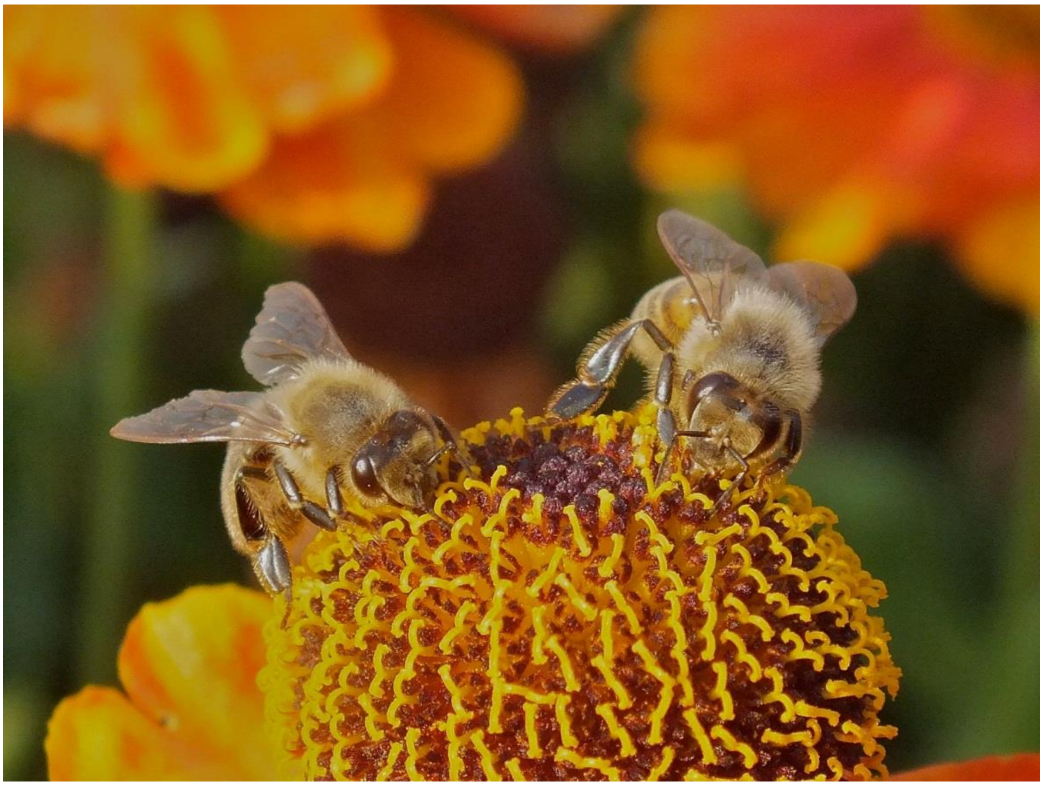
Laboratory of Apiculture and Social Insects

Annual Report January 2013



University of Sussex
Life Sciences

LASI
LABORATORY OF APICULTURE AND SOCIAL INSECTS

Fig. 1. A honey bee on apple blossom (Photo: Nick Balfour).

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LASI personnel

LASI Director

Prof. Francis Ratnieks

Postdoctoral researchers and research technicians

Dr Karin L Alton
Mr Norman Carreck
Dr Margaret J Couvillon
Dr Christoph Grüter
Mr Luciano Scandian
Dr Francisca Segers
Dr Martyn J Stenning

Doctoral students

Mr Nick Balfour
Mr Gianluigi Bigio
Mr Tom Butterfield
Mr Tommy Czaczkes
Ms Antonia Forster
Mr Sam Jones
Mr Mihail Garbuzov
Mr Hasan Al Tofailia

Masters students

Ms Fiona Riddell-Pearce

Undergraduate Summer Bursary students and assistants

Ms Katherine Fensome
Ms Elizabeth Samuelson

Volunteers

Mr Mike Kavanagh
Ms Ellie Blows

Undergraduate project students

Academic Year 2011-2

Mr Dominic Burns
Mr Shaun Quah
Mr Josh Smerdon
Ms Kiah Tasman

Academic Year 2012-13

Ms Alicia Cardona
Mr Tom Goodall
Ms Hannah van Hesteren
Ms Emily Martin
Ms Emma Warner

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.

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Overview of 2012

The Laboratory of Apiculture and Social Insects (LASI) was set up in 2008, and 2012 proved to be the year when we finally achieved our long hoped for appointment of full time support for our beekeeping, with the appointment of Luciano Scandian as Honey Bee Research Facilities Manager, funded by the Esmée Fairbairn Foundation. Since he has joined, our bee hives and apiaries have now become something that we are truly proud to show to our many visitors.

During the year we said goodbye to Dr Tomy Czaczkes and Dr Sam Jones who both successfully completed their PhDs, and Fiona Riddell-Pearce who completed her MPhil (See Appendix 3). We also said goodbye to Dr Christophe Grüter and Dr Francisca Segers, off to take up post-doctoral positions at the University of São Paulo, Brazil. In January Nick Balfour officially joined us to commence a PhD, having carried out field work as a visitor in 2011. In December we also welcomed Tom Butterfield and Antonia Forster, both starting PhDs. During the year we also hosted many undergraduates, undertaking a variety of projects

The year saw a number of projects in the "Sussex Plan for honey bee health and wellbeing" bearing fruit in the form of refereed papers in scientific journals, some attracting considerable publicity, including Margaret Couvillon's research on the honey bee waggle dance, which was featured on the satirical BBCTV show "Have I got news for you".

As usual, members of the laboratory have been fulfilling our outreach role by giving many talks at conferences and to a variety of audiences, running workshops at the university itself, and by working with school children of various ages. Full lists of publications, talks and media appearances are given in the Appendices.

Once again we thank our many benefactors whose continuing support makes our work possible, in particular Rowse Honey Ltd, our first large commercial sponsor, and the Nineveh Charitable Trust, who have both renewed their financial commitments to our work.

Fig. 2. Assessing varroa mite populations (clockwise from top left): Luciano Scandian sorting bee samples; Hasan Al Tofailia washing bee samples; sieves; varroa mites collected from adult bees (Photos: Francis Ratnieks).

Research - Undergraduate student research projects

This year five undergraduate students carried out their final year projects at LASI. Alicia Cardona and Hannah van Hesteren did a project on the effect of nectar guides on the ability of honey bee foragers to locate the nectaries. The project, supervised by Prof. Ratnieks and PhD student Nick Balfour, involved making up artificial flowers out of perspex rods and laminated paper. In contrast, Emma Warner, Tom Goodall and Emily Martin did a project on the common garden ant, *Lasius niger*. They studied trail choice at a Y bifurcation in a trail leading from the nest to food, and the effect of asymmetry in the branching angles and trail pheromone on trail choice. PhD student Antonia Forster helped with the supervision. In addition undergraduate Katie Fensome did a summer bursary in which she worked with Nick Balfour on a survey of fields, plants and flower visiting insects at Castle Hill Nature Reserve, to determine where the bees were foraging and on what, whilst Liz Samuelson worked with Mihail Garbuzov on bee foraging on garden plants.

Over the past five years at LASI we have supervised approximately 30 students in approximately a dozen projects. Students are given the opportunity to participate in real and original research projects rather than the same project repeated year after year. In fact, over half of the projects have worked out so well that they have resulted in research publications in scientific journals.

Bees and ants lend themselves well to student projects, and the students enjoy working with them. These days, it is becoming harder and harder for projects to be run where the students can work with the behaviour of live animals, so LASI is well placed to fill this gap.

Fig. 3. Bursary student Katherine Fensome recording pollinator visitation, Castle Hill National Nature Reserve, 2012 (Photo: Nick Balfour).

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

Breeding disease-resistant hygienic honey bees and providing breeder queens to beekeepers

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

Background

Honey bees are susceptible to many pests and diseases, in particular bacterial brood diseases such as American foulbrood (AFB) and European foulbrood (EFB), the fungal disease chalkbrood, and the parasitic mite *Varroa destructor* (varroa). These have traditionally been treated with a range of drugs including antibiotics and acaricides, but increasing problems with resistance have been experienced, leading to reduced efficacy. This has led to a search for chemical free alternatives.

So-called “hygienic” worker honey bees remove dead or infected larvae and pupae from their cells, reducing the spread of disease within a colony. Previous research in the USA has shown that hygienic colonies may produce as much honey as other colonies, but are resistant to brood diseases such as AFB, EFB and chalkbrood. Hygienic behaviour can also disrupt the breeding cycle of varroa, thereby slowing down mite population growth, so that beekeepers with hygienic hives will find it easier to control the mite.

Hygienic behaviour is a naturally occurring genetic trait, meaning that it can be selected for using conventional bee breeding methods. Previous studies have shown that about 10% of British hives are hygienic, so a more effective method of breeding for hygienic behaviour via “intracolony selection” has been developed. This involves keeping colonies known to exhibit hygienic behaviour in observation hives to determine which individual workers are the most hygienic. Molecular techniques are then used to determine the patriline (i.e. the identity of the drone father of the worker). Daughter queens are then reared that have the same father as the hygienic workers. In this way breeding for hygienic behaviour is more effective and rapid than breeding on a colony basis (Carreck, 2009a,b, 2011; Carreck *et al,* 2010).

Main aim

To selectively breed and then test under UK field conditions, a strain of hygienic honey bees, and to then make this available to UK beekeepers.

Funding

This project is funded by Rowse Honey Ltd, the Merrydown Trust, and the Somerset Beekeepers Association.

Progress

Any bee breeding programme is open ended. We have now, however, reached the stage of being able to evaluate the progress that we have made so far. In the autumn of 2011, a number of our reared queens were given to local semi-commercial beekeeper Luciano Scandian to see how they fared under his apiary conditions (Ratnieks *et al,* 2011). We have been evaluating these and other colonies headed by our queens throughout 2012, testing for hygienic behaviour as before, but we have also been monitoring temperament and mite infestation. Equipment has been purchased enabling us to carry out testing for hygienic behaviour in the field away from the laboratory.

As for most beekeepers in Britain, the exceptionally wet and cold 2012 season has been very frustrating for us, with queen rearing in particular proving very disappointing. Initially, we experienced serious problems with the acceptance of grafts by the bees, and later in the season although queens appeared to have mated successfully during brief periods of reasonable weather, we had unexpected problems with queen introduction. In addition, for the first time since establishing our apiaries at the University, we were forced to feed our bees in July to prevent starvation. Despite these practical difficulties, in the autumn, we were able to pass a number of our reared queens to several members of the Bee Farmers Association in different parts of England for evaluation under a range of conditions (Carreck *et al*., 2013).

Fig. 4. The LASI home apiary, August 2012, showing many queen mating mini nucleus hives (Photo: Norman Carreck).

As part of our programme at LASI of outreach to stakeholders such as beekeepers, over the last two seasons we have run several successful workshops at the University to introduce the techniques for measuring hygienic behaviour, and these have been well received (Carreck *et al*., 2011) and were attended by beekeepers travelling from a considerable distance. We hope that these workshops will result in beekeepers around the country following our lead and developing local breeding groups to make the best use of their locally occurring bees.

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

Developing new techniques for breeding disease resistant bees

Gianluigi Bigio, Norman Carreck, Luciano Scandian and Francis Ratnieks

Overview and main aim

Gianluigi Bigio started his PhD programme in April 2010. The research consists of several sections that will provide results to be exploited in the broader context of the Sussex Plan, which aims to selectively breed and then test under UK field conditions a strain of hygienic honey bees The work will be undertaken in conjunction with UK beekeepers, screening their apiaries and monitoring the queens provided, expanding the network with feedback from both parts.

Funding

This PhD project is funded by the British Beekeepers' Association.

Progress

Section 1

During the 2010 field season, we devised an improved methodology to keep virgin queens alive for a week under laboratory conditions. This will allow both beekeepers and scientists studying bees to be able to screen queens prior to mating with a minimal allocation of time and resources. We demonstrated that honey bee queens can be kept in mailing cages under optimum conditions, to be readily available for genotyping and then mating (Bigio, 2011). This work is now completed and resulted in a paper published in the peer-reviewed journal *PloS One* (Bigio *et al,* 2012a).

