan* has done well in this respect. For example, in the area of honey bee pests and diseases, it has determined the best way of killing varroa mites using oxalic acid, and has been able to show that one method (2.25g applied via sublimation in winter to broodless colonies) will kill 97% of the mites without causing any harm to the bees or colonies. Research on hygienic behaviour has shown that highly hygienic colonies have only 43% of the annual population build-up of varroa mites and have 10,000 times less deformed wing virus. The research on hygienic behaviour has also shown that it has no cost to the colony in terms of the mistaken removal of healthy brood, and that colonies headed by open-mated queens bred from hygienic breeder colonies are highly hygienic. The latter finding opens up the possibility of making hygienic queens available more simply to British beekeepers.

The research on flowers and foraging has also produced important practical results. By decoding honey bee waggle dances, the bees have “told” us where they were foraging. Average foraging distances are low in spring (<1km) and increase to a maximum in summer (2-3 km), and decrease in the autumn. Honey bees are economically rational foragers and do not fly long distances to flowers when this is not needed. The results, therefore, tell us that bee forage is less available in the summer, meaning that summer is the season to focus on for providing additional floral resources. The dance decoding research has also shown that honey bees use urban and rural areas equally, but that there are certain rural “hot spots”. We have studied one of these hot spots to find out what habitats and plant species the bees are actually visiting. In addition, this area also turned out to have many other types of flower-visiting insects, showing that the dance decoding had not just detected a good location for honey bees but for other insects as well.

Sussex Plan research on flowers and foraging has also investigated the attractiveness of garden flowers to bees. We have found that attractive summer-blooming ornamental flowers vary 100-fold in the numbers of bees and other insects that they attract. This shows that, at no cost, gardeners and park managers can make a big difference by selecting the more bee-

friendly varieties. There are many lists of bee-friendly plants available, but how good are they? Our research shows that these lists have quite a few shortcomings. For example, they omit many bee-friendly varieties and also over generalize. Asters (Michaelmas daisies) are on many of the bee and insect friendly lists. However, when we surveyed over 200 aster varieties at the national collection, at Picton Gardens in Worcestershire, we found that there was huge variation in how many insects they attracted, from many to zero.

Outreach is also an important part of the *Sussex Plan* and the overall LASI approach. Over the past six years we have run approximately 20 workshops and open days at LASI, all free of charge. The workshop topics have included integrated varroa control, testing colonies for hygienic behaviour, decoding honey bee dances, and determining best flowers for bees. In addition, we have given over 200 talks to beekeeper groups, have produced 10 videos and slide shows which are on the YouTube Channel *LASI Bee Research & Outreach*, have written numerous articles for beekeeper magazines, have a web site with useful information on bees, and have generated much publicity for bees.

Fig. 2. Honey bee queen on a comb. (Photo: Francis Ratnieks).

What about the future? We have exciting plans to continue the *Sussex Plan* and to build on our success. We are starting to raise funds for two new PhD projects to begin in September 2015. One will be on *Integrated control of honey bee pests and diseases*. The other will be of *Improving floral resources for honey bees and flower-visiting insects*. We also intend to increase our work in outreach, including bringing the results of our research to beekeepers, gardeners, land managers and other “end users” via articles, pamphlets, videos, talks and workshops. Finally, we would like to supply our hygienic queens and breeding stock to beekeepers. From our research on hygienic behaviour we now have breeder colonies that are 100% hygienic, meaning that 100% of dead brood are removed within two days.

The on-going success of the Sussex Plan is due to the generous and far-sighted donors who have supported us and to the outstanding team that has conducted the research. We have had some significant results, which will have a positive impact on the welfare of honey bees and pollinators. But the work carries on and we hope that our supporters will continue to help us to help our valuable and much loved bees.

Research – The Sussex Plan for honey bee health and well being

Hygienic behaviour: natural disease resistance in the honey bee

Karin Alton, Gianluigi Bigio, Norman Carreck, Luciano Scandian, Hasan Al Toufailia, Francis Ratnieks

Funding
This project is funded by Rowse Honey Ltd, the Merrydown Trust, the Somerset Beekeepers Association, the Esmée Fairbairn Foundation and the University of Damascus.

Hygienic behaviour is a natural defence against brood diseases. Hygienic workers clean out cells containing dead or infected brood. Hygienic behaviour is not learned. Rather, it is an inherited trait. Previous research has shown that chalk brood and American foul brood can be controlled by hygienic behaviour.

LASI research has investigated both basic and practical questions about hygienic behaviour, including whether it is effective in controlling varroa and viral diseases, how to test for hygienic behaviour, and how to supply beekeepers with hygienic queens.

Hygienic behaviour is widespread but uncommon. Surveys typically show that only about 10% of hives are hygienic. To determine how hygienic a colony is, patches of capped brood are freeze-killed with liquid nitrogen, photographed, returned to the hive, and then checked two days later. The proportion of brood cells that have been cleaned out gives the hygiene level. Colonies that clean 95% or more are considered fully hygienic. At LASI, we have been able to breed fully hygienic bees, some even 100%.

One basic research project investigated one possible reason why hygienic behaviour is rare. We determined whether colonies with higher hygiene levels also removed more healthy brood. We found that this was not the case. As far as we know, from this project and from research in the USA, hygienic behaviour is not costly to the colony.

A colony's hygiene level is not constant and we normally test each colony three or four times to get a meaningful average. We investigated factors that may cause the hygiene level to vary. We manipulated the amount of brood (by adding or removing brood frames) and also "nectar flow" (by feeding some colonies with syrup). Neither factor influenced the level of hygienic behaviour, nor did colony size. This is encouraging as it shows that a beekeeper need not worry about these factors when quantifying hygiene levels, for example in choosing a hygienic breeder colony for queen rearing.

How can queen rearers produce hygienic queens? We compared the hygiene levels of colonies headed by queens reared from fully hygienic breeder colonies. Half were allowed to mate naturally. The others were instrumentally inseminated with drones from hygienic colonies. Several months later when each colony was full of the new queen's workers we quantified hygiene levels. Colonies headed by instrumentally-inseminated queens had higher hygiene levels, but the colonies headed by open-mated queens were also highly hygienic. This shows that queen rearers could supply open-mated queens to beekeepers wanting hygienic hives. Queen rearers could supply beekeepers with young virgin hygienic queens to mate locally. LASI research has shown that it is simple to keep virgin queens alive in cages for one week prior to mating.

LASI research has also shown that hygiene can control varroa and the viral diseases it transmits. We tested varroa population build up in 42 colonies with different hygiene levels and found that fully hygienic colonies have only 40% the varroa buildup. We also found that hygienic colonies had lower levels of deformed wing virus (DWV). This is important as DWV

can kill colonies.

Fig. 3. Killing a patch of capped worker cells using liquid nitrogen to determine the level of hygienic behaviour in a colony. The frame is photographed, placed back into its hive, then checked two days later to determine the proportion of freeze-killed brood cells that have been cleaned out. Each hive is tested three or four times to determine a meaningful average hygiene level.

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Research – The Sussex Plan for honey bee health and well being

Varroa: towards integrated control

Hasan Al Toufailia, Luciano Scandian, Francis Ratnieks

Funding
This project is funded by the Esmée Fairbairn Foundation and the University of Damascus.

The parasitic mite *Varroa destructor* is a significant problem for honey bee, *Apis mellifera*, colonies. Varroa is native to the Asian honey bee *Apis cerana*. Varroa does little damage to *A. cerana* as the female mites only breed in capped drone cells, resulting in low mite populations. But in *A. mellifera* the mites can also breed in worker cells and mite populations build to high levels and damage the bees directly. Varroa also vector honey bee viral diseases and this is probably their greatest harm. The main aim of LASI's varroa research is to determine the effectiveness of different control methods used by beekeepers. We have studied three methods in detail.

Beekeepers have long used oxalic acid and many research projects have been done. However, no project had done the obvious thing: compare the effectiveness of different doses and application methods. In an experiment using 110 hives we did this. Hives were treated in early January when they were broodless, as oxalic acid kills only varroa sitting on adult bees not those in brood cells. We determined the proportion of mites killed by washing the mites off a sample of approximately 300 worker bees immediately before and 10 days after treatment.

Our results showed that applying oxalic acid directly as a gas via sublimation was superior to application as a solution via spraying or dribbling. Sublimation gave greater varroa kill at lower oxalic acid doses and gave no increase in bee mortality either soon after application or four months later. In fact, colonies treated via sublimation had more brood than untreated control colonies. The sublimation method is also quick and easy because it is applied via the hive entrance. One year later, we retested the sublimation method and obtained the same result. Just 2.25g of oxalic acid per hive kills 97% of the varroa.

The second method we tested was drone brood trapping. Varroa are particularly attracted to drone brood. Our results show that half a frame of drone comb placed into a hive in early spring, when the first drones are being reared, can trap about half the varroa.

The third method is via hygienic behaviour. We compared the build up of the varroa population in hives following oxalic acid treatment. In the 42 study hives, varroa populations increased from as few as 7 times to as many as 74 times in one year. Build up was significantly lower in highly hygienic colonies (average 19 times) than non-hygienic colonies (average 45 times).

Overall, our results show that annual treatment with oxalic acid just before or after Christmas, when most hives are broodless, is probably enough to control the varroa population, especially when colonies are also hygienic. Drone brood trapping is less effective. Because only half the mites are killed, one round of mite breeding is enough to restore the population given that a female mite breeding in a worker cell normally has one or two daughters. Killing 97% of the mites using oxalic acid would seem to be about twice as effective. Actually, it is five times as effective as it will take five varroa doublings to build back to the level before treatment.

Fig. 4. Treating a hive in winter with oxalic acid using the sublimation method. The oxalic acid is turned into a gas using a heated tool which is inserted into the hive entrance. For the purpose of the photo the tool has not been inserted and the oxalic acid vapour can be seen. (Photo H. Al Toufailia)

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Research – The Sussex Plan for honey bee health and well being

Neonicotinoid insecticides and bees

Norman Carreck, Nick Balfour, Mihail Garbuzov, Luciano Scandian, Hasan Al Toufailia and Francis Ratnieks.

Funding
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Several recent laboratory studies have shown sub-lethal effects on individual bees after treating bees or colonies with neonicotinoid insecticides. These studies have been influential in the wider debate concerning neonicotinoid use and the EU moratorium. The experimentally-applied doses of neonicotinoids aimed to be "field realistic". That is, to be similar to what bees would be exposed to when neonicotinoids are being used to treat the seeds of bee-attractive crops such as oil seed rape or maize.

