Laboratory of Apiculture and Social Insects

Annual Report January 2012

University of Sussex
Life Sciences

LASI
Laboratory of Apiculture and Social Insects

Contents

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	Dr Francisca Segers	Dr Martyn J Stenning
Dr Jelle van Zweden		

Doctoral students

Mr Gianluigi Bigio	Mr Tommy Czaczkes	Mr Sam Jones
Mr Mihail Garbuzov		

Masters students

Mr Hasan Tofalia	Ms Fiona Riddell	Ms Mengyung Jiang
Mr Edwin Lang		

Undergraduate Summer Bursary students and assistants

Mr Chris Accleton	Ms Jodie Baker	Ms Esmee Taylor

Volunteers

Mr Mike Kavanagh	Ms Ellie Blows	Ms Sarah Hudson
Ms Suzie Johanson		

Undergraduate project students

Academic Year 2010-1

Mr Kiran Bonardi-Murzello	Ms Rosa Bonifacii	Ms Laura Ellis
Ms Elizabeth Wood	Ms Ashleigh Bates	

Academic Year 2011-2

Mr Alexander Blakey	Ms Roseann Cole	Ms Rosie Cooper-Bowman
Mr Andy Madsen	Mr Hunter Phillipps	Ms Gemma Truslove

Visitors

Mr Nick Balfour (UK)	Ms Katharina Hoffmann (Germany)
Ms Aurelie Croizelle (France)	

Mission statement and goals

Research

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

Teaching

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

Community

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

Contacts

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Overview of 2011

2011 was the year in which LASI completed its set up process. The most tangible evidence of this was the completion of the main LASI facility. Thanks to a generous donation from the late Mr David Read and his family we were able to refurbish and incorporate a corridor and two rooms adjoining the existing LASI facility into lab space. With our workshop, apiaries, and various sheds we now have all the facilities we need for our work.

New laboratory facilities funded through the generosity of the late David Read

LASI now has enough space to house approximately 13 people working full time, however the actual number who worked at LASI on research in 2011 is much larger. This is because we have many people coming to the lab part time. In 2011 these included three visitors from other universities, four volunteers, two additional masters students, eleven undergraduate students doing their year-three projects, and three undergraduate helpers and summer bursary students. All of these people made their contribution in one way or another, to one project or another.

The fact that we have many people volunteering to work with us shows that people value what we are doing to help honey bees and to learn more about how honey bees and other social insects live. This is also shown in many other ways. For example, in the summer of 2011 we had forty applications for a doctoral studentship on *Helping bees and agricultural pollination in farm land*, funded by Waitrose. This is an almost unprecedented level of interest. And of course it is also shown in the generous donations we are receiving for the *Sussex Plan for Honey Bee Health and Well Being* from many individuals, charities and businesses. With their help the Sussex Plan is making good progress and is now entering the phase where we expect to see tangible evidence for our efforts and funding.

During 2011, LASI was productive in many ways. Overall, LASI researchers published twenty-seven refereed articles in scientific journals, eight book chapters or conference papers, twenty articles in beekeeping and other magazines, and produced a range of eleven educational pamphlets (see Appendix 1). Outreach is very important and in we carried out a total of sixty different activities (see Appendix 2).

In 2011 we introduced two new categories of outreach activities, farm visits, arranged with the help of Waitrose, and workshops. In total we ran six workshops, two each on three themes connected to the *Sussex Plan: Testing honey bee colonies for hygienic behaviour; How to decode the honey bee waggle dance, Finding out which garden plants are best for bees*. These were a great success, with more people applying than we had space for. Both the farm visits and the workshops will be carried on in the future and are proving to be an excellent way of reaching beekeepers,

gardeners, landowners and others who will benefit from LASI's applied research. We also consolidated our relationship with the Linklater Pavilion, an environmental centre in the nearby town of Lewes, by installing a special permanent display consisting of an observation hive complete with video camera and monitor to show the public the life of honey bees.

The most important part of LASI is the people. In 2011 we said goodbye to postdoctoral researcher Dr Jelle van Zweden and doctoral student (now Dr) Martin Kärcher, who have returned to Denmark and Austria. We wish them well. But we have also gained postdoc Dr Francisca Segers (from the Netherlands) and doctoral student Mr Nick Balfour (from Scotland).

LASI farm visits and links to other farms in 2011. Clockwise from top left: Tour of College Farm, Duxford, Cambridgeshire, 29 June; Flower rich buffer strip at College Farm; Crop of strawberries needing bee pollination at Tuesley Farm, Godalming, Surrey, 18 May; Borage patch planted on Plumpton College farm to calibrate honey bee waggle dance, with Dr David Lamb, Dr Margaret Couvillon and Mr Mihail Garbuzov, 4 August; Mr Nick Balfour and apple trees at Adrian Scripps Farm, near Tonbridge, Kent, 11 November; LASI benefactor Mr Michael Chowen leading a visit to farm rich in wild flowers, East Sussex, 19 June.

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

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

Francis Ratnieks, Norman Carreck, Karin Alton and Gianluigi Bigio

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.

Varroa mites on honey bee pupa.

Hygienic behaviour is a naturally occurring genetic trait, meaning that it can be selected for using conventional bee breeding methods. Previous studies by Professor Ratnieks found that only 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, 2011).

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 Mr Michael Chowen, Rowse Honey Ltd, the British Beekeepers Association and the Somerset Beekeepers Association.

Progress
During the summer of 2011 we tested colonies headed by queens reared in previous years of the project for hygienic behaviour. All colonies were tested four times using our standard techniques.

Breeding continued as in previous years, and we obtained further queens for evaluation from Northern Ireland and Cornwall. Michael Collier from Cornbrook Bee Farm again kindly visited us in August to carry out Instrumental Insemination for controlled crossing.


Michael Collier inseminating a honey bee queen.

As mentioned last year, we are now at the stage where we can begin to evaluate colonies headed by queens reared in the project for their characteristics under normal beekeeping conditions. We have thus donated some queens to a local beekeeper Luciano Scandian from Shoreham by Sea, who will evaluate these alongside his own colonies.

Portable equipment has now been purchased to enable testing using liquid nitrogen in remote locations, and Luciano's bees at two apiary sites have been tested this summer. His strain of bees, obtained by careful management over a number of years shows good characteristics for docility and honey production, and encouraging levels of hygienic behaviour have also been identified.

Jodie Baker field testing bee colonies in Worthing.

As mentioned elsewhere in this report, two successful Hygienic Bee testing workshops were held at LASI, and attended by over 50 beekeeping delegates from throughout Britain (Carreck *et al*, 2011). The object was to demonstrate the freeze killed brood technique, and particularly to provide instruction on the safe use of liquid nitrogen. Paul Charles from BOC kindly took part, indicating that it is feasible for beekeeping groups to obtain small quantities of liquid nitrogen for field use.

Karin Alton demonstrating at the hygienic bee workshop.

One major hurdle with any bee breeding programme is ensuring the distribution of sufficient queens to assist practical beekeepers, and the added problem that queens that might be suitable for our climatic conditions in southern England may prove less suitable for conditions elsewhere. We are therefore actively promoting our ideas to beekeeping groups in the hopes that they may establish regional or local breeding groups which will evaluate hygienic behaviour as a characteristic in locally adapted strains of bee.

As a member of the international COLOSS (prevention of honey bee COlony LOSSes) network (currently 217 scientists, representing 55 countries worldwide) funded by the EU via COST, Norman Carreck has been involved in the dissemination of results from the “Genotype Environment Interactions” experiment where sixteen strains of honey bee are being tested under standardised conditions at sixteen locations in Europe and compared at each location with two other strains from within the experiment. Initial results suggest that the local strains are proving

more suitable in each case. This seems logical to scientists, but many beekeepers believe that foreign strains are superior to those that they have already, and much international trade in queen bees exists, causing unnecessary expense to beekeepers, and also increasing the risk of transporting exotic bee diseases around the world. Unfortunately the UK was not involved in the current COLOSS experiment, which is now nearing its conclusion, but it is to be hoped that LASI can take part in the follow up experiments, which are now at the early planning stage.

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Summer view of “The Ridge” apiary above the University.

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

1a. Developing new techniques for breeding disease resistant bees

Gianluigi Bigio, Norman Carreck, Karin Alton and Francis Ratnieks

Overview and Main Aim

Gianluigi Bigio started his PhD programme in April 2010, consisting of several sections that will provide results to be exploited in the broader context of the Sussex Plan project which aims to selectively breed and then test under UK field conditions a strain of hygienic honey bees, and to work 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 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 have demonstrated that honey bee queens can be kept in mailing cages under optimum conditions, to be readily available for genotyping and then mating. This work is now completed and a paper has been submitted to a peer reviewed journal for publication.