Section 2

Starting where we left off the previous autumn, during 2012 more LASI hives were screened using the freeze-killed brood (FKB) assay in order to identify suitable colonies to expand our genepool from which to breed. We identified several colonies to include in our breeding programme and focused on one colony that showed excellent characteristics in terms of hygienic behaviour and docility. From this colony we obtained 13 "daughter colonies" which again underwent a screening process; hygienic behaviour was quantified with four freeze-killed brood assays and the docility was evaluated during each hive inspection. Three of those colonies scored high marks and were used as donors for larvae from which we managed to produce 25 mated queens. 20 queens were housed in hives located in a nearby apiary, and the remaining queens were then given to the Worthing Beekeepers' Association as a pilot study. This will allow us to have an external evaluation of our work, and we will combine their feedback with our data in order to fine tune our selection programme. In the future we plan to also monitor other traits of interest, such as honey production, wintering ability, etc. This is an ongoing project which will support the main breeding programme.

Section 3

Colonies belonging to Luciano Scandian, a semi-professional beekeeper and now LASI research facilities manager, have been screened using the FKB assay. We discovered several colonies that were included in our breeding programme, and by continuously monitoring them we were then able to correlate the expression of removal of dead brood as the season progressed. Other traits of interest were also quantified, in order to eventually correlate hygienic behaviour with defensive behaviour and calmness on the comb. This project started in Summer 2011 and ended in October 2012, the data collected were analysed statistically and the resulting paper will be submitted for publication in a peer reviewed journal.

Fig. 5. Luciano Scandian with some of his colonies at Henfield (Photo: Norman Carreck).

Section 4
In order to better understand the impact of environmental conditions on the expression of hygienic behaviour, a study was carried out to monitor how hygienic behaviour varies in relation to both the amount of brood present in the colony and food availability. The ability of the colony to detect and remove freeze-killed brood has been monitored in hives that were either being fed with sugar syrup or had frames of brood removed or added. This should eventually help both beekeepers and researchers to modify the observed behaviour accordingly and also to determine how the behaviour is influenced by other physiological factors. Data collection is completed, results are currently being analysed and the project was presented as an oral communication at the 5th meeting of the European Sections of the IUSSI held in Montecatini Terme (Tuscany, Italy) 26-30 August 2012 (Bigio *et al*, 2012b).

Section 5
While developing a breeding line of honey bees expressing high levels of hygienic behaviour, and trying to understand how external factors could cause variations, we investigated whether there were fitness costs linked to it; costs that would limit its expression and therefore explain why amongst unselected honey bee colonies, very highly hygienic ones are rare (*c.*10%). Some authors in the literature have suggested that a high ability to detect and remove dead or diseased brood also leads to a high removal rate of healthy brood. During September 2012, we set out to test this hypothesis, running 3 FKB assays on 10 hives, and based on preliminary results there does not appear to be a correlation between removal of treated *vs*. untreated brood. Data collection is completed and we are currently carrying out statistical analyses.

Future developments
We are very excited to see what the next season will bring us. As soon as winter is over, we will check our colonies in the hope of finding as many colonies alive as we can; indeed measures such as mouse guards and woodpecker cages are in place with the intent of protecting our bees. Then we will evaluate the colonies representing our latest generation, which will tell us how far down the line we are in our genetic improvement plan and again will identify which colonies are most suited to carry on the selection. Similarly, we are looking forward to hearing feedback from the beekeepers who received our first queens. This will be

very important, given the long term nature of this project. We value their input in order to provide honey bees that are able to cope with a real beekeeping scenario.

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

Honey bee diseases: management, resistance and ecology
Hasan Al-Toufailia, Norman Carreck, Luciano Scandian and Francis Ratnieks

Overview and main aim
Hasan Al-Toufailia began his PhD degree in April 2012. His research is currently focusing on the three sections below, one in the area of hive management, one on disease resistance, and one on disease ecology.

Section 1
Oxalic acid has been widely used in many countries as a control for the varroa mite. Its mode of action is uncertain, but it is known that it is only effective on mites that are living on the adult bees (phoretic) and not on mites inside brood cells. For this reason, it is usually used during the winter when colonies are broodless. Anecdotal evidence suggests, however, that many colonies in Britain may carry brood through much of the winter. We therefore want to monitor brood levels in colonies through the autumn and winter to determine the best times to apply oxalic acid solution. Hasan is seeking volunteers to carry out comparative trials in other areas of Britain (Carreck *et al*., 2013).

Oxalic acid is commonly used in other countries in one of three ways, by trickling of oxalic acid solution in syrup, by spraying combs, and by sublimation of crystals, but no controlled experiments on efficacy have been carried out in Britain. The aim of the second part of this project is therefore to determine the best method and suitable dose of oxalic acid by treating one hundred honey bee colonies by different methods using three different doses of oxalic acid solutions under British conditions.

Section 2
Some existing colonies at LASI can be shown to be very hygienic but also appear to be aggressive. Honey bee queens mate with 10-20 males, so a colony consists of groups of half sisters corresponding to the various males (patrilines).This project will therefore determine whether the hygienic worker bees are from different patrilines within the colony to the aggressive worker bees. If we can demonstrate a patriline difference in behaviour, it will be possible to breed queens from a hygienic colony that is also defensive, by rearing daughter queens of hygienic non-aggressive patrilnes. This work is being performed in observation hives (Fig 6.). So far, samples of aggressive and hygienic bees have been collected, and these will be analysed over the next few months.

Section 3
Larvae of the greater wax moth *Galleria mellonella* eat and destroy wax honey bee combs. This project will test the hypothesis that wax moth larvae help to reduce the incidence of American foulbrood caused by the bacterium *Paenibacillus larvae*. We will measure the effect of passage through the gut of wax moth larvae on the survival of *P. larvae* spores. This will be carried out in a closed microbiological laboratory away from our bee hives.

References

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Fig. 6. Experiment to investigate the defensive and hygienic behaviour in an observation hive colony (Clockwise from top left): Inserting tin can to create sampling area in test comb; freezing sample with liquid nitrogen; sampling individual bees; hygienic worker bee removing a freeze killed pupa from the hive (Photos: Hasan Al-Toufailia).

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

How good is the British countryside for honey bees? Decoding dances to determine where worker honey bees are foraging
Margaret J. Couvillon and Francis Ratnieks

Background

The honey bee, which is the most important animal pollinator (Kluser, *et al.*, 2010), is declining in many parts of the world (Neumann and Carreck, 2010). Meanwhile, the proportion of our diet that relies on pollination continues to increase, resulting in agicultural need outstripping the availability of honey bees (Aizen and Harder, 2009). One major reason for this decline, which may work alone or in concert with other challenges like pesticides and pathogens, is that landscape changes have resulted in less available forage. Healthy or sick, bees need to eat, and less available forage (Fig. 7) means insufficient food stores to see the bees through the winter months.

Fig. 7. Changes in landscape have reduced the available forage for bees. Here the rolling hills alongside the South Downs Way, which is pleasing for a Sunday ramble, provide little food for bees and other pollinators (Photo: Margaret Couvillon).

In response, both government and private companies have begun initiatives to increase the amount of forage available. Are they directing aid appropriately? Before recommendations can be made on land-use policy to reverse this decline in honey bee populations, we need a better understanding of how the bees are using the existing landscape.

We use a unique feature of the honey bee, its waggle dance, to investigate where bees forage. When a profitable forager returns to the hive, she performs a figure-of-eight dance that directs nestmates to the location of where she collected a resource, most often nectar or pollen (Fig. 8). We eavesdrop on this conversation to determine where bees are collecting food in the existing, challenging landscape.

This project began in August 2009, and three years on, we are in a very exciting time with the data. Most specifically, in the past year, we have made significant advances in the basic understanding of the dance. We have now demonstrated mathematically the most efficient and effective way to decode dances. Additionally, we have gained in our understanding of the presence of error within the dance, which has led to us building our own bee calibration curve (see below). Lastly, we have finished decoding our targeted dances and have devised a novel, exciting, and impactful way to visualize how the bees are using the landscape.

Who funds our research?
This project is supported by three major donors: the Nineveh Charitable Trust, which is an agricultural charity promoting the preservation of the countryside, who have extended their support in 2012; Waitrose Ltd, a leading supermarket with a strong commitment to social responsibility; and Burt's Bees, a company whose ethos supports sustainability and ecological responsibility and which has strong links to bees in its name, in its products and in its founder, US beekeeper Burt Kravitz;

What is the best way to decode dances? Analysis of intra-dance variation and the creation of an efficient, effective method to decode dances

In 1946, Karl von Frisch published his landmark paper demonstrating that honey bees (*Apis mellifera* spp.) communicate foraging locations to nestmates via the waggle dance (von Frisch, 1946; von Frisch, 1967), a discovery for which he later shared the 1973 Nobel Prize in Physiology. Since then, researchers have studied many aspects of the dance language (reviewed in Couvillon, 2012). Additionally, the dance has been used as a tool to investigate honey bee foraging ecology. This is an especially powerful feature, as the honey bee is the only animal which tells you where it has been foraging.

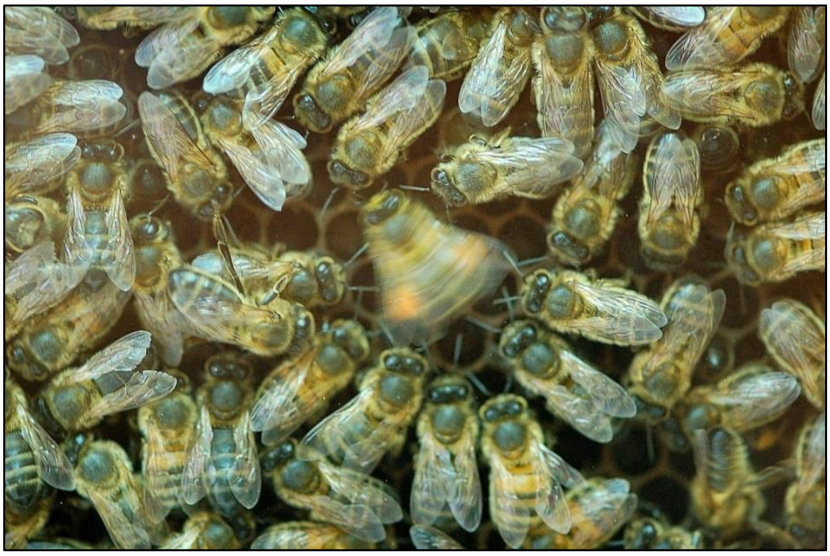

Fig. 8 A returning forager performs a waggle dance. This communication informs her nestmates of a foraging location, given in distance and angle relative to the sun. This bee was a pollen forager, as we can see yellow pollen in her pollen baskets (Photo: Christoph Grüter).

In the waggle dance, a successful honey bee forager returns to the hive and tells her nestmates where she has been collecting nectar and pollen by waggling her body in successive figures of eight (Fig. 8). The direction in which she waggles her body relative to vertical on the wax comb is the direction of the food source relative to the sun. The duration of her waggle denotes distance. These successive figures of eight may be repeated a variable number of times (1-100+) in a single dance bout. The nestmates listening to this dance take an average to derive a single distance and direction (von Frisch and Jander, 1957; Tanner and Visscher, 2008); we knew we would do the same. However, how many waggle runs are necessary to decode to obtain a good average? It stands to reason that decoding more runs per dance gives you a better, more accurate average; but as decoding is time-costly, decoding more runs per dance is at the expense of decoding more dances, and we knew we would need to decode many dances.

To combat this challenge, we made a detailed analysis of intra-dance variation in order to design time-efficient protocols for dance decoding. In this way we were able to create a methodology for an efficient and effective means to decode dances (Couvillon, Riddell Pearce *et al*., 2012). We showed mathematically that it is sufficient and necessary to decode four consecutive, non-first, non-last repeated figures of eight of the same waggle dance to obtain a single distance and direction. Employing this methodology generates a mean angle and mean duration that is a very good, highly significant fit compared to the mean angle and mean duration that is obtained if one decodes all the waggle runs within a dance (Fig. 9).