By careful survey of original data we found that these doses may have overestimated exposure in three key ways: 1) concentrations in nectar and pollen; 2) duration of exposure; 3) choice of alternative nectar and pollen sources. In one study, individual honey bees were given a one-time dose that would have taken one week to collect via foraging, and suffered reduced ability to return to their hives. Because bees can detoxify insecticides, a one-time dose would probably have caused an exaggerated acute effect, similar to the difference between drinking a bottle of whisky at a sitting versus over one week.

In another study, the dose was based on the assumption that a colony would forage exclusively on a treated crop. But this is unlikely, as there are usually alternative food sources. We decoded honey bee waggle dances and analysed the pollen loads of returning foragers to investigate honey bee foraging on oilseed rape (OSR) in the Brighton / University of Sussex area, where it widely grown. OSR is the most important insect-attractive UK crop whose seeds were treated with neonicotinoids. We found was that when hives were more than *c.* 2 km from the nearest OSR field, they did not forage on OSR. In hives located 0.8 km from the nearest field, dance decoding showed foraging in OSR fields of *c.* 23% (that is 77% of the foraging was in other locations). Pollen analysis showed that only 13% was from OSR. Although a field of OSR in bloom would appear to be a magnet for bees, and pull in all the foragers, this is not the case.

We also studied foraging on maize at a farm in West Sussex that is Britain's largest sweetcorn grower. Maize produces large amounts of pollen, but no nectar. By counting insects on maize tassels, we found that honey bees may visit maize to collect pollen, but bumble bees and other insects do not. Other flowers growing on the farm had many more insects on them per square metre. But the massive area of maize being grown resulted in about half the pollen collected by honey bee colonies located on the farm being from maize.

Unless the effect is immediate, it is not easy to determine whether colonies are actually harmed by foraging on crops grown from neonicotinoid-treated seeds. We are studying this using 72 honey bee colonies and 72 bumble bee colonies. During the spring bloom of OSR, in 2014, we placed half of the colonies immediately adjacent to OSR fields and half in apiaries sufficiently distant from these fields to give much lower levels of foraging on OSR. After flowering, the honey bee colonies were randomly allocated to different apiaries, and are being monitored for one year. We are currently collecting the final data and starting data analysis.

The final project analysed neonicotinoid residue levels in OSR and maize plants of different

sizes grown from treated seeds. We found that plants that were four times heavier had half the residue levels, presumably because the residues were diluted more in the larger plants. This suggests that one way to reduce harm to bees, and the wider environment, may be to plant fewer seeds, thereby resulting in larger, but fewer, mature plants. Crop yields need not be reduced because the plants grow larger to fill the space. This could be one method of using neonicotinoids in a way that both reduces residues in pollen and nectar and reduces overall usage.

Fig. 5. LASI researchers inspect hives placed beside a field of oil seed rape in Sussex in spring 2014. The oil seed rape was grown from seeds treated with neonicotinoids. For the following year, hives were and are being monitored to determine if there are any effects of being placed in close foraging proximity to a treated crop, in comparison to hives that were distant from flowering oil seed rape in spring. (Photo: Héloise Blanchard).

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Research – The Sussex Plan for honey bee health and well being

Waggle dance decoding: investigating honey bee foraging by "listening" to the bees.

Margaret Couvillon, Roger Schürch, Francis Ratnieks

Funding
This project is funded by the Nineveh Charitable Trust.

The main reason why the number of honey bee colonies in Britain has declined over the past century is almost certainly because their food supply; flowers providing nectar and pollen, have declined. The intensification of agricultural land, which covers 80% of Britain, is the major factor and has reduced the value of the countryside to bees and other wildlife. Flower rich hay meadows have almost all been "improved", arable fields have fewer weeds, and clover is less used in pastures. If we want to make Britain a more bee friendly country we need to increase the numbers of flowers. But to do this in the most effective way, and to maintain food production, we need better information on how foraging honey bees use the landscape.

One main way that LASI has been researching honey bee foraging is by "listening" to the bees. That is, by decoding their waggle dances. Waggle dances are made by workers foraging at high quality flower patches. The dance communicates the direction and distance of the flower patch to the dancer's nestmates. We first video the dances using observation hives. We then decode the dances by playing them back frame by frame on a computer to measure the waggle run angle, which gives the direction of the flower patch from the hive, and duration, which gives distance. We can then map the dances to determine where the bees are foraging and the distances they travel.

We began by studying the dances made over a whole foraging season (two seasons actually), which runs from March to October. This had never been done before. The results showed a clear seasonal trend, in which average foraging distance was low in early spring, March and April, at less than 1km. Average distance increased in May and June until by July and August it averaged 2-3km, before reducing again in September and October. Honey bees do not travel long distances to forage for the fun of it, as this wastes time and energy. The longer summer foraging distances tell us that summer is a more challenging season in which to find high quality patches of flowers. It also tells us that this is the season to focus on if we want to help the bees with more flowers.

So far, we have also used dance decoding in five other projects. We have compared foraging in different land use types, and also in urban versus rural areas. It seems that foraging is not significantly different in urban versus rural areas, indicating that towns are neither better nor worse than the countryside, but there is more foraging in countryside areas that benefit from "high-level stewardship". We have also investigated foraging on two crops, apple and oilseed rape. The results from the study of oilseed rape show that bees will not travel more than 1.5-2.0 km to spring flowering oilseed rape, but travel further to summer flowering rape. This fits well with our results showing that bees forage at greater distances in summer than spring.

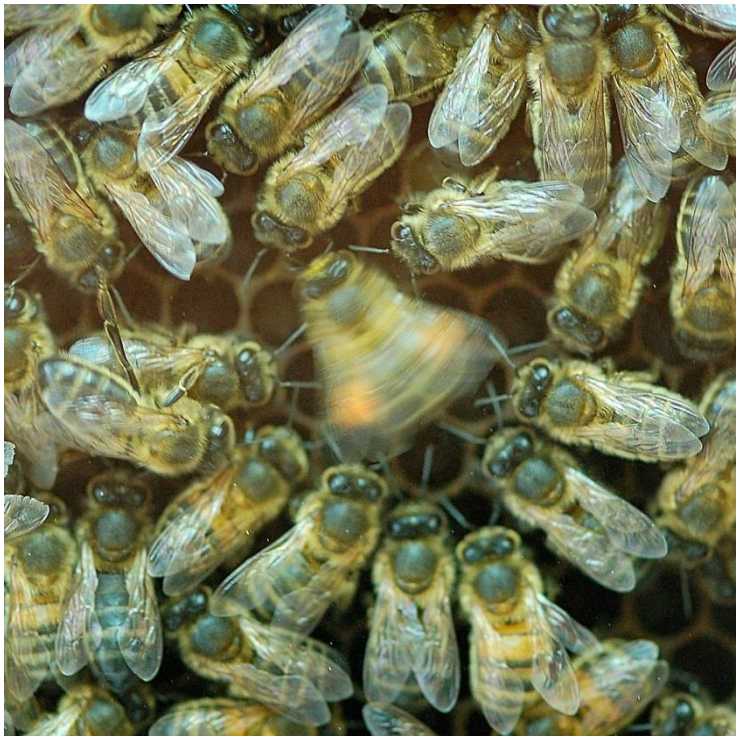

Fig. 6. A honey bee pollen forager making a waggle dance back in the hive. (Photo: C. Grüter).

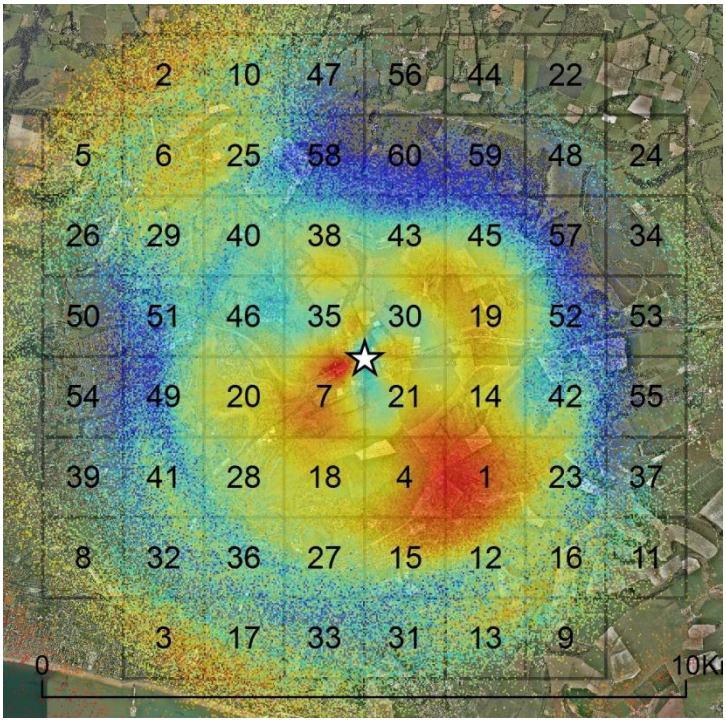

Fig. 7. Honey bee foraging intensity in 94km^2 of land around LASI over 2 foraging seasons by decoding more than 5000 waggle dances from observation hives at LASI, marked by the star. From Couvillon *et al.* 2014. *Current Biology.*

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Videos (from the LASI You Tube channel "LASI bee research & outreach"

Dancing Bees Cast their Votes on the Best Land-Types and Areas for their Food Collection
https://www.youtube.com/watch?v=AMU1KOF_Tck

Using the Honey Bee Waggle Dance to Understand Seasonal Foraging Challenges
https://www.youtube.com/watch?v=yELA7pvNUQI

Apple Pollination and the Honey Bee Waggle Dance
https://www.youtube.com/watch?v=hbGRWoqJVQs

Research – The Sussex Plan for honey bee health and well being

Helping bees in agricultural land

Nick Balfour, Francis Ratnieks

Funding
This project is funded by Waitrose Ltd and The C B Dennis Beekeepers Research Trust.

Decoding waggle dances at LASI has shown that average foraging distances are greatest in the summer, meaning that summer is a more challenging season to find good nectar and pollen sources than spring or autumn. In addition, by comparing the dance locations with land-use maps, the dance decoding research has also shown that honey bees forage more in areas under *Higher Level Stewardship*. These are farms in which a variety of conservation measures, including hedgerows and buffer strips, are present.