Gianluigi Bigio with reared queen cells.

Section 2

Following on from the work done in 2010, more hives were screened with the freeze-killed brood (FKB) assay in order to expand the genepool from which to breed hygienic queens. As the season progressed four additional colonies were identified as suitable for our breeding programme. Their daughter queens were reared and are now housed in hives either in our own apiary or have been given to a local beekeeper for field testing. This is a first step towards establishing a close network of beekeepers who will deliver information regarding the performance of our reared queens both in terms of hygienic behaviour, but also in terms of other traits of interest, such as honey production,

docility, ability to overwinter etc. This is an ongoing project which will support the main breeding programme.

Section 3
As mentioned elsewhere in this report, colonies belonging to a semi-professional beekeeper Luciano Scandian have been screened using the FKB assay in order to determine the presence of additional hygienic strains which we may be able to include in our breeding programme. Other colony behaviour traits of interest have also been quantified in order to eventually correlate hygienic behaviour with defensive behaviour and calmness on the comb. In addition, we will monitor how hygiene varies according to the season. This project is ongoing, the first phase was completed in Autumn 2011 and it will resume in Spring 2012.

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 either were 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 they will be published as a paper in a peer reviewed journal.

Future developments
In Spring 2012, we will test the queens reared last season from hygienic mothers in order to ascertain whether these carry the hygienic behaviour trait and will continue the selection programme to produce daughter queens from the best performing colonies. Further traits of interest will be monitored and taken into account in order to raise strains of bees that are suitable for field conditions.

In order to expand the network of beekeepers that was created during 2011, more workshops (see LASI Outreach) will be held in Spring and Summer 2012, and we are aiming towards a comparison trial of honey bee colonies belonging to LASI and those belonging to a local beekeeper. This will be the next step towards developing the main breeding programme, and with the support of enthusiastic beekeepers hopefully will result in the dispersal of bees carrying the hygienic genotype. It is worth remembering that like any breeding programme, it is open ended. The strains of bees we select must be tested to constantly monitor their performance, via queen rearing amongst beekeepers.

In order to better focus the project direction and outcome, we are also preparing a questionnaire to target beekeepers, both professional and amateurs, in order to have a more accurate and up-to-date knowledge of what is of interest and how we can implement our efforts with their requests but also how they can benefit from our findings.

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

2. How good is the British countryside for honey bees? Decoding dances to determine where worker honey bees are foraging

Margaret Couvillon and Francis Ratnieks

Funding
This project is supported by three major donors: the Nineveh Charitable Trust, an agricultural charity promoting the preservation of the countryside, Waitrose, 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.

Background
Contributing some £27 billion annually to the world economy, the honey bee is the single most important animal pollinator (Kluser *et al,* 2010). The proportion of animal-pollinated crops has risen rapidly (>300%) (Klein *et al,* 2007; Aizen and Harder, 2009) and is expected to continue to rise. However, concurrent with this increase, we are experiencing a global decline in wild and managed bee populations. For example, the number of honey bee colonies has decreased in England and Wales by approximately 75% since 1910 (Carreck, 2008). Globally, this results in agicultural need far outstripping the availability of honey bees, especially since 1991 (Aizen and Harder, 2009).

Reasons for the decline in honey bees are complex and multi-faceted. However, the loss of forage is most definitely an important issue. Healthy or sick, bees need to eat, and less available forage means insufficient honey stores to see the bees through the winter months.

Figure 1: Changes in landscape have reduced the available forage for bees. For example, clover used to be grown to return nitrogen to the soil. In addition to this agricultural benefit, clover was also an important provider of nectar to bees. Nowadays commercial fertilizers have mostly replaced the clover pastures (Photo: Francis Ratnieks).

Why might there be fewer flowers for bees? Most simply, our land use practices have changed in the past century. Hay meadows are increasingly rare, and heather moorland is in decline. Traditionally, clover pastures were a common source of nitrogen, but commercial fertilizers have

largely replaced these (Figure 1). Agricultural land has fewer weeds and wild flowers. All of this results in less nectar and pollen for bees and other pollinators.

However, before more 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. There are many important questions: how should we best decode the dances? During which months of the year is there less forage for bees? How does foraging change with seasons? What type of land are the bees visiting, and what type of land are the bees not visiting?

How do we know where honey bees forage?

In 1946 Karl von Frisch published his landmark paper demonstrating that honey bees communicate foraging locations to nestmates via the waggle dance (von Frisch, 1946, 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. 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 therefore the only animal who tells you where it has been foraging. At LASI, we believe that it is important therefore to listen.

Figure 2: 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. Picture by Lila Morris from video of dancing bee that can be viewed at http://www.sussex.ac.uk/lasi/resources/education/whatbeesdo

Our first step was to see what others have found out using the honey bee waggle dance. This involved conducting a literature search and writing our own literature review (Couvillon, submitted). Science after all builds on the discoveries that have come before. Our next step was to work out how best to decode dances. 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 (Figure 2). 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. The 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). For biologists eavesdropping on this conversation, quantifying and decoding waggle dances present certain experimental challenges: specifically, dance decoding is time-consuming. As a bee repeats the same waggle runs for over an hour in real time, it may take 5-6 hours to decode a single dance. Therefore, there is a need for protocols to optimise dance decoding.

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 *et al,* (submitted)). We show mathematically that it is sufficient and necessary to decode four consecutive repeated figures of eight in the same waggle dance to obtain a single distance and direction.

Where are bees foraging?

With the design of efficient waggle dance decoding methods, we were able to decode many dances from the foraging months (March – October each year, as bees do not forage in the winter). To date, we've decoded over 2,000 dances from the first year of the project (Aug 2009 – July 2010) and an additional 1,500 dances from the second year of the project. Most of these dances have been decoded by undergraduate third year project students, undergraduate researchers, and volunteers. In this way, members of the University and larger community are integrated into an important research project. 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. Already we are generating some interesting results. Most specifically, we have found that the average distance that an individual forager flies varies with month (Figure 3).

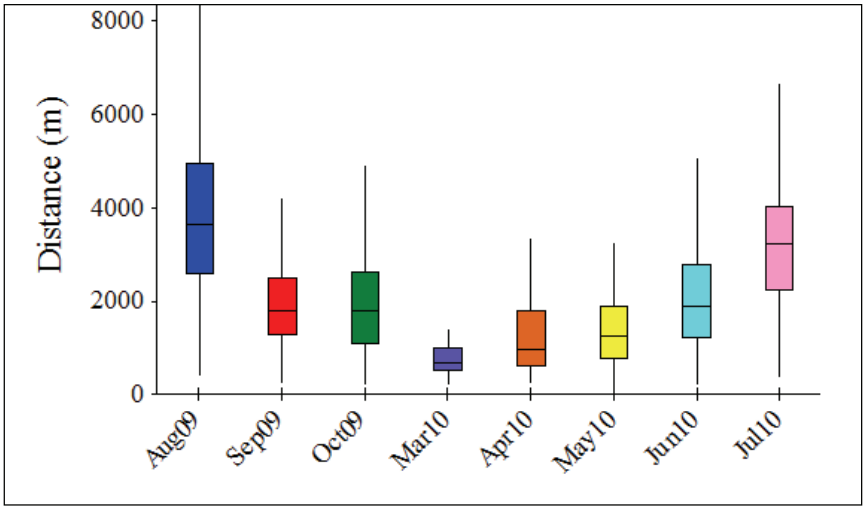

Figure 3: Average foraging distance changes with month. Bees must forage at the furthest distances in the summer months (August and July) and may forage at the nearest distance in the spring months (March and April).

From hives located on the University campus in rural East Sussex, bees fly the furthest in the summer, averaging over 4km in July and August. In contrast, most flights in March were under 1km. Flight is incredibly costly both in terms of energy (a bee must consume valuable honey to power flight) and time, which is also correlated with risk of predation. A bee will not fly far if forage is available close by. Therefore, these results indicate that summer months, which are warmest, actually are a challenging time for our bees. One recommendation arising from this work could therefore be to encourage the planting of nectar-rich plants that bloom in high summer.

After flying furthest in August, distances decrease from August to September/October (average: 2km). It is likely this decrease reflects the flowering of ivy (*Hedera helix*) (Figure 4), which is a common evergreen plant. Ivy typically represents the last nectar flow of the season before the bees begin overwintering.