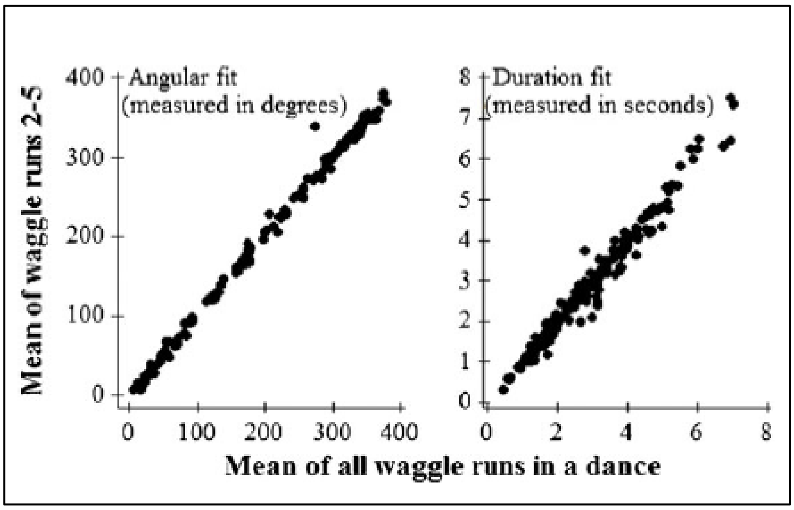

Fig. 9 Our dance decoding methodogy of decoding four, consecutive, non-first, non-last waggle runs and then taking an average (Y axis) fits extremely well with the averages obtained when all waggle runs within a dance are decoded (X axis). This is true for both angle, measured in degrees, and duration, measured in seconds (From: Couvillon, Riddell Pearce *et al.,* 2012).

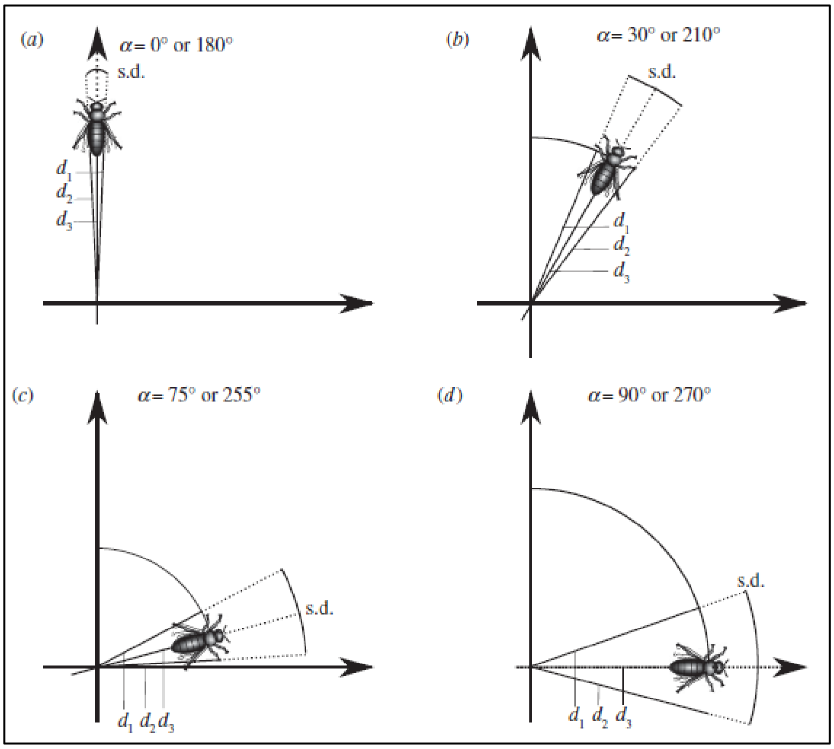

Fig. 10 Angular variability (measured in standard deviation, s.d.) is least when the bee is dancing vertically **(a)** either up or down, on the vertical comb because the gravitational force is aligned to the waggle run. A bee making a non-vertical waggle run will experience a non-aligned gravitational force, which will generate a varying amount of s.d. **(b,c)**. The maximum intra-dance angular imprecision is seen when the bee dances horizontally on the vertical comb **(d)**. (From: Couvillon, Phillipps *et al.*, 2012).

Additionally on the side, we noticed something very interesting about the error in the angles communicated in successive waggle runs. The bee seemed to have a harder time being precise when she danced for some angles (90° or 270°) on the vertical comb compared to other angles (0° or 360°; Fig. 2.10). We demonstrated that this intra-dance angular error was due to gravity (Couvillon, Phillipps *et al*,. 2012). In this way, our project contributes to our basic science understanding of the dance.

What is the best way to decode dances? Creation of a calibration curve to convert duration to distance

Most previous studies have relied on the data of Karl von Frisch (von Frisch, 1967) to convert duration of waggle run into distance of flight. However, when we checked our bees against von Frisch's data, his calibration significantly and consistently overestimated distances. Therefore, this summer, working with Dr Roger Schürch from another laboratory, we constructed our own. This involved training individually marked bees to different feeders at known distances (Fig. 11). These bees would then return to the observation hive and dance. Because we knew where they had collected food, we were able to analyse their durations of waggle runs against known distances of flight.

Fig. 11. An individually marked honey bee forager collects sucose solution from a feeder at a known distance. The waggle dance duration of this bee can then be analysed against a known distance. This process is repeated for many bees at many different distances (Photo: Roger Schürch).

In this way, we generated a calibration curve that is specific to our bees (Schürch, Couvillon *et al.*, In prep). With this in place, we were now able to convert our waggle run durations into distances.

What does monthly variation in foraging distance tell us about nectar availability?
When our calibration is applied to our dance set, we are able to determine distance of flight for the > 5000 dances that we have decoded at LASI. Flight is costly, and a bee must use energy to collect food. However, bees are very good at weighing up the cost of a flight against the benefit of what they will bring back because bees are known to be economic foragers (Schmid-Hempel, 1987). Therefore, we can use foraging distance as a proxy for food availability: if a bee is dancing for a further away resource, this means that she has already done the economic valuation and still determined that nothing of better value is closer by.

From this project, we now know that honey bee foraging distance significantly varies with month (Fig. 12). Bees fly the furthest in July and August (on average, 2.5 km) and the least far in March (on average, 700 m) (Couvillon, Schürch *et al.*, In prep). Foraging distance increases from spring through the summer and then decreases in September and October, which is most likely due to the flowering of ivy. Ivy is ubiquitous, and when it is blooming, the bees are able to collect their food much closer than before it begins to bloom (Garbuzov and Ratnieks, in prep).

Most of these dances have been decoded by undergraduate 3rd year project students, undergraduate researchers, and volunteers. In this way, members of the university and larger community are integrated into an important research project.

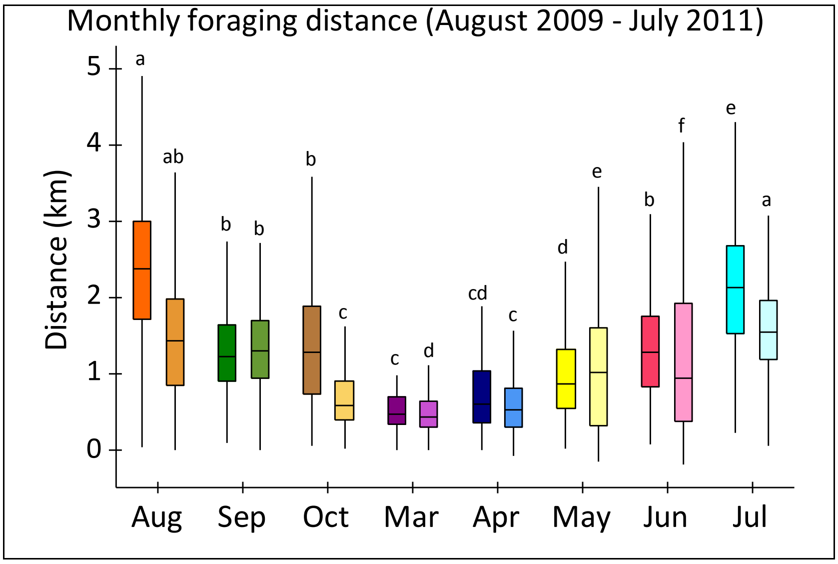

Fig. 12. Foraging distance significantly varies with month. Bees fly the furthest in summer (July and August) and the least far in spring (March and April). This indicates that forage is relatively less available in the summer compared to the spring (From: Couvillon, Schürch *et al.*, In prep).

Additionally, we are participating in the training of undergraduates in science and in research, thereby contributing to the education of the next generation of scientists.

Where are the bees foraging?

Of course, when a bee dances, she communicates a location, not just a distance. We are able to plot individual dances with colour-coded dots for each month. In this way, we can visualize where the bees are visiting with each season. In previous studies, and in the past in this study, this was plotted showing every dance is a single point (Fig. 13). This remains a simple, clean way to visualize how the bees are using the landscape.

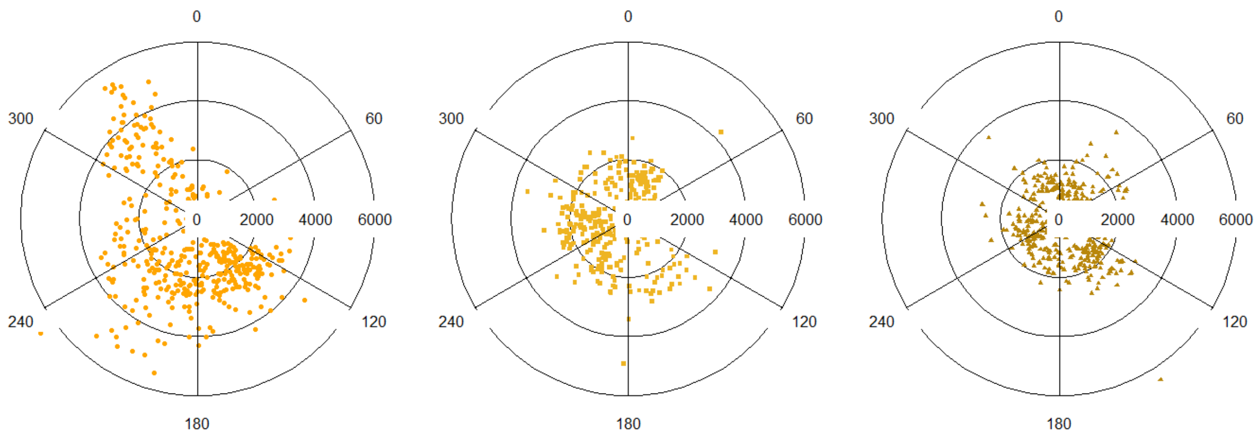

Fig. 13 Here we have plotted decoded dances for August 2009, August 2010, and August 2011. LASI is at the centre of the graph, and the concentric circles represent 2, 4, and 6 km from the university. Plotting dances in this fasion is a simple and easy way to visualize the bees' use of the landscape; however, it may over-represent what we actually know about where the bees go.

However, plotting dances as a point may over-represent what we know. We know from our calibration work that there is much variation present in the dance. Specifically, different bees visiting the same food source at the same distance may communicate via slightly different durations. Even the same bee visiting the same source many times may display variation in waggle runs between visits.

Rather than treating this as a limitation, we had the idea to handle dance variation as a benefit. We use the variation in a dance to plot the dance not as a point, but as a “cloud”, an area of probability where the bee is likely to have gone. This heat map style uses colour to denote areas of highest visit probability. Because we have such a large data set available to us, we are now able to generate amazing (and amazingly beautiful) maps of how the bees are using the landscape (Fig. 14).

Plotting dances in this way is a novel way to see how the bees are using the landscape. Additionally, it allows one to see at a glance which areas are used and which areas are not used. For example, we know from our foraging distance work that August is a difficult time for bees, as they must fly and recruit the furthest distance to collect food. When we look at all the decoded dances for August 2009, 2010, and August 2011, we see that one area of high foraging activity is Castle Hill National Nature Reserve, located just over 2 km to the south east of LASI.