In the summer there is a foraging hot spot of several square kilometres, *c.* 2-3 kilometres to the southeast of LASI in an area of the South Downs known as Castle Hill. Although dance decoding is an amazing and unique way of studying honey bee foraging, it only tells us where the bees are foraging. It does not tell us on what plant species they are foraging, or the exact habitat they are foraging in. For example, it is not precise enough to tell us if the bees are foraging in a hedge or buffer strip on the edge of a field or in the field itself.

To do this, in the summers of 2012 and 2013 we surveyed the plants in bloom at Castle Hill and the insects on them. We found that only 18% of these insects were honey bees. This is important, as it shows that the dances had highlighted a hot spot area that was also good for other types of flower-visiting insects. The four main habitats in the Castle Hill area (pasture fields, the nature reserve, set aside areas, and the hedge plus field margin) all attracted many insects. The most important flowers included bramble, hogweed, thistle, knapweed and ragwort. Ironically, several of these are considered undesirable weeds! However, the different types of insects did not all have the same preferences for plant species or habitat. Honey bees were more similar to bumble bees in their preferences than to other insects such as butterflies and hover flies.

Why is summer a challenging season for honey bees to find good foraging locations? We do not know for sure, but think that it is for two main reasons. First, because there are more insects competing for nectar and pollen at this time of year. Second, because there are fewer flowers. It would be nice to be able to count all the insects and flowers and to determine if this reasoning is correct or not. But, obviously, this is not practical.

What we are doing, however, is to collate information of the active season for flower-visiting insects. It does seem that there are more flower-visiting insects on the wing in the summer. In addition, many summer flowering plants and their habitats have been harmed by agricultural intensification. Heather, which blooms in August, is an excellent nectar sources but is much reduced in area. Clover, which is another summer-flowering plant that is an excellent nectar source, is less used today than in the past as its ability to “fix” atmospheric nitrogen is no longer as vital to farming as it once was, thanks to the availability of nitrogen fertilizers that do this industrially.

Fig. 8. A honey bee and a bumble bee both forage on a flower of knapweed, a wild flower found in agricultural land, especially grazing land. (Photo: Francis Ratnieks).

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https://www.youtube.com/watch?v=hbGRWoqJVQs

Research – The Sussex Plan for honey bee health and well being

Helping bees in urban gardens and parks

Mihail Garbuzov, Francis Ratnieks

Funding
This research is funded by the Body Shop Foundation

Bees are almost entirely dependent on flowers for food. One way of helping bees is to increase flower numbers. Garden flowers are visited by many bee species including honey bees. Honey bees routinely forage several kilometres from the hive, and maximally at 10-12 km. As a result, a garden with attractive flowers has the potential to provide food for many colonies. Garden flowers should be especially valuable in the summer, which is the season when honey bees fly the furthest to forage, indicating it is hard to find high quality flower patches.

Helping bees in gardens seems simple: just plant more flowers - but which? Ornamental garden flowers vary greatly in their attractiveness to bees and other insects. Lists of bee-friendly plants are available, but in a survey we made of these lists, we found that they have various shortcomings. Unsurprisingly, given that there are tens of thousands of garden flower varieties, lists are incomplete. In addition, they oversimplify. Asters are often included on lists, but there are many varieties. We surveyed over 200 aster varieties at the national collection at Picton Garden in Worcestershire. We found that most varieties actually attracted few bees and other insects. In short, different varieties of asters range from excellent to useless when it comes to bees.

Perhaps the biggest shortcoming is simply that it is not clear how the lists were made. In particular, which data were used to compile them? To put the process on a firmer scientific footing we planted special beds of 32 summer-flowering garden flower varieties on the University campus, and counted the insects throughout the bloom period for two years. Overall, 29% of the insects attracted were honey bees. The most attractive varieties had 100 times as many visiting insects. This is an important result, as it shows that it is possible to make a garden more bee friendly at zero cost, simply by choosing different varieties, as every variety we used was attractive to the human eye, and easy to obtain and grow. We found a similar situation in a local park, as only three of the 79 flower varieties being grown were highly attractive to insects.

Helping bees in parks and gardens is not just about planting attractive varieties. It is also possible to help what is already there. One unsung hero is ivy. Ivy has the least colourful flowers possible, green and lacking petals, but they produce pollen and nectar. By analysing pollen loads, we found that 90% of the autumn pollen collected by honey bees were ivy. Towns also contain grassy areas. In a Brighton park, the Saltdean Oval, we monitored wild flowers and insects in half of the park where the council had reduced grass cutting. A huge range of wild flowers, which had been living there all along, could now grow and bloom. The long grass area had about 20 times as many insects as the short grass area. One of the commonest wild flowers that benefitted from reduced cutting was black knapweed, which is extremely attractive to honey bees.

Fig. 9. Southover Grange Garden is a beautiful park in the Sussex town of Lewes. In August 2012 the garden has wonderful display of attractive flowers. However, most of the 79 flower varieties being grown were visited little, 47%, or not at all, 30%, by bees and other insects. Only 4% were highly attractive. This is probably typical of many gardens.

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Videos (from the LASI You Tube channel "LASI bee research & outreach"

Quantifying Variation Among Garden Plants in Attractiveness to Bees and Other Insects
https://www.youtube.com/watch?v=4u2LeTPGo9w

LASI Research on the Attractiveness of Ornamental Garden Flowers to Bees & Other Insects
https://www.youtube.com/watch?v=stMgzQ1_kVA

How to determine good plants for your garden by counting insects
https://www.youtube.com/watch?v=I8BgUjl0ayU

Research: Foraging and defence behaviour of bees

Kyle Shackleton, Francis Ratnieks

Project 1: Suicidal behaviour in stingless bees

Some stingless bee species, particularly the genus *Trigona*, are known locally in Brazil for their high levels of aggression. Lacking a sting, workers instead bite intruders with their mandibles. Workers are so tenacious and persistent in their attack, that they refuse to stop even when their life is threatened, suggesting that this behaviour may be suicidal. In São Paulo State, Brazil, using a field bioassay we recorded four measures of aggression in 12 stingless bee species, including three *Trigona*. We elicited defensive responses by waving a black flag at the colony entrance. Species varied significantly in their probability of attack, latency of attack, number of attacking bees and attack duration, with *Trigona* being more aggressive than other species. We then submitted the six most aggressive species to a second bioassay to test their propensity for suicidal behaviour. Bees were allowed to bite a flag as before. We then clamped their wings with a pair of forceps and pulled. Bees could either release their grip and fly away, or continue biting the flag which would result in damage to their bodies, such that they functionally committed suicide. In this we gave bees a behavioural choice; let go and live, or refuse and die. All six species had at least some suicidal workers, with 83% being the highest in *T. hyalinata*. We also found that aggression correlated with biting pain, and that the *Trigona* bees had five, sharp teeth on each mandible, a possible defensive adaptation. This project has been published.

Fig. 10. Biting stingless bee *Trigona rufiventris*, Brazil, March 2014. (Photo: Francis Ratnieks).

Project 2: Feeding preferences of UK garden butterflies

Gardens are being increasingly recognised as an important resource for wildlife. ‘Insect-friendly’ plant varieties are often promoted as being beneficial for flower-visiting insects such as butterflies. But are these recommended plants universally beneficial for butterflies? We studied which butterflies visited 11 recommended plant varieties. We found that each plant attracted only a subset of the butterfly community and that some species, such as *Buddleia* which is often referred to as the ‘butterfly bush’, while excellent at attracting some species, were very poor at attracting others. This shows that highly regarded plants are not universally beneficial to flower visitors, and a variety of species are needed for an insect-friendly garden.

Project 3: Does the waggle dance allow honey bees to forage at greater distances than other bees of their size?

Honey bees are known to be able to forage at great distances, with several studies reporting distances > 10km in *Apis mellifera*. The communication of the location of food sources through the waggle dance should change the economics of foraging. We hypothesised that this would allow honey bees to forage at longer distances than would be predicted by their body size. First, in a literature review/meta-analysis, we were able to show that for the four honey bee species for which data was available, all foraged further than their body size would predict. However, the data required for a formal analysis was not available in the literature. Second, through a simple mathematical model, we presented scenarios where dance communication would allow bees to forage profitably at longer distances. Our argument is very suggestive that dance communication plays a large role in allowing honey bees to forage far, but ultimately the required data is lacking and we cannot draw a firm conclusion. This project has been written up and submitted to *Frontiers in Ecology and Evolution*.

Project 4: The effect of plant height on insect foraging

Results from project 2 indicated that different plants attracted different subsets of butterfly species. One of the most striking examples of this was how *Buddleia* attracted many nymphaline species and individuals but very few satyrines compared to other species. One possible explanation was that certain butterflies may prefer foraging at different heights, and that *Buddleia*, being higher than the other plants studied, therefore attracted a disproportionate amount of these butterflies. We tested this formally by setting up a field trial using six species of potted plants. Plants were placed at one of two height treatments; ground level and 2m. Plants were elevated to 2m using platforms mounted on wooden stakes fixed into the ground. We then recorded the number of each species of butterfly, bee and hover fly that visited each plant species at each height. Preliminary analysis indicates that some insect species have preferences for certain heights. Interestingly, the honey bee was distributed almost exactly evenly between high and low plants.

Project 5: The effect of rain on the foraging of flower-visiting insects

Foraging success is critical for overall colony fitness. Adverse weather conditions, such as rain, are known to negatively impact foraging through studies on colony weight change. Little is known about how rain affects insect foraging at the level of the patch. For example, for how long after a rain event is foraging impaired, and are all plants affected the same? We performed a field experiment using five flower species in which patches were wetted with either a “light” or “heavy” rain treatment of 1/3 mm per m^2 respectively. We then measured the time taken for the insect activity on the patch to recover to pre-rain levels. We found that the heavy rain treatment affected insect foraging more severely than the light treatment. Furthermore, borage, a downward facing flower which shelters it from the rain was less affected than upward facing species, while composite flowers act like a “sponge” for rainwater and were most adversely affected of all. We also followed individual bees and recorded their foraging decisions after rain treatments. Bees rejected more flowers immediately after a rain event than before. As time passed by, bees rejected fewer flowers and approached their pre-rain levels. However, time spent on a patch did not change with time after rain.

Publications

Shackleton, K., Toufailia, H.A., Balfour, N.J., Nascimento, F.S., Alves, D.A., Ratnieks, F.L.W. (2014). Appetite for self-destruction: suicidal biting as a nest defence strategy in *Trigona* stingless bees. *Behavioural Ecology and Sociobiology*, 1–9.