Figure 4: A honey bee forages on common ivy. Ivy is an important source of nectar in the autumn (September and October) and provides the last nectar flow for the foraging year.

We are also 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 (Figure 5).

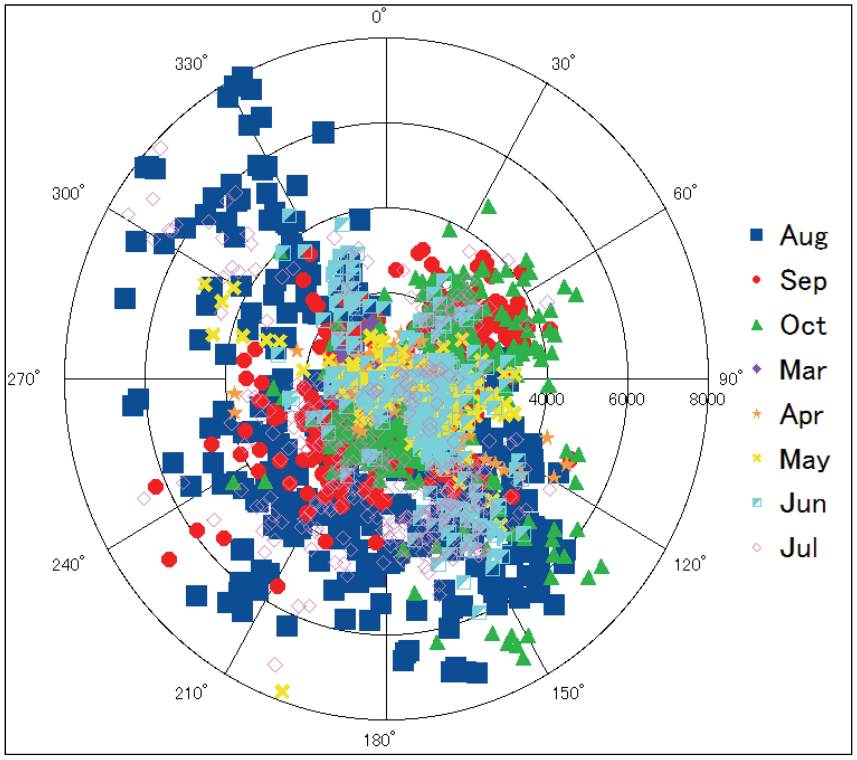

Figure 5: Patterns of individual dances varied with month. This graph displays decoded foraging locations from the first year of data collection and represents 2000 dances. LASI is located in the centre of the graph. Each month has a specific symbol.

We can identify at a glance what areas are key foraging locations. Additionally, we see which sections of the landscape are relatively untouched. We next overlay the above graph on a map for each month (Figure 6). This allows us to identify where specifically the bees are going and where specifically the bees are not going.

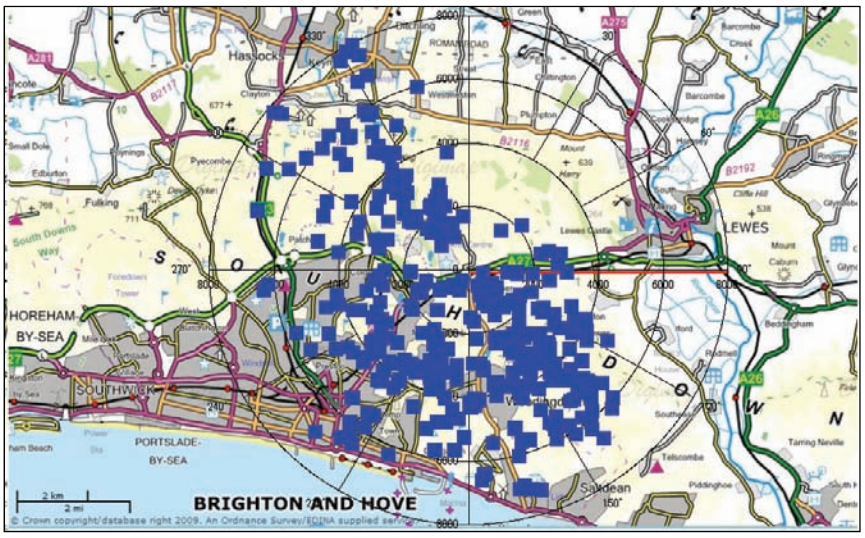

Figure 6: The foraging locations for August 2009 demonstrate where the bees are going and where they are not going. Specifically, the bees do not seem to visit NE of campus; SE of campus, which is heavily visited, is dominated by a nature reserve with large amounts of blooming wild flowers.

We have now completed these analyses for the first year of data collection. We will do the same for the second year of data, as it is important to show that the patterns we describe are general for our area and not specific to a year.

Where do we go from here?

We are still working hard to decode the second year of dances, a Herculean task that involves the coordination of many personnel and much equipment. We expect to finish these dances by spring 2012. This will represent 2 years of foraging dance data and nearly 4,000 dances. These data will provide us with a unique and critical insight into patterns of foraging ecology that will ultimately help our honey bees. We will be integrating the data with Global Positioning Systems (GPS) to determine what land type is being visited. This stage of the project is already well underway.

Finally, it is also important to calibrate the dances. The mathematical function that we use to convert seconds of waggle to metres of flight is based on Karl von Frisch's data; however, we know that different subspecies of honey bees have a slightly different seconds-to-metres translation. Calibration is an essential step, but it is one that may be done at any time in the project. It will involve decoding dances of individual bees that have foraged at a known location. Here we enlisted the help of Plumpton Agricultural College. Located an ideal 2-7km from LASI, Plumpton College planted for us four large patches of borage that were very attractive to bees. These patches were located at 3, 5, 7, and 9km from LASI. Bees were allowed to forage as usual, and we videotaped the dancing bees. Currently these tapes are being decoded by student worker Chris Accleton. Chris is a second year undergraduate worker, and he is assisting by decoding dances 10 hrs/week. These dances will be plotted in the above ways over maps that will depict the borage.

How will honey bees and other pollinators benefit from the results of the project?
This information will be of value to people who are responsible for growing plants and who want to make Britain a more bee and insect friendly country, including farmers, land managers, parks departments, and gardeners. The research will generate specific, data-verified results that will feed into recommendations to those in a position to help the honey bee. Additionally, honey bees are generalist foragers, which means they visit a large number of plant species that are also visited by other pollinating insects. Therefore, anything that is good for honey bees will also benefit other pollinators, including bumble bees, solitary bees, butterflies, and hover flies, thereby benefiting biodiversity.

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2a. Honey bee foraging in novel environments

Fiona Riddell Pearce, Margaret J. Couvillon and Francis L. W. Ratnieks

Funding
This project is funded by Waitrose, a supermarket chain with a strong commitment to the environment.

Introduction
Honey bee colonies are commonly moved long distances. In the United States colonies are regularly moved across thousands of miles to provide pollination services, a notable example being California's annual almond pollination. In the United Kingdom, although hive movement is not seen on such a scale, bees are often moved to take advantage of large nectar flows such as the pollination of the apple crop.

It has been suggested that this displacement of hives from their home locations causes stress to the honey bees and may be a factor in the recent reduction in colony numbers (Ellis et al, 2010). One possible cause of stress is the transportation itself; bees are prevented from foraging during the move as the hives are closed, and they may experience vibration in the back of a lorry.

Another potential cause of stress is experiencing a novel environment. Honey bee colonies send out scout bees to examine the landscape and gather information on worthwhile foraging locations. This information is conveyed to recruited foragers in the hive via the famous "waggle dance" (von Frisch, 1967). These forager bees retain a memory of foraging locations for several days (Grüter et al, 2008) allowing them to efficiently exploit the landscape. When a colony is moved to a novel location, the foragers are deprived of this memory, and they must build up new information of good foraging locations within the colony's catchment area. As the foraging range of a honey bee can be up to 14km in any direction, (Beekman & Ratnieks, 2000) having no memory of profitable forage sites may lead to poor or no foraging until such information is available.

We were interested in testing the hypothesis that moving honey bees to a novel location will lead to poor initial foraging, followed by an increase in foraging success as foragers locate and dance for good quality resources.

Methods
To test whether being transported to a new location has significant negative effect on a colony and its foraging behaviour, we moved three colonies (hereafter, "moved colonies") with no experience of the landscape to the laboratory and monitored their foraging success. The moved colonies had been previously located and monitored at Wakehurst place, a location with non-overlapping foraging range to the laboratory. Additionally, three control colonies were monitored on the University of Sussex campus (hereafter, "resident colonies"), in this way, we are able to compare the foraging success of moved colonies before and after their relocation and to compare the foraging success of moved colonies to resident colonies.