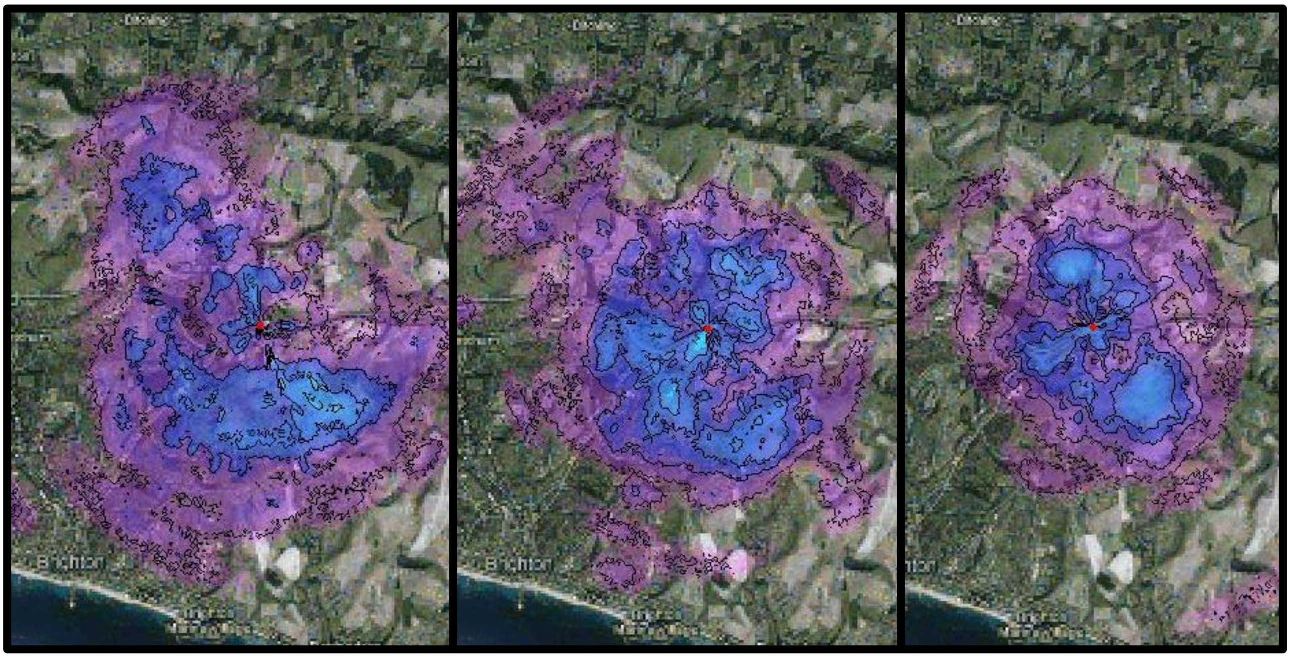

Fig. 14. Honey bee foraging in August 2009, August 2010, and August 2011. We use the variation within a dance to plot it not as a point, but as a cloud. When we then view the same dances as from Fig. 13, we can tell from colour which areas the bees tend to use more than others. Here transparent means zero likelihood that the bees use it, purple is low likelihood, dark blue is medium, and light blue is highest likelihood. One common feature from all three Augusts is the bright blue south east of LASI just over 2km. This is probably Castle Hill National Nature Reserve.

Therefore, at a time of year when the bees are finding it relatively harder to find forage, they are preferentially visiting a nature reserve. We expect these data to be of great importance to Brighton and Hove Parks Department. If we maintain these wildlife corridors, the wildlife will use them, and we will have done our part to help make Britain more bee-friendly.

Where do we go from here?

Our main project goal has always been to analyse these dances on a landscape scale using GIS. The challenge, however, is obtaining good land-type data. To combat this challenge, we recently contacted the Sussex Biodiversity Records Centre. We will be collaborating with Andrew Lawson, their GIS officer, on this project. Andrew has just this week pulled together a large, extensive land-type database. We will work with him to determine specifically what landscapes the bees are using and how this use changes with seasons. This analysis will begin in early 2013, and we anticipate full publication of these results to occur in the same year.

This is an extremely exciting time for our project, as so much of the hard work of the past three years is just now coming into fruition. We look to 2013 with eager anticipation because it will be the year that we have, finally, a complete, analysed data-set of how the bees at LASI from August 2009 – August 2011 use the landscape. This unique information will generate specific, data-verified results to feed into recommendations to those in a position to help the honey bee. Additionally, as the honey bee is the most generalist forager (Biesmeijer and Slaa, 2006), helping the honey bee also helps other insect pollinators, including bumble bees, solitary bees, butterflies, and hover flies.

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

Helping bees and agricultural pollination in farm land

Nick Balfour and Francis Ratnieks

Background

Bees and agriculture need each other. Bees pollinate many crops, and agricultural land, which covers 75 % of Britain, is a home for much of our wildlife and is also foraging territory for bees. The project, will investigate a range of questions including those below.

Funding

This project is funded by Waitrose Ltd.

The movements of honey bees in apple orchards (April-May 2012, 2013)

Apples are the most important crop grown in the United Kingdom that requires bee pollination. This project was carried out in one of the country's main apple-growing regions, west Kent near Tonbridge with the assistance of two apple growers: Adrian Scripps Ltd. and Darbyshire Ltd. The main aim was be to determine where honey bees from hives located in apple orchards are actually foraging, and whether this is on apples or not.

Foraging locations will be determined by decoding waggle dances. Pollen samples were also collected, using traps on hive entrances, and will be identified to determine the range of flowers visited and the relative importance of apples. Two aerial surveys of the area were also undertaken in April-May of 2012. This information will be used in conjunction with waggle dance data to construct a map of where bees are foraging over this period. In addition, bee counts were made on apple varieties to provide background information.

Fig. 15. Shed with three observation hives at Capel Grange Farm, Five Oak Green, Kent.

Fig. 16. Solitary bee (*Andrena* Spp.) on an apple flower.

Our results will help growers to use bee hives rented for pollination more effectively, by enabling us to address such questions as: are honey bees being drawn into nearby oilseed rape fields?

The fieldwork from April-May 2012 has been completed successfully. Waggle dance data are currently being decoded, pollen samples are being analysed, and bee data are being collated. A preliminary analysis of the data suggests that honey bees were the most frequent of all apple-flower visitors, accounting for approximately two-thirds of the insects recorded. It is planned to return to the same orchards in Kent during the spring of 2013 to collect further data.

The value of agricultural land as summer forage for bees (July-August, 2012)
Ongoing LASI research decoding waggle dances (see page 15) has shown that during July and August, honey bees do much of their foraging in agricultural land, often at long distances (up to *c.* 10km). This shows the importance of farmland as a source of forage. But what are the bees actually foraging on; which habitats, field types and plant species?

This project was carried out with the assistance of Junior Research Associate bursary student, Katherine Fensome, and investigated foraging by honey bees and other pollinating insects in and around the Castle Hill area, *c.* 2-4km SE of the University. This area was surveyed to determine what types of habitat or agricultural land type honey bees are foraging in, and on what species of plants. We also determined which other species of insects (e.g. bumble bees, solitary bees, hover flies, butterflies and moths) were also foraging in these habitats and on these plants. This was achieved by counting flower-visiting insects on transects in these areas. The abundance of flowers was estimated by recording the number of individual flowers in many 1 x 1m areas.

Fig. 17. JRA Student Katie Fensome recording the number of flowers in a 1 x 1 m area.

Fig. 18. Nick Balfour recording nectivores on a field margin, Castle Hill NNR.

This project will link in well to continuing LASI research, and will also be of great value scientifically and in wildlife conservation by linking together information on honey bee foraging from dance decoding with field work.

Fieldwork from August-September 2012 has been completed successfully, and data are currently being analysed. Preliminary analysis of the results suggests that nectivores are far more common in the Nature Reserve, SSSI (Site of Special Scientific Interest) and field margins, compared to pastoral fields and areas of set-aside within arable fields. It is planned to return to Castle Hill in the Autumn of 2013 to collect further data.

Do bumble bees deter honey bees from foraging on lavender? (August, 2012)
Previous research carried out at the University of Sussex in 2011 showed bumble bees to be superior foragers of lavender flowers compared to honey bees. Their relatively long tongues enable them to handle lavender's deep flowers over three times faster than the shorter tongued honey bees. This August we tested whether excluding bumble bees would increase the number of honey bees foraging on lavender. Furthermore, we examined several aspects of honey bee foraging behaviour to see if they were affected by the exclusion of bumble bees. To test our hypothesis, three patches of 'Grosso' lavender plants were set up on the University of Sussex campus. From one patch, bumble bees were excluded, honey bees were excluded from another and a third patch, from which there were no exclusions, acted as a control. Bees were excluded between 0900-1800h by administering a light tap with a bamboo stick on any individual that foraged in the "wrong" patch. To quantify foraging insects, at each patch

“snapshot” counts were taken, where every insect on a patch was quickly counted. To quantify bee behaviour, foragers were filmed on lavender flowers, and these recordings were later played back slowly on a computer. Lavender nectar availability was estimated by extracting lavender nectar with capillary micro-pipettes.

Fig. 19. Volunteer Sam Gandy beside a patch of lavender, Sussex University campus.

Fig. 20. Honey bee foraging on lavender.

The fieldwork has been completed successfully, and it was found that excluding bumble bees from lavender enhanced nectar availability. Furthermore, it increased honey bee numbers approximately 20-fold, and caused many changes in their foraging behaviour. Conversely, bumble bee numbers and behaviour were unchanged by honey bee exclusion. Our results present the first clear demonstration of competitive exclusion between bees. A paper has been prepared and submitted to a refereed journal.

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

Helping honey bees and insect pollinators in urban areas

Mihail Garbuzov and Francis Ratnieks

Funding

This research is funded by the Body Shop Foundation

Comparing garden and park plants for attractiveness to insect pollinators

Based on the trial and preliminary data collected in the summer of 2010 (see 2011 LASI Annual Report), this sub-project was improved and expanded in 2011 and 2012. The number of plant varieties was increased from 23 to 32, which gives the project a wider scope. In addition in 2011 and 2012, instead of using potted plants, all plants were planted out in the ground to achieve more realistic garden conditions. Each plant variety covers two 1m^2 mini-beds or patches, arranged in two concentric circles. This flower bed, located on the Sussex University campus, not only generates useful data but also looks beautiful and is appreciated by the university students and staff, who frequently stop to inquire about the work. In this way, the experiment itself serves as a wonderful outreach opportunity.

Fig. 21. Nick Balfour and Mihail Garbuzov collecting data at the experimental flower bed, July 2012 (Photo: Francis Ratnieks).

All data have now been collected and are being analysed. A preliminary look at the data showed that all years look very similar, which gives us confidence that we are in fact observing significant effects. For instance, all lavender varieties are highly attractive to insects, but the Intermedia lavenders (*Lavandula* × *intermedia*) seem to be more attractive than the English lavenders (*Lavandula angustifolia*). No insects were observed visiting a variety of geranium (*Pelargonium* × *hortorum* 'Cramden Red'). Lavenders in general seem more attractive to bumble bees than to honey bees, while borage (*Borago officinalis*) is more attractive to honey bees than to bumble bees. Although both lavenders and borage are visited by both types of bee, the reasons for such differential attractiveness were not known and developed into an interesting question in its own right, which was further explored in a project carried out by an MSc Entomology student from Imperial College, Nick Balfour, with help from Mihail Garbuzov and Francis Ratnieks. We found that differences in the preferences of honey bees and bumble bees can be explained by their ability to handle their preferred flowers more quickly and efficiently, which in turn was determined by the flower corolla-tube length (i.e. how far down the flower the nectar is found). In this way, the project, while still ongoing, is not only telling us which plants the bees prefer, but why differences in preference exist.