Media mentions

New Scientist http://www.newscientist.com/article/dn26562-zoologger-stingless-suicidal-bees-bite-until-they-die.html#.VKwAMHuMk5w

IFLScience http://www.iflscience.com/plants-and-animals/suicidal-bee-no-stinger-bites-down-until-it-dies

Making a B-Line for London

Karin Alton

Karin Alton is part of a new coalition of nine organisations, the *Making a B-Line for London Partnership,* which is planning an initiative across London aiming to deliver key recommendations within the government's new National Pollinator Strategy.

London has a key role to play in supporting pollinators and other wildlife, alongside farmers and landowners in the surrounding countryside. 33% of the capital is green space, with private gardens adding another 14%, making a whopping 47% of Greater London suitable to share with wildlife.

Making a B-Line for London aspires to increase the diversity and abundance of pollinating insects in London's green spaces and gardens. It also aims to raise awareness of the benefits of pollinators and encourage action to protect, conserve and celebrate these important insects. Subject to funding, it will do this through:

- increasing the amount of suitable habitat available for a range of pollinating insects by demonstrating and promoting simple changes to the ways we manage London's parks, gardens and other green spaces;

- monitoring changes in the abundance and diversity of pollinating insects in response to greater habitat availability in order to highlight the most effective and efficient techniques and interventions for increasing the amount of good quality habitat;

- providing tools and advice to help people improve spaces for pollinators.

A *London B-Line* has been identified, running roughly north to south from Enfield to Croydon. This is based on existing pollinator hotspots and aims to create new habitats which will link and support the existing hotspots.

Within defined target areas along the *London B-Line*, the partnership will work with the managers and owners of parks, gardens, allotments and green spaces to change the way land is designed and managed to improve or create flower-rich areas, connecting existing good quality pollinator habitat.

We are also developing an on-line toolkit to enable Londoners to identify and create local *B-Lines*, encouraging the development of a grid of *B-Lines* across London.

The partnership has agreed a five year plan to start, grow and establish the project. Monitoring is a crucial part of the delivery. We will be checking diversity and abundance of pollinating insects along the *B-Line*, in order to determine the most effective and efficient ways of achieving an increase in pollinating insects. The *Making a B-Line for London Partnership* will help improve London's landscape for pollinators. It will play a valuable role in creating and connecting essential pollinator friendly green spaces for the benefit of communities and biodiversity.

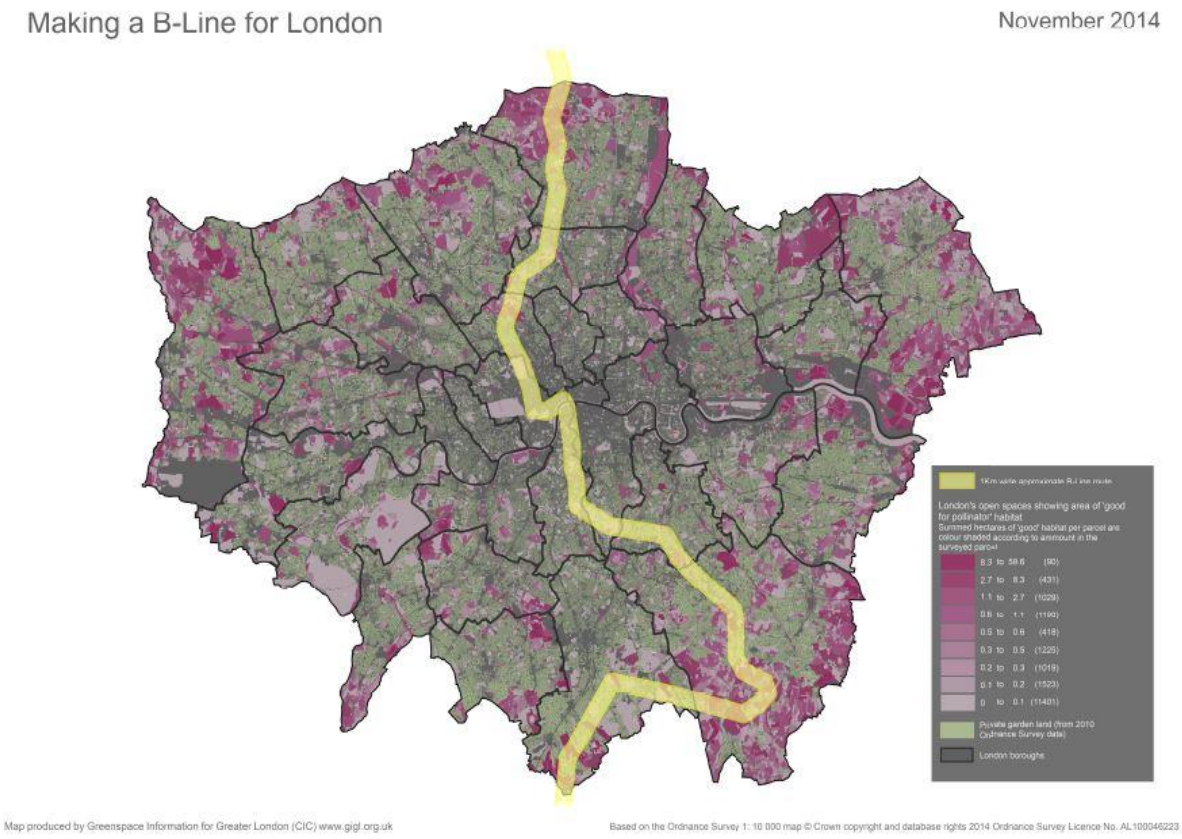

Fig. 11. The *London B-Line* shown based on a geographic information system which has been developed by Greenspace information for Greater London (GiGL), following the ranking of GiGL Open Space and Habitat Datasets' survey categories according to their suitability to support insect pollinators, to estimate a) the location of London's existing good habitat for pollinating insects, and where there may be greatest potential to improve habitat for pollinating insects b) where the most likely pollinator friendly sites are, based on open space categories for their suitability to support insect pollinators.

Making a B-Line for London Partnership

The Making a *B-Line for London Partnership* comprises the following organisations: Bee Collective, Buglife, Forestry Commission, Greater London Authority, Greenspace information for Greater London, London Wildlife Trust, Natural England, RSPB and LASI, University of Sussex. The partnership will expand during delivery to include a range of greenspace managers, landowners, community groups, households, schools, businesses, allotment associations, beekeeping associations and the public.

Outreach and Public Communication 2014

LASI has continued to make important strides in terms of disseminating our research to stakeholders. Once again talks and lectures were to beekeeping and other groups across the country, reaching an audience of nearly 3,000 people. These presentations covered a range of topics around research conducted at LASI. A list of academic and popular talks given in 2014 can be found in Appendix 2.

We hosted numerous visits to the laboratory to showcase our research, ranging from commercial beekeepers from Sweden, to international study group agents looking for suitable universities to send their students, and, of course, the new beekeeping apprentices being trained by the Bee Farmers Association sponsored by Rowse honey.

Fig. 12. Top left: A presentation to international study agents. Top right: Norman Carreck talking to a group of local pre-school children about bees. Bottom left: A delegation of Swedish bee farmers on a study tour of Britain and Germany. Bottom right: Margaret Couvillon demonstrating the 'waggle dance' to visitors to LASI.

Margaret Couvillon continued to contribute articles for the public on current bee research topics for *Beekeepers Quarterly*, one of Europe's largest hobby beekeeping journals. In August 2014 she became an Associate Editor in charge of reviews for articles for *Insectes Sociaux*, the journal of the International Union for the Study of Social Insects (IUSSI). Norman Carreck continues to be Senior Editor of the *Journal of Apicultural Research*, the journal of the International Bee Research Association (IBRA).

Workshops

During the Summer and autumn of 2014 LASI hosted two sets of workshops, Our main workshops this year were targeted at stakeholders. Following the two previous years' success, an afternoon workshop on 'Garden plants for bees' was held in July, with participants professionally involved with greenspace management. This workshop, run by Francis Ratnieks, Mihail Garbuzov and Kyle Shackleton, followed a similar format as in previous years.

In September LASI hosted a hugely popular workshop entitled 'Integrated Varroa Management'. Varroa mites are pests of the western honey bee *Apis mellifera*, and large numbers of *v*arroa mites can kill a bee colony and can also increase the virus load within a hive. Controlling *v*arroa is considered essential for successful beekeeping. This workshop was therefore targeted at beekeepers, showing LASI research which may enable them to minimise the level of varroa infestation in the hive. An introductory lecture by Francis Ratnieks gave an overview on various techniques such as hygiene, which is a natural behaviour of honey bee workers that helps confer resistance to brood diseases and to *v*arroa; how to carry out drone trapping; and the use of oxalic acid as a acaricide. The lectures were followed by demonstrations on how to use these methods. On each of the two afternoons the sessions held a total maximum booking of 25 attendees. This workshop was run by Karin Alton, Norman Carreck, Luciano Scandian and Hasan Al Toufailia.

Fig. 13. Top left: Hasan Al Toufailia demonstrates oxalic acid treatment. Top right: Karin Alton explains about varroa biology. Bottom left: Luciano Scandian demonstrates the freeze-kill liquid nitrogen technique used to determine which honey bee colonies are hygienic. Bottom right: The microscope and educational materials set-up used in the Integrated Varroa Management workshop.

LASI Open day

Once again we hosted an Open Day where the public would be able to interact with the staff and students at LASI, and gain a valuable insight to our research in the bee laboratory. Over a hundred people visited the lab on the 17th of July and witnessed a range of stations set up to demonstrate and explain LASI research. These stations covered gardening for bees, varroa control, hygienic behaviour and queen rearing, and ant communication. A whole range of visitors were represented, from beekeepers, gardeners and the general public. Francis Ratnieks gave an introductory overview of the work carried out at LASI, and visitors had plenty of opportunities to join conversations around the various stations. Many questions were asked by beekeepers who also discussed their own experiences with bees, and listened to what LASI researchers had to comment about their own work on social insects. Refreshments were available to purchase in the lab garden from the popular pop-up tea stand; these ranged from tea and coffee to a selection of delicious cakes and muffins, as well as scones with whipped cream and jam. Many comments of appreciation were proffered by visitors on both the opportunity to visit the lab and hear about LASI research, and also on the provision of afternoon teas.