We used a number of metrics of foraging were compared between resident and moved colonies:

- **Hive mass:** Colonies without adequate forage tend to lose mass. Monitoring the mass of hives can provide an indication of foraging success. Therefore we weighed both resident and moved colonies each day.

- **Forager effort:** We counted the number of bees leaving the hive over 10 minutes of both resident and moved colonies during the morning, midday and afternoon. This allowed us to determine the foraging rate in bees.min-1 at these different times throughout the day.
- **Forager success:** A successful returning nectar forager contains nectar in her crop. We collected 10 nectar foragers (those returning without pollen loads were assumed to be nectar foragers) from each colony three times each day. The bees' abdomen was gently palpitated to cause them to regurgitate the nectar. We calculated % successful returning nectar foragers per hive 3 times a day. This is the percentage of nectar foragers returning successfully (i.e. with nectar) from a foraging trip.
- **Nectar quality:** Using the above regurgitated nectar, we tested the concentration of sugar using a refractometer. Therefore we obtained a % sucrose reading for each successful returning nectar forager from both resident and moved hives 3 times a day. This we use to calculate average % sucrose. Higher % sucrose is better quality and a possible indicator of superior foraging success.
- **Pollen mass and diversity:** Pollen samples were collected from returning pollen foragers 3 times each day using small pollen traps. The traps remove a sample of pollen from the forager's legs as they pass through the mesh. Mass of pollen collected can be compared between the two groups (moved and resident) as well as the relative diversity of pollen types.
- **Foraging distances:** Flight is very energetically costly. Therefore there is a trade-off between energy out (distance flown) and energy in (foraging reward, i.e. quality of nectar). Successful foragers convey good foraging sites to nestmates via the waggle dance; conveying the distance and direction to the food source. We can record these dances and decode the information in them to discover the best foraging sites.

To allow the foraging behaviour to be tested under a number of different conditions the experiment has been repeated during late summer when flowers are sparse (August/September 2010), autumn when ivy is in bloom (October 2010) and summer when the spring flowers have finished blooming (June 2011). Trials were also planned for spring 2011 but the number of bees in the observation hives was allowed to rise to a level to permit foraging before subjecting them to the stresses of the experiment. All these trials have now been completed and the accumulated video footage is currently being decoded and the results analysed.

Preliminary results

To date 686 dances have been decoded from over 500 hours of footage. Currently little difference has been observed between the foraging distance of moved and resident hives in all experiments. There are differences in the foraging distance from each trial. These differences are easily explained by the seasonal variations in foraging conditions (Couvillon, Riddell and Ratnieks, in prep).

Preliminary results suggest that the waggle dance is an extremely efficient way of adapting to a novel or changing environment by sharing information about food sources with other foragers in the nest. Full results on exact foraging locations and full analysis of foraging distances are expected within the next two months once decoding of the final waggle dance footage is completed.

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

3. Helping honey bees and insect pollinators in urban areas

Mihail Garbuzov and Francis Ratnieks

Funder

The Body Shop Foundation funds the projects focusing on helping honey bees in urban areas.

Comparing garden and park plants for attractiveness to insect pollinators

The aim of this project is to compare the numbers of bees and other insects attracted by garden plants. Summer-flowering plants are the focus, because early results of the waggle dance decoding project are showing that in July and August honey bee foraging distances are greatest, indicating a relative shortage of flowers at this time of year.

Determining the attractiveness of summer-flowering garden plants to honey bees and other pollinating insects. Clockwise from top left: Part of the experimental garden of 32 plant varieties, each in 2 1m x 1m patches, set up by doctoral student Mr. Mihail Garbuzov; Summer bursary student Ms Jodie Baker counting flower-visiting insects on each patch; LASI visitor Mr Nick Balfour gathering data to determine why lavender receives more visits from bumble bees than honey bees as part of his master's degree project in entomology at Imperial College; Ms Sarah Raven and Professor Ratnieks during filming for BBC2 TV programme on *Bees, Butterflies & Blooms*.

In 2010, twenty-three varieties of plants were set up in pots at the University and monitored for insect visitors. Our results show clearly that there is a great deal of variation in the number of insects attracted, meaning that gardeners can make a difference simply by choosing a more bee-friendly plant. For example, we purchased two plant varieties at a local garden centre, *Dahlia* "Amazone" and *Pelargonium* "Chocolate Twist". Both cost the same. The dahlia proved to be the most attractive of the twenty-three varieties and the pelargonium the least attractive. Our results

also show that *intermedia* lavenders are more attractive than *angustifola* lavenders and that borage (*Borago officinalis*) is the most attractive plant for honey bees. Overall, 22% of the insects attracted were honey bees, 56% were bumble bees, 5% other bee species, 19% hover flies, and 1% butterflies.

Based on the trial and preliminary data collected in the summer of 2010, this project has been improved and expanded in 2011. The number of plant varieties has been increased from 23 to 32, which gives the project a wider scope. In addition, 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 University of Sussex campus, not only generates useful data but also looks beautiful and is appreciated by the students and staff, who frequently stop to inquire about the work. In this way, the experiment itself serves as a wonderful outreach opportunity. Data collected in the summer of 2011 are in the process of being analysed, while the project will continue in 2012 to allow for the overall results to include any year-to-year variation.

Whilst it is still too early to provide definitive conclusions, the observations from this year (2011) mirror the patterns observed last year (2010) and give 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 insect was observed visiting one variety of geranium (*Pelargonium* × *hortorum*) both this year and last year. Lavenders in general seem more attractive to bumble bees than honey bees, whilst borage is more attractive to honey bees than to bumble bees. Although both lavenders and borage are visited by both types of bee, the reason for such differential attractiveness was not known and has developed into an interesting question in its own right, which has been further explored in a spin-off project carried out by Nicholas Balfour, an MSc Entomology student from Imperial College, with help from Mihail Garbuzov and Francis Ratnieks. It seems that differences in the preferences of honey bees and bumble bees can be explained by their ability to handle their ‘favourite’ flowers more quickly and efficiently. In this way, the research, 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 help of summer bursary student Jodie Baker, who assisted in identifying and recording the numbers of insects visiting the different plants.

Part of the experimental flower bed showing some of the 32 plant varieties set-up at Sussex University campus, July 2011.

Apiary design for keeping bee hives in urban areas and allotments

Bee hives can be kept in towns because 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. This will provide 'best practice' guidance for keeping bee hives in urban areas and will give councils and landowners an incentive to encourage beekeeping.

One of the main data collection periods took place at Royal Botanic Gardens Kew, Wakehurst Place in the summer of 2011. We have set up a suitable lattice fence around our apiary in the nursery garden, which can easily be removed, allowing bee flight paths with and without fencing or temporary hedging to be studied. 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 (see photo). The flight heights at these distances were then measured by analysing the videos.

This project is also involving us in working with a local commercial beekeeper, Luciano Scandian from Shoreham by Sea, Sussex, who kindly provided four bee hives for this project. The project will continue in 2012 in a new apiary to be set up in collaboration with Plumpton College.

Study apiary at Wakehurst Place with four hives behind the lattice fence, August 2011.

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 at the University campus. 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. In particular, it will address to what degree the urban area can support the 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.

Mihail Garbuzov filming bee waggle dances in observation hives at Dorothy Stringer school.

Based on the previous work, it is expected that in spring most foraging will be local and hence urban, while in the summer the bees will fly longer distances, including to the countryside. The hives were installed in April 2011 with the data collection commencing soon after and lasting until October 2011. The waggle dances are filmed using video cameras and the information on foraging locations is to be decoded using video analysis. However, analysing large volumes of video using this method is a slow and labour-intensive process, and is therefore still ongoing.

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

Oilseeds, including oilseed rape (*Brassica napus*) and linseed (*Linum usitatissimum*), are major crops grown throughout Europe. Oilseed rape is the most important arable crop grown in the UK after barley and wheat, with 642,000 ha under cultivation (Defra 2010). The area of linseed is less, but still considerable, at 44,000 ha. These crops flower in spring, around April-May, and are thought to present a superabundant, even if short-lasting, forage resource of both nectar and pollen for honey bees and other insects. Honey bees can fly up to approximately 14km to flower patches, so bees from urban hives may also visit the countryside if urban areas are not providing enough food. The aim of this project is to determine to what extent urban honey bees forage in

agricultural fields of these flowering crops, and how the distance of fields from the hives and field area affect bee foraging preferences.