This project also benefitted from the assistance of two summer bursary students, Jodie Baker in 2011 and Elizabeth Samuelson in 2012, who assisted in identifying and recording the numbers of insects visiting the different plants.

Apiary design for keeping bee hives in urban areas and allotments
Honey bee hives can be kept in towns, as parks and gardens in urban areas have plenty of flowers. However, it is often a challenge to find suitable places to keep urban hives. Allotments are one possible location which has the added advantage of the bees helping to pollinate the crops being grown. However, councils may be reluctant to allow hives on their land due to the danger of stinging.

This project is examining the effect that lattice fencing and hedging have on the flight paths taken by forager bees when departing or returning to their hive. In particular, we hope to show that by forcing the bees to fly above head height, a 2m lattice fence or hedge will reduce the number of bees that bump into or even sting people near to the hives. If this proves true, it will provide ‘best practice’ guidance for keeping bee hives in urban areas and will give councils and landowners an incentive to encourage beekeeping.

One season of data collection was completed in 2011 at an experimental apiary set up with the help of our collaborators from Wakehurst Place (part of the Royal Botanic Gardens, Kew). In 2012 the experiment was replicated in another experimental apiary set up with the help of Plumpton College, Sussex. The flight paths of bees were recorded with video cameras against a white plywood background 3.5m high × 1m wide positioned at different distances from the apiary. The flight heights at these distances were then measured by analysing the videos. The analysis of data collected from Wakehurst Place showed that lattice and hedge do indeed raise the flight heights of honey bee foragers compared to the control (absence of a barrier). However, this effect does not extend further than 1m from the barrier. Nevertheless, the results do show the usefulness of a barrier in the predicted way. The data gathered in Plumpton in 2012 await analysis. Luciano Scandian kindly provided us with four bee hives for this project.

Fig. 22. (a) Study apiary near Plumpton College with four hives behind the lattice fence, July 2012. **(b)** Plaque explaining the experiment to the public in Wakehurst Place (Photos: Francis Ratnieks).

Investigating honey bee foraging in urban areas by dance decoding
Previous research at LASI has shown that a large proportion of honey bee foraging occurs in urban areas, particularly from July to September, despite the hives being located in a rural setting (the University of Sussex campus, just north east of Brighton). Thus, urban areas are very attractive to bees. This is, perhaps, not surprising given that private gardens occupy an

estimated 22-27 % of the urban environment in the UK. This project is investigating bee foraging patterns using hives located inside the city of Brighton, at the Dorothy Stringer High School who are collaborating with us. It is addressing the degree to which an urban area can support bees and to what extent they fly to the countryside. The school's biodiversity co-ordinator Dr Dan Danahar has kindly allowed and helped us to move and install three observation bee hives in the Brian Foster Environment Centre. These bee hives will not only help us to do this research, but are also an asset to the school enjoyed by the pupils and used in education.

Fig. 23. Experimental setup with video cameras filming honey bee waggle dances in observation hives at Dorothy Stringer School, Brighton (Photo: Francis Ratnieks).

Based on the previous work, it was expected that in spring most foraging would be local and hence urban, while in the summer the bees would fly longer distances, including to the countryside. Data collection took place between April and October 2011. Honey bees communicate foraging locations within the hive by means of the famous 'waggle dance'. The dance involves a worker bee performing a stereotypic behaviour communicating the direction and the distance to the food source. Glass-walled observation hives allow us to effectively "eavesdrop" on honey bee communication. The waggle dances are filmed using video cameras and the information on foraging locations is later decoded using video analysis.

The results from this project are now nearly fully analysed and show that, as expected, spring foraging occurs at very close distances (<1km) and hence is entirely urban. However, surprisingly and in contrast to the rural hives, urban hives forage in close proximity (<1km) throughout the whole season, with the exception of July (mean distance 1.8km). This result gives us insight into honey bee foraging ecology in a modern landscape and implies that urban areas are richer in flowers than the countryside. Urban areas are probably not brilliant for bees, but are seemingly better than farmland. This study shows that agricultural intensification, which has been great in Britain since the end of WW2, has reduced the bee and wildlife value of farmland, such that urban areas are now better for bees.

Investigating foraging by urban honey bees on agricultural crops, oilseed rape and linseed

Oilseed rape (OSR) is the third most important UK arable crop, after wheat and barley, doubling to 705,000 ha (2.9 % of the UK land area) between 1984 and 2011. It is also the most abundant insect-pollinated crop, and provides nectar and pollen for honey bees, bumble bees, and other insects. Most UK OSR (96 %, 2011) is sown in autumn, and so blooms in spring when many other flowers are also available. OSR is widely grown in Sussex, including near the University of Sussex. This study aimed to determine the value of OSR for both rural and urban honey bees by decoding their own communication dances to determine foraging locations.

In April and May 2011 and 2012 we made two aerial surveys by renting a light aircraft and pilot from nearby Shoreham Airport. OSR in bloom is easily seen and photographed from the air. We surveyed an area within 6km of the study hives which were located at the University of Sussex (rural) and Dorothy Stringer School (urban). Waggle dances made by forager bees in three observation hives at each location were videotaped. Waggle runs were decoded on computer by measuring durations and angles and then mapped.

The proportion of honey bee foraging on spring-blooming OSR as indicated by the dances differed between the two hive locations (a,b). From the rural hive location, University of Sussex, it was *c.*10 % in 2011 and *c.* 20% in 2012 of the total. But, from the urban location, Dorothy Stringer School, it was 0 % in both years. On average, foraging distances of the urban bees were shorter than those of the rural bees (c). This pattern persisted throughout the whole foraging season in 2011, except October. It implies that the urban areas may be richer in floral resources than the rural areas.

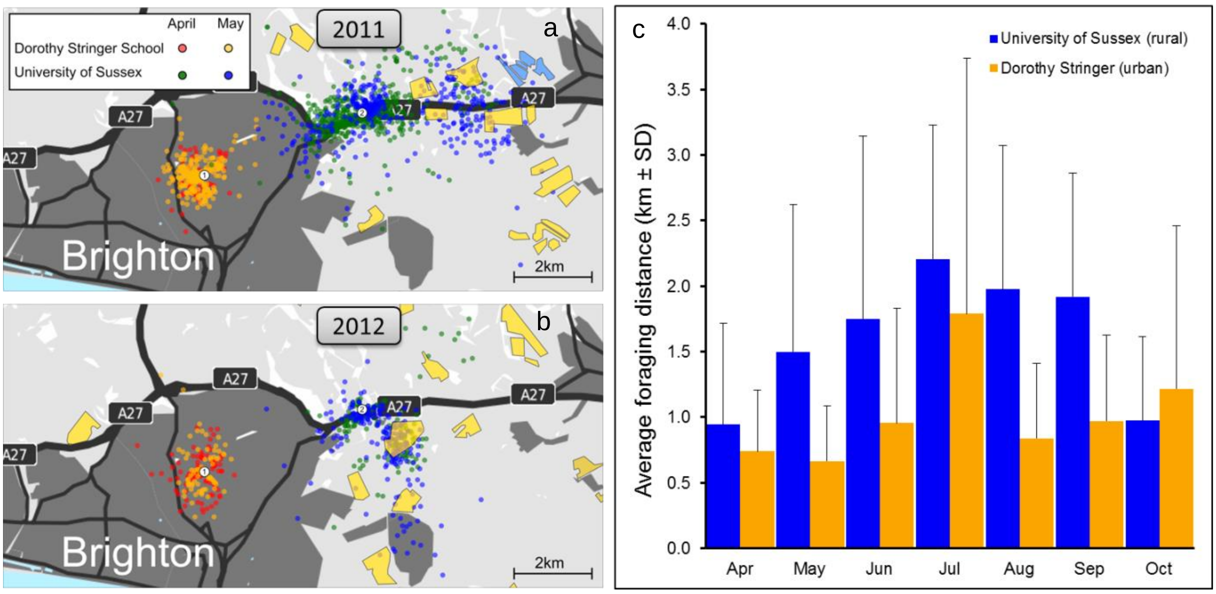

Fig. 24. (a,b) Fields of oilseed rape (yellow) and linseed (blue) flowering in spring in the study area. Dots are dance-decoded honey bee foraging locations; **(c)** Monthly variation in foraging distance.

The dance results indicate that honey bees forage little on OSR in spring, probably because flowers, such as dandelions, are abundant. But flowers are less abundant in summer, so the bees forage at longer distances. Increased use of summer-flowering OSR may make this crop more useful to bees. Urban bees foraged closer to their hives, indicating that flowers are more abundant in town than country. This supports the view that agricultural intensification has reduced the wildlife value of farmland. Urban areas are probably not brilliant for bees, but are better than farmland.

Investigating the importance of ivy flowers to honey bees and other flower visiting insects.

Earlier studies of honey bee foraging at LASI suggested that floral resources become more abundant in the very late season (September and October) compared to the previous months. We hypothesized that this is could be largely or entirely due to ivy (*Hedera helix* and *H. hibernica*), which has a late peak blooming period and is a very common and widespread native plant found throughout Britain. Ivy bloom can be prolific, although this is often overlooked as the flowers are not showy, being rather small (*c.* 5 mm) and dull coloured.

In this project, we used five complementary approaches (pollen trapping, nectar refractometry, local and regional surveys of insects foraging on ivy flowers, local survey of ivy abundance) to evaluate its importance to the honey bee and other flower-visiting insects in Sussex. Pollen trapping at six hives in two locations showed that an average 89 % of pollen loads collected by honey bees in the autumn were from ivy. Observations of foraging honey bees on ivy showed that ivy nectar is an even greater target than pollen, as 80 % were collecting only nectar. Measurement of nectar samples from ivy flowers and from honey bees foraging on ivy showed that ivy nectar is rich in sugar, 49 % w/w. Surveys showed that the main taxa of insects foraging on ivy were honey bees (21 %), bumble bees (*Bombus* spp., 3 %), ivy bees (*Colletes hederae*, 3 %), common wasps (*Vespula vulgaris*, 13 %), hover flies (Syrphidae, 27 %), other flies (29 %) and butterflies (4 %). The surveys also showed significant temporal and spatial variation in taxon abundance and proportion. A survey showed that ivy was very abundant on a small scale in both rural and urban areas, being present in 10/10 and 6/10 0.2 × 0.2 km samples within two 4 × 4 km areas, respectively.

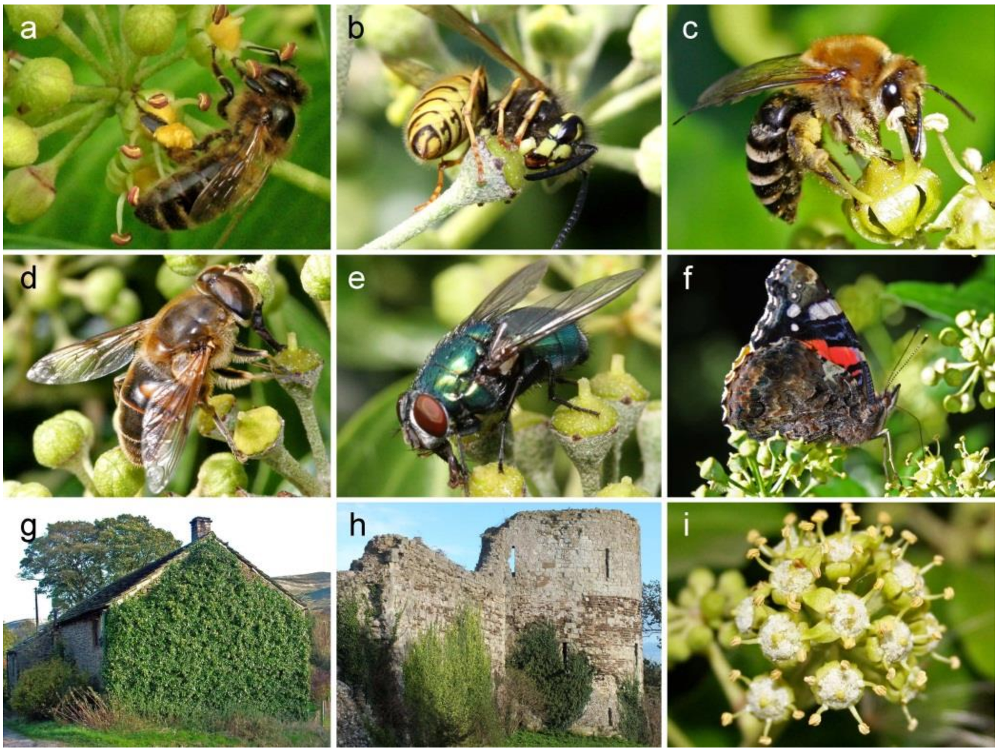

Fig. 25. Insects on ivy flowers: **(a)** honey bee (*Apis mellifera*) worker with a pollen load in its basket; **(b)** common wasp (*Vespula vulgaris*) ♂; **(c)** solitary ivy bee (*Colletes hederae*) ♀; **(d)** hover fly (*Eristalis tenax*, Syrphidae, honey bee mimic); **(e)** green bottle fly (*Lucilia* sp., Calliphoridae); and **(f)** red admiral butterfly (*Vanessa atalanta*). **(g)** Mature ivy climbing over the wall of a house in Derbyshire, and **(h)** Pevensey castle, Sussex. **(i)** Ivy flowers with nectar sugars turned into white crystals due to evaporation of water (Photos: Francis Ratnieks).