Fig. 14. Top left: The LASI team on the Open Day. Top right: PhD student Thomas Butterfield show visitors ant colonies and explain how pheromone trails work. Bottom left: PhD student Nick Balfour shows the intricate differences between bees and other flower visitors. Bottom right: Gaby Lethbridge with the pop-up tea stand kindly provided home-made cakes and beverages.

LASI website and other on-line resources

The web statistics for 2014 show that our website www.sussex.ac.uk/lasi continues to attract viewers from across the world, enabling them to access 85 pages of information about LASI and about bees. Around 37,000 pages were viewed this year, once again our educational

resources for youngsters, the details of the *Sussex Plan for Honey Bee Health and Wellbeing,* and our latest news and events were the most popular views.

Karin Alton continues to maintain a twitter account @LasiBee and a Facebook page, currently with 315 members, https://www.facebook.com/groups/366029775708/ where bee and ant related news and information is shared with colleagues from other academic institutions and also members of the public with an interested in social insects.

A further four video clips were added to LASI's You Tube channel including 'Dancing bees cast their votes on the best land-types and areas for their food collection' and 'A returning honey bee forager tells her nestmates where she collected food. ' These two clips refer to research carried out by Margaret Couvillon and other researchers from LASI. Additional film clips relating to research on dance decoding and garden plants have also been added.

These video clips are located on our LASI You Tube channel **http://www.youtube.com/user/LASIbeeResearch?feature=watch** , and have so far had over 12,000 viewings, proving that LASI research disseminated using visual media is an excellent tool to reach our stakeholders.

Funding

Since 2008, the *Sussex Plan for Honey Bee Health and Wellbeing* has been generously funded by philanthropic donations. We would like to thank our all our supporters who have recognised the importance of LASI's research in helping to find evidence-based solutions to the problems facing the honey bee and other critical pollinators. Donations large and small have come from a wide variety of sources, including companies, trusts and foundations, beekeepers' associations and individuals.

Doctoral students funded by the Body Shop Foundation and the British Beekeepers' Association have now successfully completed their PhDs, and both have made significant contributions to honey bee research. A further PhD student, funded by Waitrose and the CB Dennis Trust, is making excellent progress. Support from the Esmée Fairbairn Foundation for our Honey Bee Research Facilities Manager continues to enhance the research capability and output of LASI.

As always we are particularly grateful to all the donors who make a commitment to support LASI over a number of years. One of our funders, Rowse Honey Ltd, has been supporting our research for six years. Rigorous scientific research is a long term investment and we are grateful that our donors have the vision to recognise the importance of continuity and commitment.

We are now seeking support for a range of exciting new projects, which build on the achievements of the past six years. In the future, philanthropic support will be essential to ensure that the momentum of the *Sussex Plan* is maintained so we can continue to conduct excellent research to help honey bees and pollinators. Everyone at LASI would like to thank our donors, past and present, for their generosity and hope that they will continue to support our vital work in the years to come.

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Media engagement

Media highlights, 2014

APRIL

Scientists decode honey bee waggle dance.
Francis Ratnieks interviewed about waggle dances.
The Guardian. By Alison Benjamin, 3/4/14

Dancing bees reveal why summer isn't the season of plenty.
LASI researchers interviewed about waggle dance.
Phys.Org, 3/4/14

Why summer is anything but a holiday for the bees.
LASI researchers and the waggle dance.
The Telegraph, by Jasper Coppin, 13/4/14

To bee or not to bee is a worrying question.
Francis Ratnieks interviewed about pesticides.
The Independent. By Martha Kearney, 13/4/14.

The wonder of bees with Martha Kearney.
Margaret Couvillon interviewed about waggle dances.
BBC 4 TV, 28/4/14

Target the best bee friendly plants.
Francis Ratnieks and Mihail Garbuzov interviewed about plant lists.
The Telegraph. By Ken Thompson, 29/4/14

MAY

Das rätselhafte Bienensterben
Norman Carreck interviewed in article about European Epilobee study.
Märkische Oderzeitung: 21/5/14

The Sarah Gorrell Show.
Margaret Couvillon interviewed about waggle dances.
BBC Radio Sussex and Surrey, 22/5/14

If you're looking for a healthy environment, follow the dancing bee.
Margaret Couvillon interviewed about waggle dances.
Scientific American. By Geoffrey Giller, 22/5/14

Eavesdropping bees reveals the state of the environment.
Margaret Couvillon interviewed about waggle dances.
News Discovery. By Jennifer Viegas, 22/5/14

Honey bee dances map healthy landscapes.
Margaret Couvillon interviewed about waggle dances.
National Geographic, By Jennifer S. Holland, 22/5/14

Honey bee dances lead the way on agriculture and the environment.
Margaret Couvillon interviewed about the waggle dance.
Western Daily Press, 23/5/14

Newsdrive.
Margaret Couvillon interviewed about waggle dances.
BBC Radio Scotland, 23/5/14

The Pete Morgan Show.
Norman Carreck interviewed about Asian hornets.
BBC Radio WM 95.6, 27/5/14

Honey bee waggle dance tells researchers about the health of the ecosystem.
Margaret Couvillon interviewed about the honey bee waggle dance.
TreeHugger, 28/5/14

Dancing bees reveal better land.
Margaret Couvillon interviewed about waggle dances.
Nature Highlights, 29/5/14

JUNE
The Danny Kelly Show.
Norman Carreck interviewed about Asian hornets.
BBC Radio WM 95.6, 5/6/14

JULY
Wild honey bees - does their disappearance really matter?
Norman Carreck interviewed about native honey bees.
BBC Nature website. By Zoe Gough, 15/7/14

Are animals the best allies in war?
Norman Carreck interviewed about sniffer bees
BBC News website. By Claire Jones, 19/7/14

SEPTEMBER
Dancing bees waggle their way to a happier habitat.
Margaret Couvillon interviewed about waggle dances.
Ensia Magazine. By Leah Shaffer, 8/9/14

A step into the unmown creates a win-win for wildlife and humans.
Francis Ratnieks and Mihail Garbuzov interviewed about Saltdean Oval Project.
Phys.Org, 18/9/14

More or less
Francis Ratnieks interviewed about the weight of ants.
BBC Radio 4, 22/9/14

Are all the ants as heavy as the humans?
Francis Ratnieks interviewed about the weight of ants.
BBC News Magazine. By Hannah Moore, 22/9/14

Uncut grass a big hit with park users.
Francis Ratnieks and Mihail Garbuzov interviewed about Saltdean Oval Project.
The Argus, 24/9/14

For city parks head for the great unmown.
Francis Ratnieks interviewed about Saltdean Oval Project.
CityLab. By Laura Bliss, 26/9/14

Add sunspots to the list of possible causes of honey bee Colony Collapse Disorder.
Norman Carreck interviewed about magnetic fields and bees.
Entomology Today, 29/9/14

Colony Collapse Disorder may also be due to sunspots.
Norman Carreck interviewed about magnetic fields and bees.
Red Orbit, 30/9/14

OCTOBER
Aussie bees fight 'hive wars'.
Francis Ratnieks interviewed about stingless bees.
BBC News Science and Environment. By Jonathan Webb, 21/10/14

Sick honey bees may be nursed by doctors.
Francis Ratnieks interviewed about nurse bees.
BBC Earth. By Richard Gray, 24/10/14

NOVEMBER
Farming Today
Norman Carreck interviewed about National Pollinator Strategy.
BBC Radio 4, 5/11/14

Will the UK's Pollinator Strategy be enough to stop bee decline?
Norman Carreck interviewed about National Pollinator Strategy.
The Guardian. By Karl Mathieson, 5/11/14

Breakfast with Claire Carter.
Norman Carreck interviewed about National Pollinator Strategy.
BBC Radio Gloucestershire, 8/11/14

The Bill Buckley Show.
Norman Carreck interviewed about National Pollinator Strategy.
BBC Radio Devon, 11/11/14

Inner workings - breaking down bee dances.
Margaret Couvillon interviewed about waggle dances.
Proceedings of the National Academy of Sciences. By Helen Shen, 11/11/14

Zoologger - stingless bees bite until they die.
Francis Ratnieks and Kyle Shackleton interviewed about stingless bees.
New Scientist Life. By Penny Sarchet, 14/11/14

Suicidal bee with no stinger bites down until it dies
Francis Ratnieks and Kyle Shackleton interviewed about stingless bees.
IFLScience. By Janet Fang, 21/11/14

LASI staff biographies

Professor Francis Ratnieks
Francis Ratnieks is Professor of Apiculture and Director of the Laboratory of Apiculture and Social Insects at the University of Sussex. He obtained his PhD at Dyce Laboratory for Honey Bee Studies, Cornell University, USA, and then worked for the New York State Apiary Inspection Service and as a commercial beekeeper with 180 hives in California. He has studied honey bees on all continents, taught honey bee biology at five universities (Cornell, Berkeley, Sheffield, Sussex, São Paulo) and published more than 250 articles on honey bees and social insects.

Dr Karin Alton
Karin Alton is a Research Fellow at LASI. Following a career in commercial and retail finance, she obtained a Zoology degree at Nottingham University, followed by a PhD in Entomology. Karin has worked with hover flies, aphids, tephritid flies, bugs and beetles of various grasslands, and now with honey bees. Her research interests include not only honey bee diseases and pollination but also habitat selection; looking at insect-plant interactions from both an intra-and inter-specific level. Karin is a keen beekeeper with an interest in outreach and education. She teaches beginner courses and helps give hands-on practical experience to novice beekeepers.

Hasan Al-Toufailia
Hasan Al Toufailia studied for his BSc at the University of Damascus, Syria where he had also been working as an entomologist. He came to LASI in June 2010 to carry out a PhD in honey bee biology so that he can return home and become Syria's honey bee expert. His research is investigating how to help honey bees and insect pollinators in urban areas. He has broad interests in ecology and conservation.

Nick Balfour
Nick Balfour read his BSc in Ecological Science at Edinburgh University and followed this with an MSc in Entomology at Imperial College, London. He began his PhD '*Helping Bees and Agricultural Pollination in Farm Land*' in January 2012. His research will investigate both crop pollination (apples and blueberries) and measures to help nectivores on farmland. This research is being sponsored by Waitrose Plc and the C B Dennis Beekeepers Research Trust.

Dr Gianluigi Bigio
Gianluigi Bigio obtained his BSc in Italy before moving to Ireland to do research in plant genetics. He came to LASI in April 2010 to carry out a PhD in applied honey bee biology. His research is investigating hygienic behaviour in honey bees and improved methods of using queens in a breeding programme.