Fields of oilseed rape as seen from the air 700m above ground (left) and the map of oilseed rape and linseed fields around LASI and Dorothy Stringer School (right).

The fields, when in bloom, are brightly coloured and very distinctive. We therefore located fields using two survey flights from a small aircraft in April and May 2011. The aircraft was rented from the Shoreham Airport and each survey flight was completed in approximately 1 hour. This was a big saving in time and resources over the alternative way of doing it from the ground driving hundreds of miles. The data on bee foraging locations will be obtained using the same methods as those used in the project investigating urban bee foraging. The data will likely be collected again in the spring of 2012 to include any year-to-year variation.

Research - Undergraduate student research projects

In their third year, undergraduate students in the School of Life Sciences carry out a research project. This project is important to them as it is their main opportunity to carry out research during their BSc degree. It is also very significant in the time and effort involved and it counts for 25% of their grade for the final year. Projects normally start in October, although a few students begin during the summer vacation. In January, each student gives a 15-minute presentation about their project, and in February they hand in a completed report in the style of a scientific paper.

Each year Professor Ratnieks has approximately six projects to supervise at LASI. Honey bees and social insects are ideal for student projects. They give students an opportunity to work with live animals, and by carefully choosing projects it is possible to carry out research in the autumn. It is actually easier to study honey bee guarding behaviour and nestmate recognition in the autumn, as this is the time of year when robbing is most prevalent, as there are few flowers to forage on. Similarly, it is possible to train worker honey bees to artificial feeders easily in the autumn, and this makes it possible to study certain kinds of foraging behaviour such as flower constancy. Some honey bee projects also investigate honey bee dancing, and here weather and season are not a factor, as we work with video tapes of dancing made earlier using observation hives. Projects carried out on ants are also unaffected by season or weather as we study foraging in laboratory colonies.

The student research projects greatly contribute to LASI goals as they give students important training in conducting real research. Students normally carry out projects in pairs and in addition to Professor Ratnieks, each project has one or two other LASI researchers helping with supervision. In addition, every year one or two projects go on to be published as scientific papers. In 2010 and 2011, two student projects involving five students that Professor Ratnieks supervised in 2008-9, LASI's first year at Sussex, were published as papers in refereed scientific journals:-

Grüter, C., Moore*, H., Firmin*, N., Helanterä, H., Ratnieks, F. L. W. (2011) Flower constancy in honey bee workers (*Apis mellifera*) depends on ecologically realistic rewards. *Journal of Experimental Biology* 214, 1397-1402.

Couvillon, M. J., Barton*, S. N., Cohen*, J. A., Fabricius*, O. K., Kärcher, M. H., Helanterä, H., Ratnieks, F. L. W. (2010) Alarm pheromones do not mediate rapid shifts in honey bee guard acceptance threshold. *Journal of Chemical Ecology* 36: 1306-1308.

* project student

Project Students, Projects and Co-Supervisor in 2010-11 and 2011-12

2010-2011

Mr Kiran Bonardi-Murzello and Ms Rosa Bonifacii (co-supervisor Dr Jelle van Zweden).
Topic: Honey bee guarding behaviour.

Ms Laura Ellis and Ms Elizabeth Wood (co-supervisors Dr Christoph Grüter and Mr Tommy Czaczkes). *Topic: Foraging behaviour in* Lasius niger *ants.*

Mr Ashleigh Bates (co-supervisor Dr Margaret Couvillon).
Topic: Decoding honey bee waggle dances to investigate foraging locations

Student project of Mr Andy Madsen. Clockwise from top left: Honey bee worker foraging on borage; Andy gathering data on the number of honey bees visiting borage patches of different sizes; Mihail Garbuzov helping Andy to move the borage plants to a second location on the campus to gather more data; Collating data during a break.

2011-2012

Mr Alexander Blakey and Ms Roseanne Cole (co-supervisor Dr Christoph Grüter)

Topic: Food discovery and recruitment behaviour in Lasius niger *and* Monomorium pharaonis *ants.*

Ms Rosie Cooper-Bowman and Ms Gemma Truslove (co-supervisor Dr Margaret Couvillon)

Topic: Effect of social context on nestmate recognition errors by honey bee guards.

Mr Andy Madsen (co-supervisor Mr Mihail Garbuzov).

Topic: Effects of patch size and flower colour proportions on honey bee foraging on borage.

Mr Hunter Phillipps (co-supervisor Dr Margaret Couvillon).

Topic: Does waggle run angle relative to vertical affect variation among waggle runs?

Teaching

One of the most important activities conducted at LASI is the teaching and training of students. At a post-graduate level LASI currently has seven doctoral students who are supervised directly by Professor Ratnieks. In addition, Professor Ratnieks is also supervising the research projects of two students doing the Biological Chemistry master's degree in the School of Life Sciences.

At the undergraduate level we have four students doing their final year research projects on honey bees and two on ants. Professor Ratnieks lectures in undergraduate courses on Behavioural Ecology (year three), Social Insects (year three), and Conflict & Cooperation in Animal Societies (year three) and gives tutorials in the Animal Behaviour course (year one). He is also the academic advisor to fifteen undergraduates.

Other members of the LASI team, including Margaret Couvillon, Christoph Grüter, Jelle van Zweden and doctoral students Sam Jones, Tommy Czaczkes, Fiona Riddell-Pearce, Martin Kärcher and Mihail Garbuzov are also involved in undergraduate teaching, ranging from helping to supervise final year projects to giving tutorials. All the labs in the Social Insects class take place at LASI, and include one lab in which the students decode honey bee dances and another in which they study ant foraging trails. Because LASI is on campus and only two minute's walk from the main Life Sciences buildings, this greatly helps link undergraduate students to LASI.

Undergraduate students gathering data for a guarding project

Outreach and public communication

2011 was a busy year for the LASI extension programme. As well as 64 talks given to public groups such as school children, beekeepers, horticultural organisations, Café Scientifique, and Women's Institutes (see Appendix 2), we have been engaged in many different activities aimed at bringing our research to the attention of the public.

Once again this year both Norman Carreck and Karin Alton were involved with instructing and training beekeepers. Norman taught on the National Diploma in Beekeeping "Advanced beekeeping course" and, in conjunction with Central Sussex Beekeepers Association, Karin instructed a "Beekeeping for beginners" course.

Workshops at LASI (clockwise from top left): Norman Carreck and Karin Alton demonstrate the "freeze killed brood" technique; visitors comparing different varieties of *Lavendula*; Mihail Garbuzov showing difference between bee species; and delegates studying hygienic bees.

Three workshops showcasing our current research themes were held at LASI during the months of May, June and July. The workshops were each repeated on two afternoons, with a maximum attendance of 25 per afternoon. The first workshop, 'Hygienic Behaviour Training', was targeted at more experienced beekeepers interested in queen rearing and breeding. The workshop gave the background on hygiene followed by hands-on experience of how to test attendees' own colonies for hygiene using the freeze-killed brood bioassay. This technique allows beekeepers to select for this particular behavioural trait when queen rearing. We had an overwhelming response to this workshop, with subscription full just a couple of weeks after advertising. Not wanting to turn people away, we compiled a waiting list for our next hygienic workshop which now numbers over 50 people.

The second workshop, ‘Decode the Honey Bee Waggle Dance’, was targeted at anyone interested in science, as well as people with particular interests in honey bees, plants, and conservation. Talks included delving into how honey bees communicate, highlighting the importance of the waggle dance and its role in foraging. We set up interactive demonstrations of how to decode these honey bee waggle dances and how to plot the data from dance decoding on a map.

The last workshop, entitled ‘Garden Plants for Bees’, was aimed at gardeners, growers, garden centre workers, conservationists, land managers, parks departments, teachers, beekeepers and others who want to make the land they are responsible for more bee friendly. The techniques taught were also applicable to wild flowers and crop plants. The afternoons’ schedule included a talk on the subject of ‘Bees, pollinators and flowers’ followed by an overview, and later a demonstration, of methods used in determining what flower visitors are attracted to our research flower beds, together with an easy guide to identifying insect pollinators. Steve Alton from Sussex Nature delivered a talk on bee botany. We finished the workshop with ideas on how to use the information collected.

The laboratory’s honey bee colony housed in an observation hive travelled to various fairs, fetes and wildlife events, for instance, to an Eco and Sustainability Fair held in March, and to an Apple and Honey Fair in October.