Our results show that ivy flowers have great importance to flower-visiting insects in autumn. Given that ivy is abundant and well-distributed both locally and nationally, being recorded in almost all 10 × 10 km squares in Britain, and because it is undoubtedly the most abundant autumn-flowering species, it is unlikely that there is a more important autumn flowering plant species in Britain for honey bees and other flower-visiting insects, including late season butterflies. Indeed, ivy may well be a keystone species for flower-visiting insects in autumn. Our study investigated the value of flowers, but ivy also provides berries and nesting sites for birds, and in Britain alone is a foodplant for 77 species of herbivorous insects and mites. From a human perspective, ivy is rather unappreciated or even considered undesirable, perhaps because its flowers are not showy and because it is a climber. It is frequently blamed for damaging walls and harming trees and so is often removed. But, contrary to popular belief, ivy rarely presents a problem to the trees it climbs. Indeed, it has recently been appreciated for its benefits in the insulation of buildings and pollution reduction in urban areas. Our study provides further evidence of the benefits of ivy to wildlife, which we hope can be used to inform decisions by householders, land owners, environment managers and policy makers.

Outreach and Public Communication 2012

This year the LASI outreach programme continued again to reach a wide audience. As well as training undergraduates, some fifty talks were given to a range of public groups such as school children, beekeepers, horticultural organisations, Café Scientifique, and Women's Institutes. We also took part in organised nature days and held a series of workshops at the laboratory. A full list of all academic and popular talks given in 2012 can be found in Appendix 2.

This year both Norman Carreck and Dr Karin Alton instructed and trained beekeepers. Norman taught on the National Diploma in Beekeeping course at York, and in conjunction with the Central Sussex Beekeepers Association, Karin instructed a 'Beekeeping for beginners' course.

In June LASI once again held three workshops showcasing our current research themes. The workshops were each repeated on two afternoons, and were equally popular, with an attendance of 25 participants per afternoon.

The first workshop, 'Hygienic behaviour training', was targeted at more experienced beekeepers interested in queen rearing and breeding. The afternoon involved a series of demonstrations and talks, with the talk on obtaining and the safe handling of liquid nitrogen was given by the Department of Life Science's Safety and Technical Co-ordinator, Dr Steve Pearce.

LASI's second workshop, 'Decoding the honey bee waggle dance', was aimed at people with a particular interest in honey bees, plants, and conservation. Topics included how honey bees communicate, the importance of the waggle dance and its role in foraging. The audience participated in demonstrations on how to decode the honey bee waggle dance, and how to plot the data from decoding the dances on a map to help locate where the bees are foraging.

The third workshop, 'Garden plants for bees', was not only targeted at the horticultural sector including gardeners, growers, garden centre workers, conservationists, land managers, parks departments, but also at teachers, beekeepers and any others interested in growing bee and pollinator friendly plants. An introductory talk on the subject of 'Bees, pollinators and flowers' was followed by an overview by Steve Alton, senior ecologist from FlowerScapes Ltd., about how the British landscape has changed to its current state, and how these changes in land use affect our flower visitors. The afternoon concluded with a visit to LASI's flower beds and a demonstration of methods used in data collection, together with an easy guide to identifying insect pollinators, and some ideas on how the information collected may be used.

One of the laboratory's honey bee colonies is housed in a portable observation hive which can be used to visit schools, wildlife events, and fairs. For example, Dr Karin Alton used it to explain the role of honey bees in fruit pollination and the research taking place at the University to halt their much publicised decline. Thanks to a further generous grant from the John Spedan Lewis Foundation, this year we were able to purchase new outreach materials and now have a collection of practical teaching materials to take out to schools.

Dr Margaret Couvillon continues her role as a column writer for *The Beekeepers Quarterly*, where she writes on a current topic of bee research in an engaging way for the magazine's readers. This year Margaret was also invited to speak at Parliament to a distinguished audience organised by the prestigious TEDx. A video of the can be seen at http://www.youtube.com/watch?v=tcXkQBY0i0k.

Prof Francis Ratnieks appeared in an episode of 'Bees, butterflies and blooms' presented by Sarah Raven, who is on a mission to halt the decline of bees and other insect pollinators with the help of insect friendly flower planting in this three part BBC series. The programme was aired in July 2012, and has received many good reviews.

In December, Dr Karin Alton was interviewed by Carol Kirkwood for a BBC1 Inside Out documentary about this year's inclement weather. It featured a section on how the cold and wet weather has prevented bees foraging, and also how the popularity of beekeeping in urban areas has dramatically increased in the last three years.

Both Prof. Ratnieks and Norman Carreck appeared in the BBC 4 documentary entitled 'Who killed the honey bee?' and have been interviewed for radio broadcasts both in the UK and abroad.

Fig. 26. (clockwise from top left): Karin Alton (and Mitey Kate) talking to local primary school children, Ardingly, Sussex; Francis Ratnieks describing bee diseases to beekeepers; Karin Alton being interviewed by Carol Kirkwood for BBC TV; Norman Carreck talks about LASI research on display at the British Beekeepers Association Spring Convention, Harper Adams College (Photos: 1-3. Karin Alton; 4. Andrea Quigley).

This year saw an eight-legged creature joining the lab's outreach programme, a realistic model of a varroa mite, was constructed by the special effects company, Millennium FX. Dr Karin Alton approached the company having been inspired by an episode of Dr Who, where his companion, Donna Noble, sports a 'time beetle' on her back. Karin thought this might capture the imagination of youngsters, as the size of the gruesome mite is to scale (with its bee host). Indeed, it has proved a very popular exhibit at schools and other public events. "Mitey Kate", named after her creator, was generously donated for free by the company.

LASI's website (www.sussex.ac.uk/lasi) has continued to be a useful tool to disseminate LASI research and information for academics, beekeepers, the media and the general public. From January to mid-December it attracted nearly 40,000 page views, with education being amongst the most viewed pages. Social networking sites such as Facebook and Twitter continue to be used to disseminate our research, and to broadcast events and news occurring in the lab. It is also used to relay other interesting social insect articles.

LASI currently has a live bee cam connected to the website, so the public can view honey bee activity day and night, with plans to install a further webcam in an outside hive, once the season progresses. The webcam can be accessed at http://139.184.164.70/view/index.shtml

Media engagement

Media highlights, 2012

JANUARY

Bees on guard

Francis Ratnieks and colleagues have found the first known species of 'soldier bees' in Brazil.
BBC Radio Two, 11/01/12.
International Business Times, 11/01/2012.
Ohio Standard, 11/01/2012.
The Guardian, 12/01/2012.
BBC News Online, 12/01/2012.
Daily Mirror, 15/01/2012.
Metro, 23 /01/2012.

Dr Who inspires honey bee boffin

Karin Alton enlisted the help of Dr Who special effects experts to create a monster-size varroa mite “Mitey Kate” who will tour schools as part of outreach work explaining the importance of the honey bee.
Brighton Argus, 07/01/2012.
East Grinstead Observer, 19/01/2012.

FEBRUARY

Death of a thousand cuts for honey bees

Norman Carreck interviewed in article about colony losses.
Western Farm Press, 06/02/12

Liquid nitrogen from BOC - vital to the bees’ needs

Article about hygienic bee workshops at LASI.
BOC online, 08/02/12

Save our bees: scientists reveal the plants that could halt bee decline

Mihail Garbuzov is leading a project to identify which flowering garden plants are most attractive to insects.
Telegraph.co.uk 19/02/12
BBC News; Isle of Man 19/02/12

Bees butterflies and blooms

Francis Ratnieks and Mihail Garbuzov join flower expert Sarah Raven to explore the world of flowers and pollinators, detailing an experiment into the best varieties of lavender for bees and other pollinators.
Sarah Raven "Bees butterflies and blooms: BBC2, 8pm, 22 Feb 2012

MARCH

Fundraising talk gets experts in a buzz about threat to bees.

Norman Carreck gives talk about the importance of bees in aid of Holy Innocents Church, Southwater.
West Sussex County Times, 9/3/12

APRIL

Black honey bees rediscovered in Britain

Francis Ratnieks comments on the rediscovery of native black honey bees in northern Britain.
The Guardian, 17/04/12

Bees' waggle dance disturbed by gravity.
Margaret Couvillon's research shows that honey bees that dance to give directions to flowers make more errors when performing horizontally than vertically because of gravity.
msnbc.com 17/04/2012
BBC Nature, 18/04/2012
Zee News, 19/04/12
American Scientist, 19/04/12

Waggle dance research referenced on Have I Got News for You!
Margaret Couvillon's research referenced as a news story on the top BBC quiz show.
BBC 1, 22/04/2012

Gardens: British wildflowers
University of Sussex research has found that bees fly into gardens in search of food most commonly during July and August.
The Guardian, 27/04/12

JUNE
Genetic weapon against bee killer
Francis Ratnieks comments on research to combat the deadly varroa mite in bees.
Farming UK, 09/06/12

JULY
Who killed the honey bee?
Francis Ratnieks and Norman Carreck were interviewed about declining populations of honey bees.
BBC4, 24/07/12

AUGUST
Rain bashes bees: fruit prices set to soar due to wet summer weather
Poor weather in spring and summer meant that bees at the University of Sussex had to be fed to be kept alive.
Daily Mirror, 04/08/12
EE News agriculture, *07/08/12*

OCTOBER
The wonderful world of bees and their gifts to humankind
Norman Carreck interviewed about bees and the environment.
One Radio Network, Texas, USA. 11/10/12

DECEMBER
Wild weather in London 2012 - London.
Karin Alton interviewed about keeping bees in urban areas.
BBC One TV London, 30/12/12

Funding

The Sussex Plan for honey bee health and wellbeing continues to be funded through the vision and generosity of our philanthropic donors. Since 2008, our supporters 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.

Generous donations have come from a wide variety of sources, including companies, trusts and foundations, beekeepers' associations and individuals. Some of our biggest funders have pledged to renew their support, Rowse Honey Ltd for a further three years and the Nineveh Charitable Trust for eighteen months. In addition, the John Spedan Lewis Foundation has made a second donation for educational and outreach materials and the Ernest Cook Trust has provided a grant for the first time to help with outreach.

The Body Shop Foundation, the British Beekeepers' Association and Waitrose continue to fund PhD students, who are conducting honey bee research over three years. Existing support from the Merrydown Trust and the Esmée Fairbairn Foundation continues to enhance the research capability of LASI.

As always we are particularly grateful to all the donors who make a commitment to support LASI over a number of years. Rigorous scientific research is a long term investment and we are grateful that during these uncertain times for higher education we have been able to continue this crucial research.

Over the next few years, support of this kind will be essential if the Sussex Plan is to be successful. Everyone at LASI would like to thank our donors, past and present, for their generosity and hope that they might consider supporting our vital work in the future.