Tom Butterfield
Ton Butterfield has a 1st Class BSc (Hons) in Biological Sciences (Zoology) from the University of Leicester. He began his PhD at LASI in December 2012 and is studying the chemical ecology and organization of ant colonies, primarily their use of pheromones for intra and inter colony communication. His current study species is the yellow meadow ant, *Lasius flavus*. Initially he will be identifying the constituent compounds in their trail pheromones via

GC/MS and subsequently deducing whether these compounds are modified in response to changes in the foraging environment.

Norman Carreck
Norman Carreck is the senior research technician at LASI and has been keeping bees since the age of 15. He read Agricultural Science at the University of Nottingham and then worked at Rothamsted Research, Hertfordshire, UK, for nearly twenty years as a research scientist studying bee behaviour, pollination ecology and bee pathology. He is the UK member of the Executive Committee of the international bee research network COLOSS, and is also Senior Editor of the *Journal of Apicultural Research* and Science Director of the International Bee Research Association. He holds the National Diploma in Beekeeping and is a Fellow of the Royal Entomological Society and a Fellow of the Society of Biology.

Dr Margaret Couvillon
Margaret Couvillon is a postdoctoral researcher at LASI. She received her BSc from Loyola University, New Orleans, USA in Biology, where she was the highest ranked graduate in 2000. She was awarded a Fellowship from the National Science Foundation to study at the University of Sheffield, from which she obtained her PhD for work on mechanisms of nestmate recognition in honey bees and stingless bees. Afterwards, she won a fellowship to work at the University of Arizona, USA (2007-2009) on honey bees and bumble bees. Her interests include behavioural ecology and evolutionary biology of social insects and science education and outreach.

Dr Mihail Garbuzov
Mihail Garbuzov did his BSc at the University of Sussex, and began his PhD research at LASI in June 2010. His research is investigating how to help honey bees and insect pollinators in urban areas. He has broad interests in ecology and conservation.

Dr Martyn Stenning
Martyn Stenning studied for his PhD at Sussex and is technical supervisor for LASI. He has supervised much of the renovation and ongoing expansion work at the lab. His research interests include the study of organisms (especially birds and dormice) in relation to their environment and he is particularly fascinated by the dependence of species on other species or their own for cues that lead to reproductive regulation. He also has an active interest in investigating effects of climate change on the local ecology and phenology.

Appendix 1.

Publications 2014 (University of Sussex authors in bold).

Papers in refereed journals

Bigio, G., Al Toufailia, H. Ratnieks, F.L.W. (2014) Honey bee hygienic behaviour does not incur a cost via removal of healthy brood. *Journal of Evolutionary Biology* **27,** 226-230. http://dx.doi.org/10.1111/jeb.12288

Bigio, G., Al Toufailia, H, Hughes, W.O.H, Ratnieks, F.L.W. (2014) The effect of one generation of controlled mating on the expression of hygienic behaviour in honey bees. *Journal of Apicultural Research* **53(5),** http://dx.doi.org/10.3896/IBRA.1.53.5.07

Carreck, N.L., Ratnieks, F.L.W. (2014) The dose makes the poison: have "field realistic" rates of exposure of bees to neonicotinoid insecticides been over estimated in laboratory studies? *Journal of Apicultural Research* **53(5):** 607-614. http://dx.doi.org/10.3896/IBRA.1.53.5.08

Couvillon, M. J., Boniface, T.J., Evripidou, A.M., Owen, C.J., Ratnieks, F.L.W. (2014) Unnatural contexts cause honey bee guards to adopt non-guarding behaviours towards allospecifics and conspecifics. *Ethology*, http://dx.doi.org/10.1111/eth.12347

Couvillon, M. J., Fensome, K. A., Quah, S. L. K., Schürch, R (2014) Summertime blues: August foraging leaves honey bees empty-handed. *Communicative and Integrative Biology* 7, e28821 http://dx.doi.org/10.4161/cib.28821

Couvillon, M. J., Riddell-Pearce, F. C., Accleton, C., Fensome, K. A., Quah, S. L. K., Taylor, E., Ratnieks, F. L. W. (2014) Honey bee foraging distance depends on month and forage type. *Apidologie* 46(1), 61-70. http://dx.doi.org/10.1007/s13592-014-0302-5

Couvillon, M. J., Schürch, R., Ratnieks, F. L. W. (2014) Dancing bees communicate a foraging preference for rural lands in high-level agri-environment schemes. *Current Biology* 24, 1-4. http://dx.doi.org/10.1016/j.cub.2014.03.072

Couvillon, M. J., Schürch, R., Ratnieks, F. L. W. (2014) Waggle dance distances as integrative indicators of seasonal foraging challenges. *PLoS ONE,* http://dx.doi.org/10.1371/journal.pone.0093495

Czaczkes, T. J.,Grüter, C., Ratnieks, F.L.W. (2014) Rapid up- and down-regulation of pheromone signalling due to trail crowding in the ant *Lasius niger. Behaviour* **151(5),** 669-682. http://dx.doi.org/10.1163/1568539X-00003157

Garbuzov, M., Schürch, R., Couvillon, M. J. C., Ratnieks, F.L.W. (2015) Honey bee dance decoding shows limited foraging on oilseed rape, a potential source of neonicotinoid contamination. *Agriculture, Ecosystems, Environment*, http://dx.doi.org/10.1016/j.agee.2014.12.009

Garbuzov, M., Ratnieks, F. L. W. (2014) Listmania: The strengths and weaknesses of lists of garden plants to help pollinators. *BioScience,* http://dx.doi.org/10.1093/biosci/biu150

Garbuzov, M., Samuelson, E. E. W., Ratnieks, F.L.W. (2014) Survey of insect visitation of ornamental flowers in Southover Grange garden, Lewes, UK. *Insect Science,* http://dx.doi.org/10.1111/1744-7917.12162

Garbuzov, M., Fensome, K., Ratnieks, F. L. W. (2014) Public approval plus more wildlife: twin benefits of reduced mowing of amenity grass in a suburban public park in Saltdean, UK. *Insect Conservation and Diversity*, http://dx.doi.org/doi: 10.1111/icad.12085

Garbuzov, M., Ratnieks, F. L. W. (2014) Ivy: an underappreciated key resource to flower-visiting insects in autumn. *Insect Conservation & Diversity* 7, 91-102.

Garbuzov, M., Ratnieks, F.L.W. (2014) Quantifying variation among garden plants in attractiveness to bees and other flower-visiting insects. *Functional Ecology* **28,** 364-374.

Garbuzov, M., Ratnieks, F. L. W. (2014) Lattice fence and hedge barriers around an apiary increase honey bee flight height and decrease stings to people nearby. *Journal of Apicultural Research* **53,** 67-74. http://dx.doi.org/10.3896/IBRA.1.53.1.06

Garbuzov, M., Schürch, R., Ratnieks, F. L. W. (2014) Eating locally: dance decoding demonstrates that urban honey bees forage mainly in the surrounding urban area.

Kärcher, M.H., Ratnieks, F. L. W. (2014) Killing and replacing queen-laid eggs: low cost of worker policing in the honey bee. *American Naturalist* **184(1),** 110-118. http://dx.doi.org/10.1086/676525

Meixner, M.D., Büchler, R., Costa, C., Francis, R., Hatjina, F., Kryger, P., Uzunov, A., **Carreck, N.L.** (2014) Honey bee genotypes and the environment. *Journal of Apicultural Research* **53(2),** 183-187. http://dx.doi.org/10.3896/IBRA.1.53.2.01

Pinto, M.A., Henriques, D., Chávez-Galarza, J., Kryger, P., Garnery, L., van der Zee, R., Dahle, B., Soland-Reckeweg, G., de la Rúa, P., Dall' Olio, R., **Carreck, N.L.,** Johnston, J.S. (2014) Genetic integrity of the Dark European honey bee (Apis mellifera mellifera) from protected populations: a genome-wide assessment using SNPs and mtDNA sequence data. *Journal of Apicultural Research* **53(2),** 269-273. http://dx.doi.org/10.3896/IBRA.1.53.2.08

Shackleton, K., Toufailia, H.A., Balfour, N.J., Nascimento, F.S., Alves, D.A., **Ratnieks, F.L.W.** (2014). Appetite for self-destruction: suicidal biting as a nest defence strategy in *Trigona* stingless bees. *Behavioural Ecology and Sociobiology*, 1–9.

Al Toufailia, H., Amiri, E., **Scandian, L.,** Kryger, P., **Ratnieks, F.L.W.** (2014) Towards integrated control of varroa: effect of variation in hygienic behaviour among honey bee colonies on mite population increase and deformed wing virus incidence. *Journal of Apicultural Research,* **53(5),** http://dx.doi.org/10.3896/IBRA.1.53.5.10

Al Toufailia, H., Couvillon, M.J., Ratnieks, F.L.W., Grüter, C. (2013) Honey bee waggle dance communication: signal meaning and signal noise affect dance follower behaviour. *Behavioural Ecology and Sociobiology*, **67(4),** 549-556. http://dx.doi.org/10.1007/s00265-012-1474-5

Al-Toufailia, H., Grüter, C., Ratnieks, F.L.W. (2013) Persistence to unrewarding feeding locations by forager honey bees (*Apis mellifera*): the effects of experience, resource profitability, and season. *Ethology*, **119,** 1096-1106. http://dx.doi.org/10.1111/eth.12170

Al Toufailia, H., Scandian, L., Ratnieks, F.L.W. (2015) Towards integrated control of varroa: Comparing application methods and doses of oxalic acid on the mortality of phoretic *Varroa destructor* mites and their honey bee hosts. *Journal of Apicultural Research* (in press).

Books

Matheson, A., **Carreck, N.L.** (Eds) (2014) *Forage for pollinators in an agricultural landscape*. International Bee Research Association; Treforest, UK. 75 pp. Soft cover. ISBN: 978-0-86098-277-7

Wilson-Rich, N., Allin, K., **Carreck, N.L.,** Quigley, A.S. (2014) *The bee - a natural history*. Ivy Press; Lewes, UK. 224 pp. Hardback. ISBN: 978-1-78240-107-0

Wilson-Rich, N., Allin, K., **Carreck, N.L.,** Quigley, A.S. (2014) *The bee - a natural history*. Princeton University Press; Princeton, NJ, USA. 224 pp. Hardback. ISBN: 978-0-691-16135-8

Book chapters, conference proceedings etc.