Karin Alton also took the honey bees to the South of England Showground in July to a special annual event, “Connect with the Countryside”, where schools are invited to bring their year 5 and 6 pupils. The day, which was free to schools, aimed to encourage children to think about where their food comes from and the processes involved in getting food from the field to the table. The event, organised by the South of England Agricultural Society, proved to be successful, though extremely busy, and attracted around 2,400 school children.

Karin Alton at “Connect with the Countryside”.

The Linklater Pavilion is a recently-constructed environmental and social centre in the nearby town of Lewes. It is located next to the River Ouse and is part of the Railway Land Project http://www.railwaylandproject.org/, which turned 20 acres of former railway yards into a nature reserve. Soon after moving to the University of Sussex, Professor Ratnieks was contacted by Dr John Parry, the chief organizer of the Railway Land Project and Pavilion. From this came the plan

of setting up an exhibit featuring an observation hive specially designed for public viewing and running educational events on bees for the public.

The first bee related event at the Pavilion was in May when one of LASI's research observation hives, a video camera and a monitor were installed in the still unfinished building. This was combined with small exhibits, and a talk about bees by Professor Ratnieks.

On 11 June 2011 a much bigger event was held to celebrate the *Arrival of the Bees*. This involved a permanent exhibit of a large observation hive with a flat screen TV and video camera to show the live behaviour of the bees in the colony in close up. With live music, exhibits about bees, a display of artwork on bees and flowers by pupils from the Priory School in Lewes and talks by Professor Ratnieks, the event showcased the importance of the LASI research. The exhibits were manned by a small army of LASI researchers, supplemented by Sussex University students. In all about 500 people attended and the day was a great success.

The Linklater Pavilion. Clockwise from top left: The Linklater Pavilion, located on the Railway Land next to the River Ouse in Lewes; Professor Francis Ratnieks moving the observation hive into the Pavilion; The observation hive with video camera and monitor acting as a microscope to show the activities of the bees within the colony; Dr John Parry announcing the arrival of the bees to the Mayor of Lewes.

During the summer the observation hive was managed by feeding it with syrup so that it could build up in population and store enough food to get through the winter. It is much larger than most observation hives, with eight medium-depth Langstroth frames, which means that it gives a natural-sized cavity for the colony and so requires less management. It is also more impressive as a display. The hive is clamped to the wall and has glass only on the front side with plywood on the back. A short length of plastic tubing passes from the hive through the wall, allowing the bees to forage naturally. The exit point on the wall is about 4m above ground level to minimize any stinging

risk to passers by. To manage the hive it is first unclamped from the wall and taken outside under the entrance hole. The glass is removed to allow normal beekeeping management.

The next bee event at the Pavilion will be on 2 June 2012 as part of the Railway Land Festival. LASI and the Pavilion aim to continue the bee exhibit and gradually to incorporate other activities and technology, such as a computer to allow the decoding of waggle dances made by bees in the hive. This will allow school pupils and other visitors to determine where the bees are foraging. Honey bees forage on average 1 to 4km from their hive, depending on the time of year. For a local environmental centre, an observation hive is both an opportunity to learn more about bee behaviour and a way of seeing how wildlife uses the local environment, and it appeals to children from 2 to 102 years of age.

Pupils from the Priory School in Lewes during their one week bee project at the Linklater Pavilion. Left: Pupil cutting out a bee wing; centre: Pupils printing flowers using foam blocks; right: Pupil and teacher making a bee and flower display.

In August Karin Alton was invited to the Channel Island of Alderney to launch the Alderney Honey Bee Challenge at the Alderney Wildlife Weekend organised by the island's Wildlife Trust. Karin gave a presentation about honey bees and LASI research to 80 islanders and visitors at a WWII bunker, restored to provide a wildlife educational information area.

As in 2009, the annual meeting of the Northwest-European Section (NWE) of the International Union for the Study of Social Insects (IUSSI) was organised by members of the University of Sussex, including members of LASI. During two days in December 2011, talks and posters on a wide range of topics including colony organisation, natural history, social evolution and diseases highlighted recent advances made in social insect research. The organising committee was particularly pleased with the diversity of topics, the high quality of student talks and the presentations of the two plenary speakers, Dr Audrey Dussutour from the Université Paul Sabatier in France and Prof. Tristam Wyatt from the University of Oxford. The meeting was particularly popular among students this year thanks to the generous financial support provided by the IUSSI NWE section.

Thanks to a generous donation from the John Spedan Lewis Foundation LASI has been able to produce new outreach material in the form of 12 leaflets and 3 large banner posters describing not only our current research, but also basic facts about honey bees, how they make honey, the waggle dance and how bees forage.

This summer saw Margaret Couvillon become a regular column writer for *“The Beekeepers Quarterly”.* Dr Couvillon writes on a current topic of bee research in a funny and engaging way for the magazine’s readers, and occasionally book reviews are also undertaken.

In March, TV chef Ainsley Harriott visited the lab with a camera crew to learn more about the honey bee for a new BBC series about British food. Ainsley learnt about the decline of the British honey bee, and why so little of the honey we eat is actually made by bees in Britain. Joining the bee researchers for breakfast, Ainsley said *"As soon as I walked in I noticed the positive energy and the passion there is here for everything about bees. It's a little bit of bee heaven - sharing a honey breakfast with the next generation of bee scientists. With LASI on their side, we might not need to worry about the honey bee after all."*

LASI also hosted a BBC2 camera crew for the filming of a TV documentary entitled: “Bees, Butterflies and Blooms”. The show is presented by Sarah Raven, and has yet to be viewed on air.

LASI’s 75 page website www.sussex.ac.uk/lasi has continued to attract the attention of the academics, the public and media alike. Social networking sites such as Facebook and Twitter continue to be used to disseminate our research and broadcast events and news occurring in the lab. During the month of 16th December 2011 to 16th January 2012, the website attracted nearly 3,500 page views.

Media engagement

Media highlights, 2011

- **Daily Telegraph, 21.01.2011: Pesticides could be behind honey bee demise.** *Norman Carreck talks about neonicotinoid insecticides and bees.*

- ***The Garden*** **magazine, 01.02.2011: Gardens vital for feeding honey bees.** *Francis Ratnieks talks about the flowers that bees like.*

- **The Smallholder, 07.02.2011: International Bee Research Association welcomes more action on bee health.** *Norman Carreck talks about EU Commission paper on bee health.*

- **Meridian ITV, 10.03.2011:** *Francis Ratnieks talks about the threats to bees in the wake of a UN report about banning insecticides.*

- **The Parliament Magazine, 21.03.2011: Colony Collapse.** *Norman Carreck writes about bee decline for the European Parliament.*

- **BBC2, 30.03.2011:** Ainsley Harriott talks to Professor Francis Ratnieks and the LASI team about the importance of the honey bee in TV programme *The Great British Food Revival*

- **Daily Mail, 12.05.2011: Why a mobile phone ring may make bees buzz off**. *Norman Carreck talks about mobile phones and bees.*

- **BBC Blogs, 02.09.2011: Nina Perry on 'Spirit of the Beehive'**

- **The Spectator, 03.09.2011: The bees' knees**

- **Radio 4, 03.09.2011: Spirit of the beehive** *Francis Ratnieks and Margaret Couvillon talk about the waggle dance of bees.*

- **The Gazette (John Lewis magazine), 30.09.2011: There is a plan bee.** *Four-page article on Waitrose-funded research at LASI*

- **American Scientist, 14.12.2011: How Bees Choose Home**

Press releases 2011

- Ainsley Harriott tours the bee lab for BBC food show (28/03/2011)

- Student buzzes the skies to map bee-friendly crops (08/06/2011)

Funding

The Sussex Plan for Honey Bee Health and Well Being 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. LASI's research continues to receive support from Rowse Honey Ltd, Burt's Bees, the Nineveh Charitable Trust, Somerset Beekeepers Association, The Tansy Trust, the John Spedan Lewis Foundation and Mr Michael Chowen.

The Body Shop Foundation, the British Beekeepers' Association and Waitrose continue to fund PhD students, who are conducting honey bee research over three years. New donors in 2011 included the Merrydown Trust and the Esmée Fairbairn Foundation, whose donations will enhance the research capability of the Laboratory.