Major donors
Body Shop Foundation
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Helen Wilson and Ealing and District Beekeepers' Association in memory of John Wilson MBE
High Wycombe Beekeepers' Association
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Isobel Ponsford and Jasmin Bannister and Kingsbridge Primary School
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Sir Peter Daniell Charitable Trust
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University of Sussex Students' Union
Vale and Downland Beekeepers' Association
Yew Tree WI

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BJ Sherriff
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Weber Shandwick
Millenium FX

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.

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 currently being sponsored by Waitrose Plc.

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 COLOSS network to investigate the causes of honey bee colony losses, and is also Senior Editor of the *Journal of Apicultural Research* and Science Director of the International Bee Research Association. He is a fellow of the Royal Entomological Society and 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.

Antonia Forster
Antonia Forster has BSc and MSc degrees from the University of Bristol, and began a PhD at LASI in December 2012. She has always been fascinated by the study of decision-making and the processes that organise it. In the final year of her degree she became interested in social insects, especially the way that individuals can cooperate and behave like a single super-organism. For her MSc she studied one particular aspect of this decision-making capability, in the context of house-hunting in rock ants, but for her PhD she wants to branch out and look more broadly across a number of species and situations. Her current work involves investigating trail organization in *Lasius niger*, the most common ant in Britain, and she I hopes to characterise the behaviour of this species in the field, and synthesise artificial pheromone trails for further laboratory studies.

Dr Christoph Grüter
Christoph Grüter is a postdoctoral researcher at LASI. He obtained an MSc in Biology at the University of Bern, Switzerland and his PhD at the University of Bern and the Universidad de Buenos Aires, Argentina. He studies honey bees (*Apis mellifera*) and ants (e.g. *Lasius niger*) to investigate when foraging workers use different types of information (personal memory versus social information from waggle dances and pheromone trails) to locate food sources. In addition, he studies the organisation of nest defence in stingless bees.

Fiona Riddell-Pearce
Fiona Riddell attended the University of Dundee, receiving a First Class Honours degree in Zoology. Her final year project investigated how house sparrows (*Passer domesticus*) regulate their body mass to prevent starvation and minimise risk of predation. She joined LASI in June 2009. Her MPhil research used the waggle dance to determine how the bees utilise the British landscape and also to investigate the stress caused by moving a colony to a new foraging location.

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.

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.

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.

Tomer Czaczkes
Tomer Czaczkes is a PhD student studying organisation and communication in ants at LASI. As an undergraduate at Oxford University he spent time volunteering, and later working at, the Entomology Department in the Oxford Natural History Museum. He began working with ants during his undergraduate research project, which was carried out on leaf cutter ants in Costa Rica. He also spent six months studying parasitoid wasps at the applied entomology group in the Freie Universität in Berlin, Germany. His PhD research is on the organization of foraging in ants, with studies carried out in the field in Brazil and at LASI.

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.

Sam Jones
Sam Jones has BSc degrees in both biology and chemistry and an MSc degree in Entomology from Imperial College. He came to LASI in October 2009 to carry out a PhD in the chemical ecology of social insects. His research is investigating foraging behaviour in ants and defence in stingless bees.

Appendix 1.

Publications 2012 (University of Sussex authors in bold).

Papers in refereed journals

Bigio, G., Grüter, C., Ratnieks, F.L.W. (2012) Comparing alternative methods for holding virgin honey bee queens for one week in mailing cages before mating. *PLoS ONE* **7(11),** e50150. http://dx.doi.org/10.1371/journal.pone.0050150

Carreck, N.L., Brent, C.S., Dade, H.A., Ellis, J.D., Hatjina, F., VanEnglesdorp, D. (2013) Standard methods for *Apis mellifera* anatomy and dissection. In *V. Dietemann, J.D. Ellis, P. Neumann (Eds) The COLOSS* BEEBOOK*, Volume I: standard methods for* Apis mellifera research. *Journal of Apicultural Research* **52(4),** http://dx.doi.org/10.3896/IBRA.1.52.4.03 (in press).

Contrera, F.A.L., **Couvillon, M.J.,** Nieh, J. (2012). Hymenopteran collective foraging and information transfer about resources. *Psyche* **2012,** 1-2.

Couvillon, M.J. (2012) The dance legacy of Karl von Frisch. *Insectes Sociaux* **59(3),** 297-306. http://dx.doi.org/10.1007/s00040-012-0224-z

Couvillon, M.J., Phillipps, H.L.F., Schürch, R., Ratnieks, F.L.W. (2012) Working against gravity: horizontal honey bee waggle runs have greater angular scatter than vertical waggle runs. *Biology Letters* **8(4),** 540-543. http://dx.doi.org/10.1098/rsbl.2012.0182

Couvillon, M.J., Riddell Pearce, F.C., Harris-Jones, E.L., Kuepfer, A.M., Mackenzie-Smith, S.J., Rozario, L.A., Schürch, R., Ratnieks, F.W.L., (2012) Intra-dance variation among waggle runs and the design of efficient protocols for honey bee dance decoding. *Biology Ope*n **1,** 467-472.

Couvillon, M.J., van Zweden, J.S., Ratnieks, F.L.W. (2012) Model of collective decision-making in nestmate recognition fails to account for individual discriminator responses and non-independent discriminator errors. *Behavioural Ecology and Sociobiology* **66(2),** 339-341. http://dx.doi.org/10.1007/s00265-011-1298-8

Czaczkes, T.J., Grüter, C., Jones, S.M., Ratnieks, F.L.W. (2012) Uncovering the complexity of ant foraging trails. *Communicative and Integrative Biology* **5(1),** 78-80.

Czaczkes, T.J., Ratnieks, F.L.W. (2012) Pheromone trails in the Brazilian ant *Pheidole oxyops*: extreme properties and dual recruitment action. *Behavioural Ecology and Sociobiology* **66(8),** 1149-1156. http://dx.doi.org/10.1007/s00265-012-1367-7

Dall, S.R.X., Bell, A.M., Bolnick, D.I., **Ratnieks, F.L.W.** (2012) An evolutionary ecology of individual differences. *Ecology Letters* **15(10),** 1189-1198. http://dx.doi.org/10.1111/j.1461-0248.2012.01846.x

Grüter, C., Menezes, C., Imperatriz-Fonseca, V.L., **Ratnieks, F.L.W.** (2012) A morphologically specialized soldier caste improves colony defence in a neotropical eusocial bee. *Proceedings of the National Academy of Sciences of the USA* **109(4),** 1182-1186. http://dx.doi.org/10.1073/pnas.1113398109

Grüter, C., Schürch, R., Czaczkes, T.J., Taylor, K., Durance, T., **Jones, S.M., Ratnieks, F.L.W.** (2012) Negative feedback enables fast and flexible collective decision making in ants*. PLoS ONE* **7(9)**, e44501. http://dx.doi.org/10.1371/journal.pone.0044501

Holcombe, M., Adra, S., Bicak, M., Chin, S., Coakley, S., Graham, A.I., Green, J., Greenough, C., Jackson, D., Kiran, M., MacNeil, S., Maleki-Dizaji, A., McMinn, P., Pogson, M., Poole, R., Qwarnstrom, E., **Ratnieks, F.L.W.,** Rolfe, M.D., Smallwood, R., Sun, T., Worth, D. (2012) Modelling complex biological systems using an agent-based approach. *Integrative Biology* **4(1),** 53-64. http://dx.doi.org/10.1039/c1ib00042j

Jones, S.M., van Zweden, J.S., Grüter, C., Menezes, C., Alves, D.A., Nunes-Silva, P., **Czaczkes, T.,** Imperatriz-Fonseca, V.L., **Ratnieks, F.L.W.** (2012) The role of wax and resin in the nestmate recognition system of a stingless bee, *Tetragonisca angustula*. *Behavioural Ecology and Sociobiology* **66(1),** 1-12. http://dx.doi.org/10.1007/s00265-011-1246-7

Martin, S.J., Ball, B.V., **Carreck, N.L.** (2013) The role of deformed wing virus in the initial collapse of varroa infested honey bee colonies in the UK. *Journal of Apicultural Research* (in press).
Schürch, R., Couvillon, M.J., (2013). Too much noise on the dance floor: intra- and inter-dance angular error in honey bee waggle dances. *Communicative and Integrative Biology* 6(1).
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* (in press).
Wenseleers, T., **Bacon, J.B., Couvillon, M.J., Kärcher, M.,** Nascimento, F.S., Nogueira-Neto, P., Robinson, E.J.H., Tofilski, A., **Ratnieks, F.L.W.** (2012) Bourgeois behaviour and freeloading in the colonial orb-web spider *Parawixia bistriata* (Araneae, Araneidae). *American Naturalist* (in press).

Book chapters, reports, conference proceedings, etc.

Bigio, G., Schürch, R., Ratnieks, F.L.W. (2012) Hygienic behaviour in honey bees: influencing factors and behavioural correlates. *Abstracts of 5th Congress of the European Sections of the International Union for the Study of Social Insects, Tuscany, Italy, 26-30 August, 2012.* 184.
Carreck, N.L. (2012) Why bees need help. In *W D J Kirk and F N Howes (Eds) Plants for bees.* International Bee Research Association; Cardiff, UK. ISBN: 978-0-86098-271-5 pp 1-11.
Carreck, N.L. (2012) “Disseminating the results of the COLOSS Network”. In *Proceedings of 8th COLOSS Conference - Prevention of Honey bee COlony LOSSes, Halle-Salle, Germany,1-3 September, 2012.* 9.
Couvillon, M.J., Ratnieks, F.L.W. (2012) Seasonal variation in honey bee foraging distance demonstrates critical gaps in food availability. *Abstracts of 5th Congress of the European Sections of the International Union for the Study of Social Insects, Tuscany, Italy, 26-30 August, 2012.* 181.
Al Toufailia, H., Grüter, C., Ratnieks, F.L.W. (2012) Persistence to unrewarding feeding locations by forager honey bees (*Apis mellifera*): the effects of experience, resource profitability, and season. *Abstracts of 5th Congress of the European Sections of the International Union for the Study of Social Insects, Tuscany, Italy, 26-30 August, 2012.* 180.

Popular articles

Carreck, N.L. (2012) Are bad beekeepers to blame for honey bee colony losses? *Bee World* **89(1)**, 10-11.
Carreck, N.L. (2012) How can we quantify bumble bee populations? *Bee World* **89(2)**, 30-31.
Carreck, N.L. (2012) Ninety years of bee research at Rothamsted. *Bee World* **89(2)**, 53-54.
Carreck, N.L. (2012) Eva Crane Memorial Award 2011. *Bee World* **89(3)**, 58-59.
Carreck, N.L. (2012) Where are we now with *Nosema ceranae*? *Bee World* **89(3)**, 62-63.
Carreck, N.L. (2012) Book Review: “Honey bee colony health - challenges and sustainable solutions” edited by Diana Sammataro and Jay Yoder. *Bee World* **89(3)**, 67.
Carreck, N.L. (2012) Is beekeeping a hazardous occupation? *Bee World* **89(4)**, 82-83.
Carreck, N.L. (2012) COLOSS and EurBee meetings. *Bee World* **89(4)**, 84-85.
Carreck, N.L., Alton, K.L., Bigio, G., Scandian, L., Al-Toufailia, H., Ratnieks, F.L.W. (2013) News from the University of Sussex hygienic bees project. *An Beachaire* **68(1)**, 8-10.
Carreck, N.L., Alton, K.L., Bigio, G., Scandian, L., Al-Toufailia, H., Ratnieks, F.L.W. (2013) News from the University of Sussex hygienic bees project. *Beekeeping* **79(1)**, 15-16, 22.
Carreck, N.L., Alton, K.L., Bigio, G., Scandian, L., Al-Toufailia, H., Ratnieks, F.L.W. (2013)

University of Sussex hygienic bees research project update. *British Beekeepers Association News* **209**, 15-16.
Carreck, N.L., Alton, K.L., Bigio, G., Scandian, L., Al-Toufailia, H., Ratnieks, F.L.W. (2013) News from the University of Sussex hygienic bees project. *Gwenynwyr Cymru* (in press).
Carreck, N.L., Alton, K.L., Bigio, G., Scandian, L., Al-Toufailia, H., Ratnieks, F.L.W. (2013) News from the University of Sussex hygienic bees project. *The Scottish Beekeeper* (in press).
Couvillon, M.J. (2012) All in the eye of the bee-holder: properties of the honey bee visually-driven odometer. *Beekeepers Quarterly* 110.
Couvillon, M.J. (2012) Seasonal importance of the dance language. *Beekeepers Quarterly* 109, 33-34.
Couvillon, M.J. (2012) New studies investigating the effect of systemic pesticides in bees generates more questions. *Beekeepers Quarterly* 108, 41-42.
Couvillon, M.J. (2012) A big job for a little bee: a morphologically distinct stingless bee worker provides effective nest defence. *Beekeepers Quarterly* 107, 40-41.