Brodschneider, R., Bozic, J., **Carreck, N.L.,** Coffey, M.F., Crailsheim, K., Dahle, B., Danihlík, J., Filipi, J., Gray, A., González-Porto, A-V., Ion, N., Klima, J., Kristiansen, P., Lilek, N., Mayr, J., Medrzycki, P., Moosbeckhofer, R., Odoux, J-F., Peterson, M., Podrižnik, B., Ruiz, J.A., Jørgensen, A.S., Tosi, S., Vejsnæs, F., Williams, G., van der Steen, J. (2014) Outcome of the Workshop. *Proceedings of COLOSS workshop:*

CSI Pollen - training the National Coordinators, Graz, Austria 6-7/2/14.
Carreck, N.L. (2014) Pollen sources for bees in the UK. *Proceedings of COLOSS workshop: CSI Pollen - training the National Coordinators, Graz, Austria 6-7/2/14.*
Carreck, N.L. (2014) Introduction. In *A. Matheson, N.L. Carreck (Eds) Forage for pollinators in an agricultural landscape.* International Bee Research Association, Treforest, UK. pp 3-6.
Carreck N.L. (2014) *What future for local bees in Britain?* In abstracts, BIBBA / SICAMM Anniversary Conference, Llangollen , UK, 26-28 September, 2014. p 11.
Carreck N.L., Ratnieks, F.L.W. (2014) Bee visitation on neonicotinoid treated maize in the UK. In *Proceedings of 6th European Conference of Apidology, Murcia, Spain, 9-11 September 2014*. 23-4.
Al Toufailia, H., Scandian, L., Ratnieks, F.L.W. (2014) Towards integrated control of varroa: effect of variation in hygienic behaviour among honey bee colonies on mite population increase and symptoms of deformed wing virus. In *Abstracts, BIBBA / SICAMM Anniversary Conference, Llangollen , UK, 26-28 September, 2014.* p 32.
Williams, I.H., **Carreck, N.L.** (2014) Land use changes and honey forage plants. In *A. Matheson, N.L. Carreck (Eds) Forage for pollinators in an agricultural landscape.* International Bee Research Association, Treforest, UK. pp 7-20.

Popular articles.

Carreck, N.L. (2014) What is: IBRA? *British Beekeepers Association News* **221**, 66.
Carreck, N.L. (2014) Biology of other *Apis* honey bees. *Beekeeping* **80(2)**, 32.
Carreck, N.L. (2014) Are we beginning to understand worldwide colony losses? *Bee World* **91(1)**, 20-21.
Carreck, N.L. (2014) Book review: “Pot honey - a legacy of stingless bees” edited by Patricia Vit, Silvia Pedro and David Roubik. *Bee World* **91(1)**, 21.
Carreck, N.L. (2014) CSI Pollen: an opportunity for beekeepers to help research. *British Beekeepers Association News* **221**, 135.
Carreck, N.L. (2014) Fancy yourself as a scientist? CSI Pollen. *Bee Craft* **96(4)**, 41.
Carreck, N.L. (2014) CSI Pollen: an opportunity for beekeepers to help research. *Beekeeping* **80(4)**, 92-3.
Carreck, N.L. (2014) CSI Pollen: an opportunity for beekeepers to help research. *Welsh Beekeeper* **185**, 16-18.
Carreck, N.L. (2014) Honey bee genotypes and the environment. *Bee World* **91(2)**, 38-39.
Carreck, N.L. (2014) Editorial. *Bee World* **91(4)**, 85.
Carreck, N.L. (2014) The small hive beetle and IBRA. *Bee World* **91(4)**, 91-2.
Carreck, N.L. (2014) Electromagnetic radiation and bees again... *Bee World* **91(4)**, 101-102.
Carreck, N.L. (2014) COLOSS and EurBee, Murcia, Spain. *Bee World* **91(4)**, 110-111.
Carreck, N.L. (2014) *Bienenrassen und lokale umwelt*. Mellifera.ch magazin. Verein Schweizerischer Mellifera Bienenfreunde VSMB, November 2014.
Couvillon, M.J. (2014) Promiscuous queens produce tenacious foragers and happy colonies. *Beekeepers Quarterly,* **115.**
Couvillon, M.J. (2014) Summertime and the living ain’t easy: honey bee dances indicate seasonal challenges in food availability. *Beekeepers Quarterly,* **116.**
Couvillon, M.J. (2014) Dancing bees as environmental consultants give effective, efficient, and important information about the state of the rural landscape. *Beekeepers Quarterly,* **117.**
Couvillon, M.J. (2014) Hive wisdom: all foragers can be elite, even if not all foragers are. *Beekeepers Quarterly*, **118.**
Ratnieks, F. L. W. (2014) LASI student’s success: honey bee hygienic behaviour. *Bee Craft* **96,** 39.
Ratnieks, F. L. W. (2014) Varroa: towards integrated control. *British Bee Journal* **1,** 15.
Ratnieks, F. L. W. (2014) Waggle dance decoding: investigating honey bee foraging. *British Bee Journal* **1,** 16.
Ratnieks, F. L. W. (2014) Helping bees in urban gardens and parks. *British Bee Journ*al **1,** 17.

Ratnieks, F. L. W. (2014) Hygienic behaviour: Natural disease resistance in the honey bee. *British Bee Journal* **1,** 18.
Ratnieks, F. L. W. (2014) The Sussex Plan. *Bee Craft* **96,** 20-23
Ratnieks, F. L. W., Garbuzov, M., Balfour, N. J. (2014) Honey bees return in summer 2014. *Bee Craft* **96,** 27-31.
Schürch, R., Couvillon, M.J. (2014) Follow the bees' dance to find landscape's green hotspots. *The Conversation.* https://theconversation.com/follow-the-bees-dance-to-find-landscapes-green-hotspots-27004

Appendix 2.

Talks, exhibitions, workshops and public events given in 2014

8/1/14	Talk: *"Honey bee losses and the facts about neonicotinoids"* to the Grasshoppers Association, Stockbridge, Hampshire. (NC).
18/1/14	Talk and demonstration to "admissions day" visit of prospective students and their parents, University of Sussex. (FR).
30/1/14	Talk: *"The Sussex Plan for Honey Bee Health & Well Being"* to The Pirbright Institute, Surrey. (FR).
2/2/14	Talk: *"pollen sources in the UK"* at COLOSS pollen workshop, Graz, Austria. (NC).
7/2/14	Talk: *"Breeding hygienic honey bees and oxalic acid treatment (best method and dose)"* to Associazione Apicoltori di Breganze, Breganze. Italy. (LS).
18/2/14	Talk: *"How to attract wildlife into your garden"* to Eastbourne Beekeepers Association, East Sussex. (KA).
22/2/14	Talk *"Honey bees as integrative indicators of seasonal foraging challenges"* to West Norfolk Beekeepers' Association. (MC).
22/2/14	Talk and demonstration to "admissions day" visit of prospective students and their parents, University of Sussex. (FR).
22/2/14	Talk: *"Landscape and forage"* at British Beekeepers Association Special Interest Day, Stoneleigh, Warwickshire. (KA).
28/2/14	Talk and demonstration to a group of *c.* 30 agents (people, mainly from Asian countries, who recruit students to UK universities), University of Sussex. (FR).
2/3/14	Talks: *"Science for the thinking beekeeper"* and *"Breeding bees for tolerance to Varroa"* to Co Offaly beekeepers, Birr, Eire. (NC).
7/3/14	Talk and demonstration to a group of c. 30 agents (people, mainly from Asian countries, who recruit students to UK universities), University of Sussex. (FR).
8/3/14	Talk: *"LASI research on varroa control"* to British Beekeepers Association "Varroa Day", National Beekeeping Centre, Stoneleigh, Warwickshire. (FR).
8/3/14	Talk: *"How far do honey bees travel to forage?"* to Cambridgeshire Beekeepers Association. (NC).
9/3/14	Talk: *"Planting for pollinators"* to South East Hampshire Beekeepers Association Convention. (KA).
10/3/14	Talk: *"What does bee foraging distance tell us about forage availability?"* to Guildford Beekeepers' Association. (MC).
17/3/14	Talk: *"LASI research on the attractiveness and value of ornamental garden flowers to bees and other insects"* to Wildlife Gardening Forum meeting, Royal Horticultural Society, Wisley, Surrey. (FR).
19/3/14	Talk: *"The Sussex Plan for Honey Bee Health & Well Being"* to Department of Ecology, University of São Paulo, Riberão Preto, Brazil. (FR).
25/3/14	Talk: *"The Sussex Plan for Honey Bee Health & Well Being"* to Department of Entomology, University of São Paulo "ESALQ", Piracicaba, Brazil. (FR).
29/3/14	Talk: *"Breeding hygienic honey bees and oxalic acid treatment (best method and dose)"* to "Any Natural Thing Club" Guilford, Surrey. (LS).
5-6/4/14	Talk: *"What is the NDB all about?"* at British Beekeepers Association Spring Convention, Harper Adams University. (NC).
8/4/14	Talk: *"Control of varroa mite using different methods and hygienic behaviour in honey bees"* to Chichester Beekeepers Association, West Sussex. (HT).
10/4/14	Presentation at to visit by Swedish Beekeepers, University of Sussex. (MC).
15/4/14	Talk: *"LASI research on helping bees and flower visiting insects in urban parks and gardens"* to Merrow Horticultural Society, Merrow, Guildford, Surrey. (FR).