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 challenging times for higher education we are 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
The Body Shop Foundation
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Elizabeth Boyling

Falling Tree Productions
Freddie Sowrey
Habitat Aid
Helen Wilson and Ealing and District Beekeepers' Association in memory of John Wilson MBE
High Wycombe Beekeepers' Association
Hindon and Fonthill Bishop WI
Isobel Ponsford and Jasmin Bannister and Kingsbridge Primary School
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Vale and Downland Beekeepers' Association and Newbury Beekeepers' Association
Yew Tree WI

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LASI staff biographies

Professor Francis Ratnieks
Francis Ratnieks is Professor of Apiculture and head of the Laboratory of Apiculture & Social Insects at the University of Sussex. He obtained his PhD at Dyce Laboratory for Honey Bee Studies, Cornell University, and 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 5 universities (Cornell, Berkeley, Sheffield, Sussex, São Paulo) and published 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, then a PhD in Entomology. Karin has worked with hoverflies, 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.

Norman Carreck
Norman Carreck is the senior technician at LASI and has been keeping bees since the age of 15. He read Agricultural Science at Nottingham University and worked at Rothamsted Research for nearly twenty years, as a research scientist, studying bee behaviour, pollination ecology and bee pathology. He is a UK member 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) 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 (2007-2009) on honey bees and bumble bees. Her interests include behavioural ecology and evolutionary biology of social insects and science education & outreach.

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.

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.

Dr Jelle van Zweden
Jelle van Zweden is a postdoctoral researcher at LASI. He did his PhD at the Centre for Social Evolution (CSE) at the University of Copenhagen, carrying out research on recognition in ants. At LASI he has been doing research on nestmate recognition and colony defence on honey bees and stingless bees. He is interested in combining the methods of behavioural ecology, chemical ecology and neuroscience to investigate how social insects defend their nests and recognize intruders.

Hasan Altoufailia
Hasan Altoufailia studied for his BSc at the University of Damascus where he has 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 to Syria and become that country'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 did 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 program.

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. 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 a 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.

Dr Martin Kärcher
Martin Kärcher has completed his PhD project at LASI studying conflicts and conflict resolution in societies of honey bees and stingless bees, specifically focusing on worker policing and nest-mate recognition. As a Zoology undergraduate at Karl-Franzens-Universität, Graz (where Nobel prize-

winner Karl von Frisch conducted his ground breaking research) he studied the predator-prey interaction between drones of *Apis mellifera carnica* and insectivorous birds. He started to keep bees when he was 16 and his other research interests include traffic organization in stingless bees and beekeeping in honey 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 PhD research is using 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.

Appendix 1.

Publications 2011 (University of Sussex authors in bold).

Books

Carreck, N.L. (Ed) (2011) *Varroa - still a problem in the 21st Century?* International Bee Research Association, Cardiff, UK. 78 pp. Soft cover ISBN: 978-0-86098-268-5

[Book awarded Gold Medal at 42nd International Apicultural Congress, Buenos Aires, Argentina, September 2011]

Papers in refereed journals

Bonckaert, W., Tofilski, A., Nascimento, F.S., Billen, J., **Ratnieks, F.L.W.,** Wenseleers, T. (2011) Co-occurrence of three types of egg policing in the Norwegian wasp *Dolichovespula norwegica. Behavioural Ecology and Sociobiology* **65(4),** 633-640. doi: 10.1007/s00265-010-1064-3

Bonckaert, W., **van Zweden, J.S.,** d'Ettorre, P., Billen, J., Wenseleers, T. (2011) Colony stage and not facultative policing explains pattern of worker reproduction in the Saxon wasp. *Molecular Ecology* **20(16),** 3455-3468. doi: 10.1111/j.1365-294X.2011.05200.x

Boomsma, J.J., Beekman, M., Cornwallis, C.K., Griffin, A.S., Holman, L., Hughes, W.O.H., Keller, L., Oldroyd, B.P., **Ratnieks, F.L.W.** (2011) Only full-sibling families evolved eusociality. *Nature* **471**, E4-5. doi: 10.1038/nature09832

Bouga, M., Alaux, C., Bienkowska, M., Büchler, R., **Carreck, N.L.,** Cauia, E., Chlebo, R., Dahle, B., Dall'Olio, R., De la Rúa, P., Gregorc, A., Ivanova, E., Kence, A., Kence, M., Kezic, N., Kiprijanovska, H., Kozmus, P., Kryger, P., Le Conte, Y., Lodesani, M., Murilhas, A.M., Siceanu, A., Soland, G., Uzunov, A., Wilde, J. (2011) A review of methods for discrimination of honey bee populations as applied to European beekeeping. *Journal of Apicultural Research* **50(1),** 51-84 doi: 10.3896/IBRA.1.50.1.06

Carreck, N.L. (2011) Fifty years of the *Journal of Apicultural Research. Journal of Apicultural Research* **50(4),** 249-256**.** doi: 10.3896/IBRA.1.50.4.01

Contrera, F.A.L., **Couvillon, M.J.,** Nieh, J. (2012) Hymenopteran group foraging and information transfer about resources. *Psyche*. (In press).

Couvillon, M.J. (2012) The dance legacy of Karl von Frisch*. Insectes Sociaux* (Accepted).

Couvillon, M.J., Jandt, J.M., Bonds, J., Helm, B.R., Dornhaus, A. (2011) Percent lipid is associated with body size but not task in the bumble bee *Bombus impatiens*. *Journal of comparative physiology* **A197(11),** 1097-1104.

Couvillon, M.J., vanZweden, 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* (Accepted).

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

Czaczkes, T.J., Grüter, C., Jones, S.M., Ratnieks, F.L.W. (2011) Synergy between social and private information increases foraging efficiency in ants. *Biology Letters* **7(4),** 521-524. doi: 10.1098/rsbl.2011.0067

Czaczkes, T.J., Nouvellet, P., Ratnieks, F.L.W. (2011) Cooperative food transport in the Neotropical ant, *Pheidole oxyops. Insectes Sociaux* **58(2),** 153-161. doi: 10.1007/s00040-010-0130-1

Czaczkes, T.J., Ratnieks, F.L.W. (2011) Simple rules result in the adaptive turning of food items to reduce drag during cooperative food transport in the ant *Pheidole oxyops*. *Insectes Sociaux* 58(1), 91-96. doi: 10.1007/s00040-010-0121-2

Grüter, C., Czaczkes, T.J., Ratnieks, F.L.W. (2011) Decision making in ant foragers (*Lasius niger*) facing conflicting private and social information. *Behavioural Ecology and Sociobiology* **65(2)**, 141-148. doi: 10.1007/s00265-010-1020-2

Grüter, C., Kärcher, M.H., Ratnieks, F.L.W. (2011) The natural history of nest defence in a stingless bee, *Tetragonisca angustula* (Latreille) (Hymenoptera: Apidae), with two distinct types of entrance guards. *Neotropical Entomology* 40(1), 55-61.

Grüter, C., Menezes, C., Imperatriz-Fonseca, V. L., **Ratnieks, F. L. W.** (2012) A soldier caste in a social bee. *Proceedings of the National Academy of Sciences USA* 109: 1182-1186.

Grüter, C., Moore, H., Firmin, N., **Helanterä, H., Ratnieks, F.L.W.** (2011) Flower constancy in honey bee workers (*Apis mellifera*) depends on ecologically realistic rewards. *Journal of Experimental Biology* **214(8),** 1397-1402. doi: 10.1242/jeb.050583

Grüter, C., Ratnieks, F.L.W. (2011) Honey bee foragers increase the use of waggle dance information when private information becomes unrewarding. *Animal Behaviour* **81(5),** 949-954. doi: 10.1016/j.anbehav.2011.01.014

Grüter, C., Ratnieks, F.L.W. (2011). Flower constancy in pollinators: adaptive behaviour or cognitive limitation? *Communicative and Integrative Biology* **4**, 1-4.

Helanterä, H., Walsh, C.J., **Ratnieks, F.L.W.** (2011) Effect of foraging trail straightness on U-turning probability in forager pharaoh's ants. *Sociobiology* 57(3), 445-459.

Higginson, A. D., Barnard, C. J., Tofilski, A., Medina, L. M., **Ratnieks, F. L. W.** (2011) Experimental wing damage affects foraging effort and communicated foraging distance in honey bees *Apis mellifera*. *Psyche* doi: 10.1155/2011/419793. Article ID 419793

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. 2011. Modelling complex biological systems using an agent-based approach. Integrative Biology DOI: 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.** (2011) The role of wax and resin in the nestmate recognition system of a stingless bee, *Tetragonisca angustula*. *Behavioural Ecology & Sociobiology* (published on line http://www.springerlink.com/content/j66708x6168572nv/)

Nanty, L., Carbajosa, G., Heap, G., **Ratnieks, F.L.W.**, van Heel, D., Down, T., Rakyan, V. 2011. Comparative methylomics reveals gene-body H3K36me3 in *Drosophila* predicts DNA methylation and CpG landscapes in other invertebrates. *Genome Research* **21:** 1841-1850.