Appendix 2.

Talks, exhibitions, workshops and public events given in 2012

19/1/12	Talk: *"The amazing honey bee: the common British insect that is vital to agriculture, a gateway to discoveries in science, and man's best insect friend"* at Mole Valley Probus Club, Leatherhead, Surrey (FR).
19/1/12	Talk: *"Wither honey bee research?"* to Colchester Beekeepers Association (NC).
2/2/12	Talk: *"Bees, ants and science education"*. to science educators meeting, University of Sussex (FR).
9/2/12	Talk: *"Bee research at the University of Sussex"* to Worthing Beekeepers Association (NC).
15/2/12	Talk on bees at the Latest Music Bar, as part of Brighton Science Festival (FR).
16/2/12	Talk: *"Do bees matter?"* in aid of Holy Innocents Church, Southwater, West Sussex (NC).
16/2/12	Talk: *"Helping honey bees and insect pollinators in urban areas"* in Evolution, Behaviour and Environment seminar series, University of Sussex (MG).
23/2/12	Talks: *"The science of bees* (FR)" and *"Helping honey bees and insect pollinators in urban areas* (MG)" at Brighton Science Festival, Friends Meeting House. Ship Street, Brighton.
24-25/2/12	Talks: *"A survey of previous crises in beekeeping – lessons for today"*; *"Discovering where and on what bees are foraging at particular times"*; and *"Where are we now with control of Varroa?"* to Ulster Beekeepers Convention, Greenmount College, Antrim, Northern Ireland (NC).
25/2/12	Talk to West Sussex Beekeepers' Convention (MC).
6/3/12	Invited seminar at University of Bristol (MC).
9/3/12	The Leaver Memorial Lecture, Newbury Beekeepers Association (MC).
10/3/12	Talks: *"Honey bee viruses - what are they and why are they important"*; and *"Honey bee colony losses - what are the causes?"* to Cambridgeshire Beekeepers Association (NC).
17/3/12	South East Hampshire Beekeeping Spring Convention (MC).
20/3/12	Talks: *"Altruism, cooperation, and the principles of self-organization"*, *"Case studies: honey bees and Pharaoh's ants,* Monomorium pharaonis" and *"The organization of ant colony foraging systems: informational complementarity and feedback processes"* to *"The Organization of Insect Societies to Entomology"* MSc and PhD students, Departamento de Biologia, Faculdade de Filosofia Ciencias e Letras de Ribeirão Preto, University of São Paulo at Riberão Preto, Brazil (FR).
31/3/12	Talk to Central Association of Bee-Keepers Spring Meeting, Roots and Shoots, London (MC).
12/4/12	Talk: *"Bee research at the Laboratory of Apiculture & Social Insects at the University of Sussex"* to West Suffolk Beekeepers (FR).
17/4/12	Peter Springall Memorial Lecture *"Breeding bees for hygienic behaviour to fight Varroa"* to Bromley Beekeepers Association (NC).
20/4/12	Talk: *"The honey bee: gateway to discoveries in biology"* to New Forest Beekeepers Association, Hampshire (FR).
24/4/12	Talk: *"The amazing honey bee: the common British insect that is a gateway to science, man's best insect friend, honey maker and pollinator"* to Cafe Scientifique, Portsmouth, Hampshire (FR).
2/6/12	Demonstration of bee behaviour with observation hive and video cameras at Railway land Festival, Lewes, East Sussex (FR).
8,9/6/12	Talks: *"Hygienic behaviour and bee breeding* (NC)"; and *"Quantifying levels of* hygiene (NC)" at Hygienic Behaviour Training Workshop, University of Sussex.
10-11/6/12	Talks at Waggle Dance Training Workshop, University of Sussex (MC).

19/6/12	Talks: *"The amazing life of a common British insect"* with demonstrations of behaviour of honey bees using observation hive and video cameras to Biology Experience Day for A-level pupils, University of Sussex (FR).
22/6/12	Technology Entertainment Design (TEDx) talk: *"Democracy and society"* to UK Houses of Parliament, The Banqueting House, Whitehall (MC).
6/7/12	LASI outreach day, ran demonstrations on how to decode waggle dances
13/7/12	Observation hive exhibit and presentation at the Dorothy Stringer High School, Brighton (FR, MG).
17/7/12	Talk: *"Wildflower planting for bees"* to NDB Advanced Beekeeping Course, Fera, York (NC).
26-31/8/12	Talks: *"Hygienic behaviour in honey bees: influencing factors and behavioural correlates"* (GB); *"Seasonal variation in honey bee foraging distance demonstrates critical gaps in food availability"* (MC); *"Persistence to unrewarding feeding locations by forager honey bees (*Apis mellifera*): the effects of experience, resource profitability, and season"* (HT) at International Union for the Study of Social Insects (IUSSI) Combined European Sectional Meeting, Tuscany, Italy.
2/9/12	Talk: *"Disseminating the results of the COLOSS Network"* at 8th "Prevention of honey bee COLony LOSSes" (COLOSS) Conference, Halle-Salle, Germany (NC).
3-4/9/12	Talk: *"Honey bee foraging on oilseed rape from urban and rural locations"* at the Annual Life Sciences Postgraduate Research Colloquium, University of Sussex (MG).
15-16/9/12	Talks: *"What do we know about honey bee colony losses?"* and *"The University of Sussex hygienic bees project"* to Midland and South West Counties Convention, Derbyshire (NC).
4/10/12	Talk: "Honey *bee nutrition"* to Meon Valley Beekeepers Association, Warnford, Hampshire (NC).
13/10/12	Talk at Cheshire Beekeepers' Association Autumn Meeting (MC).
20/10/12	Talk: *"Honey bee losses and possible causes".* to Weald Beekeepers Association, Smarden, Kent (NC).
25-27/10/12	Jean Blaxland Memorial Lecture at National Honey Show, Weybridge, Surrey (MC).
6/12/12	Talk in Environment, Behaviour and Evolution seminar series, University of Sussex (MC).
10/12/12	International Union for the Study of Social Insects (IUSSI) Northwest European Section Winter Meeting, London (MC).

Appendix 3.

Theses by members of LASI

Tomer Joseph Czaczkes.

Organisation of foraging in ants.

PhD thesis, 2012.

Abstract.

In social insects, foraging is often cooperative, and so requires considerable organisation. In most ants, organisation is a bottom-up process where decisions taken by individuals result in emergent colony level patterns. Individuals base their decisions on their internal state, their past experience, and their environment. By depositing trail pheromones, for example, ants can alter the environment, and thus affect the behaviour of their nestmates. The development of emergent patterns depends on both how individuals affect the environment, and how they react to changes in the environment.

Chapters 4 – 9 investigate the role of trail pheromones and route memory in the ant *Lasius niger*. Route memories can form rapidly and be followed accurately, and when route memories and trail pheromones contradict each other, ants overwhelmingly follow route memories (chapter 4). Route memories and trail pheromones can also interact synergistically, allowing ants to forage faster without sacrificing accuracy (chapter 5). Home range markings also interact with other information sources to affect ant behaviour (chapter 6). Trail pheromones assist experienced ants when facing complex, difficult-to-learn routes (chapter 7). When facing complicated routes, ants deposit more pheromone to assist in navigation and learning (chapter 7). Deposition of trail pheromones is suppressed by ants leaving a marked path (chapter 5), strong pheromone trails (chapter 7) and trail crowding (chapter 8). Colony level ‘decisions’ can be driven by factors other than trail pheromones, such as overcrowding at a food source (chapter 9). Chapter 10 reviews the many roles of trail pheromones in ants.

Chapters 11 – 14 focus on the organisation of cooperative food retrieval. *Pheidole oxyops* workers arrange themselves non-randomly around items to increase transport speeds (chapter 11). Groups of ants will rotate food items to reduce drag (chapter 12). Chapters 13 and 14 encompass the ecology of cooperative transport, and how it has shaped trail pheromone recruitment in *P. oxyops* and *Paratrechina longicornis*. Lastly, chapter 15 provide a comprehensive review of cooperative transport in ants and elsewhere.

Fiona C. Riddell-Pearce.

An efficient method for decoding the honey bee waggle dance and its use in determining the effects of hive relocation on foraging efficiency.

MPhil thesis, 2012

Abstract.

Our understanding and uses of the honey bee waggle dance have come a long way since its discovery by Karl von Frisch in the 1940s. It is now used as a powerful research tool for investigating various features of honey bee biology. Manual dance decoding is time-consuming. It is impractical to decode all circuits of a dance to determine foraging location; however, intra-dance waggle runs vary, so it is important to decode enough to obtain a good average.

In chapter 2 I examine the variation among waggle runs made by foraging bees to devise a method of dance decoding. The first and last waggle runs within a dance are significantly more variable than the middle run. We recommend that any four consecutive waggle runs, not including the first and last runs, may be decoded.

This thesis also examines how artificially moving hives affects the foraging efficiency of colonies that are moved and whether it has any effect on resident colonies (Chapter 3). We moved three colonies (in observation hives) onto the University of Sussex campus from a site more than 20km away and compared their foraging efficiency to three similarly sized resident colonies. Foraging distance, forager effort, nectar concentration, percentage of successful nectar foragers and were the factors used to quantify foraging efficiency. We found that bringing new hive onto the apiary site had no effect on the foraging efficiency of the resident colonies that moved colonies were able to match the foraging efficiency of resident colonies immediately after the move.

Hasan Al Toufailia.

Honey bee foraging: persistence to non-rewarding feeding locations and waggle dance communication.

MPhil thesis, 2012.

Abstract.

The honey bee, *Apis mellifera*, is important in agriculture and also as a model species in scientific research. This Master's thesis is focused on honey bee foraging behaviour. It contains two independent experiments, each on a different subject within the area of foraging. Both use a behavioural ecology approach, with one investigating foraging behaviour and the other foraging communication. These form chapters 2 and 3 of the thesis, after an introductory chapter.

Chapter 2. Experiment 1: Persistence to unrewarding feeding locations by forager honey bees (*Apis mellifera*): the effects of experience, resource profitability, and season. This study shows that the persistence of honey bee foragers to unrewarding food sources, measured both in duration and number of visits, was greater to locations that previously offered sucrose solution of higher concentration (2 versus 1molar) or were closer to the hive (20 versus 450m). Persistence was also greater in bees which had longer access at the feeder before the syrup was terminated (2 versus 0.5h). These results indicate that persistence is greater for more rewarding locations. However, persistence was not higher in the season of lowest nectar availability in the environment.

Chapter 3. Experiment 2: Honey bee waggle dance communication: signal meaning and signal noise affect dance follower behaviour. This study shows that honey bee foragers follow fewer waggle runs as the distance to the food source, that is advertised by the dance, increases, but invest more time in following these dances. This is because waggle run duration increases with increasing foraging distance. The number of waggle runs followed for distant food sources was further reduced by increased angular noise among waggle runs within a dance. The number of dance followers per dancing bee was affected by the time of year and varied among colonies. Both noise in the message, that is variation in the direction component, and the message itself, that is the distance of the advertised food location, affect dance following. These results indicate that dance followers pay attention to the costs and benefits associated with using dance information.