25/4/14	Talk: *"Dancing bees as bioindicators of landscape 'health' "* to Wellcome Trust "Art of Pollination" exhibition, University of Plymouth, Devon. (MC).
28/4/14	Talk: *"Dancing bees as integrative indicators of landscape quality"* to Department of Zoology, University of Oxford. (MC).
15/5/14	Demonstration: *"bees and honey"* to Holy Innocents Playgroup, Southwater, West Sussex. (NC).
21/5/14	*"The Insect Pollinator Initiative and other new research"* to National Diploma in Beekeeping Advanced Beekeeping Course, Fera, Sand Hutton, York. (NC).
7/6/14	Talk and demonstration: *"Honey bee behaviour / biology and LASI research"* at "open day" visit of prospective students and their parents, University of Sussex. (FR).
11/6/14	Presentation to "Life Sciences Taster Day", University of Sussex (MC).
19/6/14	Talk and demonstration: *"Honey bee behaviour / biology"* to "open day" visit for prospective students from disadvantaged socioeconomic groups ("widening access"). University of Sussex. (FR).
25/6/14	Talk and demonstration: *"Honey bee behaviour / biology and LASI research"* visit of Senior Administrators to the UK from Thai Universities. University of Sussex. (FR).
12/7/14	LASI Open Day (all).
26/7/14	LASI Workshop: "Determining the best garden plants for bees and insects" (KA, MG, KS, FR).
30/7/14	Talk: *"What have bees ever done for us?"* to Haywards Heath Society, West Sussex. (KA).
1/8/14	Talk: "*Bumble bee versus honey bee competition on lavender"* at University of Sussex Post Graduate Colloquium. (NB).
5/9/14	Talk and demonstration: *"Honey bee behaviour / biology and LASI research"* at "open day" visit of prospective students and their parents, University of Sussex. (FR).
5-6/9/14	LASI Workshops: *"Integrated varroa management".* (KA, NC, FR, LS, HT).
9/9/14	Talk: *"Bee visitation on neonicotinoid treated maize in the UK"* at 6th European Bee Research Conference (EurBee), Murcia, Spain. (NC).
22/9/14	Talk and demonstration: "LASI Research on the benefits of reduced mowing of amenity grass at the Saltdean Oval, Brighton" to fact finding tour by Members of the Brighton & Hove City Council and members of the B&G Parks Department. University of Sussex. (FR).
26-28/9/14	Poster: *"Towards integrated control of varroa: Effect of variation in hygienic behaviour among honey bee colonies on mite population".* at BIBBA 50th Anniversary Conference / SICAMM Biennial Conference, Llangollen. (HT).
27/9/14	Talk: *"What future for local bees in Britain?"* at BIBBA 50th Anniversary Conference / SICAMM Biennial Conference, Llangollen. (NC).
4/10/14	Talk and demonstration: *"Honey bee behaviour / biology and LASI research"* at "open day" visit of prospective students and their parents, University of Sussex. (FR).
4/10/14	Talk: *"Breeding hygienic honey bees and oxalic acid treatment (best method and dose)"* to "Fiera Nazionale di Apicoltura" Lazise, Italy. (LS).
7/10/14	Talk: *"Honey bee health & well being: What are the problems and what are the solutions?"* at 2 day conference on bees at the University of São Paulo (ESALQ), Piracicaba, Brazil. (FR).
8/10/14	Talks: *"How a social insect colony can use pheromone trails and other communication mechanisms to organize its foraging"* to Entomology MSc students at the University of São Paulo (ESALQ), Piracicaba, Brazil. (FR).
9/10/14	Talk: *"Urban pollinators and the importance of providing forage"* to Worthing Beekeepers Association, Sussex. (KA).
15/10/14	Talk: *"Colony losses"* to Brighton and Lewes Beekeepers Association, East Sussex. (NC).

17/10/14 Talk: *"Planting for bees and other flower visitors"* to Ansty Horticultural Society, West Sussex. (KA).

21/10/14 Talk: *"Control of varroa mite using different methods and hygienic behaviour in honey bees"* to Mid Kent Beekeepers Association. (HT).

25/10/14 Talk: *"Control of varroa and oxalic acid treatment"* to Barnet and District Beekeepers Association, Hertfordshire. (HT).

25/10/14 Talk: *"Breeding hygienic honey bees and oxalic acid treatment (best method and dose)"* to "Associazione Provinciale Apicoltori Veronesi" Verona. Italy. (LS).

28/10/14 Talk: *"Towards integrated control of varroa and oxalic acid treatment"* to Chalfonts Beekeepers Association, Buckinghamshire. (HT).

7/11/14 Talk: *"The Sussex Plan for Honey Bee Health & Well Being: applied research to assist an important beneficial insect in agriculture"* to Joint Symposium on Frontier Research in Biodiversity and Agricultural Resources, Mahidol University, Bangkok, Thailand. (FR).

13/11/14 Talk: *"Environmental consultancy: dancing honey bees give biologically relevant information about forage availablity"* to University of Bern, Switzerland. (MC).

19/11/14 Talk: *"Coordinating foraging in insect societies: Why are multiple information signals used?"* to Program Symposium of the Entomological Society of America Annual Meeting: "Social insects as models for biological complexity: lessons learned and challenges on the horizon", Portland, Oregon, USA. (FR).

27/11/14 Talk: *"Collapse of bees and other pollinators"* To National Institute of Agricultural Botany Technical Advice Group growers group, Salisbury. (NC).

28/11/14 Talk: *"Accuracy of the identification of flower visiting insects by volunteers, and the effects of different types of training"* to Wildlife Gardening Forum meeting on "Citizen Science and biological recording", Natural History Museum, London. (FR).

9/12/14 Talk: *"Towards integrated control of varroa"* to Slough, Windsor and Maidenhead Beekeepers Association, Berkshire. (HT).

15/12/14 Talk: *"Effect of variation in hygienic behaviour among honey bee colonies on mite population increase and deformed wing virus incidence".* to International Union for the Study of Social Insects (North West European Section) winter meeting, Natural History Museum, London. (HT).

Appendix 3.

Theses by members of LASI

Sam Jones

Chemical based communication and its role in decision making within the social insects.

PhD thesis, 2013

Abstract

This thesis investigates chemical communication and decision making in a stingless bee (*Tetragonisca angustula*) and two species of ants (*Lasius flavus* and *L. niger*). Complex chemical signalling and seemingly elaborate behavioural patterns based upon decisions made by individuals of a colony have facilitated the evolution of social living in these insects. This thesis investigates two important features of social living that involve these features: nest mate recognition and navigation. The first part of this thesis (Chapter 3 and Appendix 3) investigates nestmate recognition and nest defence in the Neotropical stingless bee *T. angustula*. In Chapter 3, two mechanisms are investigated which could potentially facilitate the extremely efficient nest mate recognition system, previously demonstrated in this bee species. Both are found to play no role which will enable further work to focus on the few remaining possibilities. The second part of this thesis (chapters 4-6) focuses on navigational decision making in two common British ant species with contrasting ecologies. Chapter 4 investigates how *L. niger* foragers adapt to foraging at night when the visual cues, so important to these ants for diurnal foraging, are unavailable. This study showed that nocturnal foraging is achieved in these ants by increasing trail pheromone deposition while concomitantly switching to a greater reliance on these cues to navigate. Chapter 5 contrasts the navigational strategies and capabilities of *L. niger* with another *Lasius* ant species, *L. flavus,* and demonstrates how these species can flexibly switch dependency between available navigational cues to cope with foraging within a fluxional ecological environment. Finally, Chapter 6 focuses on the glandular components and trail pheromone of *L. flavus* by measuring behavioural responses to glandular constituents and identifying the glandular source of the trail pheromone. The aim was to also identify the trail pheromone(s) but due to time constraints this was not possible. However, a new methodology that simplifies the process of identifying trail pheromone components was developed and is described. Furthermore, this study has laid the foundations for further work to establish if the compound prevalent in the Dufour glands' of *L. flavus* does indeed serve as an antibacterial agent within the humid nest environment.

Gianluigi Bigio

Hygienic behaviour in honey bees.

PhD thesis, 2014.

Abstract

This thesis focuses on hygienic behaviour in honey bees. In beekeeping, brood diseases incur heavy economical and biological costs and are no longer effectively treated with chemicals. Previous research has shown how hygienic behaviour, a trait expressed by c. 10% of unselected colonies, can be effective in reducing the impact and presence of such diseases. Hygienic behaviour is experimentally measured using the freeze-killed brood (FKB) bioassay and can be increased by selective breeding, generating lines of hygienic colonies. Chapter 4 demonstrates that the relative rarity of hygienic behaviour in unselected colonies is not because it incurs a cost via the removal of healthy brood. Chapter 5 - 6 focus on the impact of external factors on hygienic behaviour. Specifically, we demonstrate that the presence of brood, amount of food, and strength of the colony affect hygienic levels (Chapter 5). Chapter 6 shows that hygienic behaviour does not correlate with aggressiveness or agitated behaviour. When breeding honey bees, it is possible to exploit instrumental insemination to have complete control over the genetic composition of the resulting progeny. This technique is however laborious and requires particular equipment and training. In Chapter 7 we show that it is possible to obtain acceptable levels of hygienic behaviour without artificial insemination. Chapter 8 illustrates how we obtained the first breeding line of hygienic honey bees through a selective breeding program that saw its first milestone in autumn 2013 when we detected high levels of hygienic behaviour. The results obtained represent the foundation for future research projects. Chapter 9 presents a valid, minimal methodology to keep virgin queens. We tested a variety of methods and factors to determine the best, most cost-effective way to maintain queens for the week prior their introduction into a queenless hive. The results obtained provide some insights on both basic and applied aspects of honey bee breeding for hygienic behaviour and represent the foundation of what will be an ongoing selection programme towards a disease-resistant honey bee.

Mihail Garbuzov

Helping the honey bee and other flower-visiting insects in urban areas.

PhD thesis, 2014.

Abstract

As is much of the world's biodiversity, bees and other flower-visiting insects are in global decline, largely due to human activities. The impacts of humans on wildlife can be ameliorated, at least to an extent, by wildlife-friendly management practices in both rural and urban areas. This thesis comprises two introductory chapters (Part 1), followed by a series of ten research chapters (Parts 2 - 5) aimed at informing management practices that encourage bees and other flower-visiting insects in urban areas, and ends with a concluding chapter (Part 6). The projects are grouped in four parts making contributions to four broad areas of research. Part 2 is concerned with evaluating the attractiveness of ornamental garden plants to insect flower-visitors. Individual projects examine the advice currently available to gardeners via recommended plant lists, and describe surveys of plant varieties grown in a public garden (Southover Grange garden, Lewes), a Plant Heritage national collection of asters (Picton Garden, Malvern), and the experimental gardens planted on campus of the University of Sussex, Brighton, as well as in towns of Plumpton and Magham Down. Part 3 evaluates the attractiveness to insects of urban wild flowers, including those growing in amenity grass areas in parks, and the effects on their abundance and diversity of the various mowing regimes, as well as the attractiveness of the common autumn flowering ivy. Part 4 uses waggle dance decoding to investigate honey bee foraging in the urban landscape of Brighton, with an additional particular focus on foraging on spring-blooming oilseed rape in the surrounding agricultural land. Part 5 examines an aspect of good practice in urban apiary set up, the use of lattice fence or hedge barriers, which should facilitate beekeeping in urban areas, including in private gardens
and allotments.