Ratnieks, F.L.W., Kärcher, M.H., Firth, V., Parks, D., Richards, A., Richards, P., **Helanterä, H.** (2011) Acceptance by honey bee guards of non-nestmates is not increased by treatment with nestmate odours. *Ethology* **117(8),** 655-663. doi: 10.1111/j.1439-0310.2011.01918.x

Ratnieks, F.L.W., Foster, K.R., Wenseleers, T. (2011) Darwin's special difficulty: the evolution of "neuter insects" and current theory. *Behavioural Ecology and Sociobiology* 65(3), 481-492. doi: 10.1007/s00265-010-1124-8

van Zweden, J.S., **Grüter, C., Jones, S.M., Ratnieks, F.L.W.** (2011) Hovering guards of the stingless bee *Tetragonisca angustula* increase colony defensive perimeter as shown by intra- and inter-specific comparisons. *Behavioural Ecology and Sociobiology* **65(6),** 1277-1282. doi: 10.1007/s00265-011-1141-2

Book chapters, reports, conference proceedings, etc.

Carreck, N.L. (2011) Prologue. In *Varroa - still a problem in the 21st Century? (N.L. Carreck Ed).* International Bee Research Association, Cardiff, UK. 1-4.

Carreck, N.L. (2011) Breeding honey bees for varroa tolerance. In *Varroa - still a problem in the 21st Century? (N.L. Carreck Ed).* International Bee Research Association, Cardiff, UK. 63-69.

Carreck, N.L., Aston, D. (2011) Honey bee winter losses in England, 2007-10. In *Proceedings of 7th COLOSS Conference - Prevention of Honey bee COlony LOSSes, Belgrade, Serbia, 25th - 28th August 2011.* 16.

Carreck, N.L., Aston, D. (2011) Pérdida inviernal de abejas en Inglaterra, 2007-10. In *Proceedings of 42nd International Apicultural Congress, Buenos Aires, Argentina, 21st-25th September 2011.* 80-81.

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Farina, W.M., **Grüter, C.**, Arenas, A. (2011). Olfactory information transfer during recruitment in honey bees. In: *Honey bee neurobiology and behaviour - a tribute for Randolf Menzel.* Eds.: Eisenhardt, D., Galizia, C.G., Giurfa, M., Springer Verlag.

Grüter, C. (2011) Communication in social insects: sophisticated problem solving by small brains. In: *Animal thinking: Contemporary issues in comparative cognition*. Eds.: Fischer, J., Menzel, R., Cambridge, MA: MIT Press.

Wheeler, B., Searcy, W.A., Christiansen, M.H., Corballis, M.C., Fischer, J**., Grüter, C.**, Margoliash, D., Owren, M.J., Price, T., Seyfarth, R. & Wild, M. (2011) Communication. In: *Animal thinking: Contemporary issues in comparative cognition.* Eds.: Fischer, J., Menzel, R., Cambridge, MA: MIT Press.

Popular articles

Alton, K.L. (2011) The Garden Plants for Bees Workshop at LASI. *Bee Craft* **93(9),** ??-??.

Carreck, N.L. (2011) IBRA - What's new? *Bee Culture* **139(1),** 48-50.

Carreck, N.L. (2011) Is my bee better than yours? *Bee World* **88(1)**, 9-10.

Carreck, N.L. (2011) Colony collapse. *The Parliament Magazine*. **324**, 89.

Carreck, N.L. (2011) Documenting pollinator decline. *Bee World* **88(2)**, 35-36.

Carreck, N.L. (2011) What future for stingless bees? *Bee World* **88(3)**, 62-63.

Carreck, N.L. (2011) COLOSS in Serbia, 2011. *Bee World* **88(4)**, 73.

Carreck, N.L. (2011) Apimondia in Argentina, 2011. *Bee World* **88(4)**, 77-8.

Carreck, N.L. (2011) Happy birthday - the *Journal of Apicultural Research* is 50! *Bee World* **88(4)**, 82-3.

Carreck, N.L. (2011) Beekeeping at Sutton Bonington. *Agrimag* **2011**, 130.

Carreck, N.L., Alton, K.L., Bigio, G., Charles, P., **Ratnieks, F.L.W.** (2011). Hygienic behaviour training workshops at the University of Sussex. *An Beachaire* **66(9),** 241-248.

Carreck, N.L., Alton, K.L., Bigio, G., Charles, P., **Ratnieks, F.L.W.** (2011). Hygienic behaviour training workshops at the University of Sussex. *Bee Craft* **93(12),** 23-25.

Carreck, N.L., Alton, K.L., Bigio, G., Charles, P., **Ratnieks, F.L.W.** (2011). Hygienic behaviour training workshops at the University of Sussex. *Beekeeping*. **77(10)**, 215-218.

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Carreck, N.L., Alton, K.L., Bigio, G., Charles, P., **Ratnieks, F.L.W.** (2011). Hygienic behaviour

training workshops at the University of Sussex. *The Scottish Beekeeper*. **88(10)**, 260-262.

Carreck, N.L., Aston, D. (2011) Honey bee winter losses in England, 2007-10. *Mellifera* [in Turkish]. (in press).

Couvillon, M.J., Ratnieks, F.L.W. (2011) How good is the British countryside for honey bees? Decoding waggle dances to determine where bees forage. *Beekeepers Quarterly* **103**, 29-31.

Couvillon, M.J. (2011) All in the genes: genetic control of honey bee foraging. *Beekeepers Quarterly* **105**, 22-23.

Couvillon, M.J. (2011) Aphids, cabbage, and other interesting insect books. *Beekeepers Quarterly* (In press)

Ratnieks, F.L.W., Carreck, N.L., Alton, K.L., Bigio, G. (2011) Breeding disease-resistant hygienic honey bees and providing breeder queens to beekeepers. *British Beekeepers Association News* **191,** 7.

Outreach material

Ratnieks, F.L.W. (2011) Information sheets on honey bees and social insects. The topics are:-

Beekeeping
The Honey Bee
How Bees Make Honey
What is a Bee
Honey Bees & Human Culture
The Honey Bee Dance Language
Bees & Flowers
LASI: The Laboratory of Apiculture & Social Insects
The Sussex Plan for Honey Bee Health & Well Being
Learning About Bees & Flowers by Looking
What is an Ant?

Appendix 2.

Talks, exhibitions, workshops and public events given in 2011

12/1/11	Talk to Central Sussex Beekeepers Association, Horsham (MC).
15/1/11	*Studying honey bees - what do we do and why?* to Life Sciences Open Day for prospective undergraduates, University of Sussex (FR).
20/1/11	*Adaptive shifts in acceptance thresholds of honey bee guards* in Evolution, Ecology, Environment & Behaviour Seminar Series, University of Sussex (FR).
24/1/11	*The honey bee and why scientists study it* at the Aim Higher meeting at the University of Brighton to audience of secondary school pupils (FR).
26/1/11	*Science and beekeeping* to Chalfonts Beekeepers Association (NC).
26/1/11	*The Evolution, Behaviour & Ecology Subject Group* at open day for prospective graduate students, University of Sussex (FR).
29/1/11	*Breeding honey bees for varroa tolerance* at International Bee Research Association Conference "Varroa - still a threat in the 21st Century", University of Worcester (NC).
4/2/11	Scientific seminar at British Trust for Ornithology, Norwich, Norfolk (MC).
19/2/11	*Update on colony losses* to Sidcup Beekeepers Association, Kent (NC).
24/2/11	*Nestmate recognition in stingless bees and honey bees*. Departmental seminar at University of São Paulo, Riberão Preto, Brazil (FR).
25/2/11	*Darwin's special difficulty: the evolution of "neuter insects".* Departmental seminar at University of São Paulo, Riberão Preto, Brazil (FR).
March 2011	4 x 2hr spring apiary training sessions for new beekeepers, Central Sussex Beekeepers Association, Pease Pottage, West Sussex (KA).
3/3/11	Talk to Dean Forest Beekeeper's Association (MC).
4/3/11	*The honey bee: one of the little things that we depend on.* Talk & discussion, Lewes University of the Third Age Science Series (FR).
9/3/11	*Breeding disease resistant bees* to Wokingham Beekeepers Association (NC).
12/3/11	*Honey bee tolerance to* Varroa destructor - *the "holy grail" of beekeeping* to Cambridgeshire Beekeepers Association (NC).
12/3/11	*Honey bee research at the University of Sussex and the Sussex Plan for Honey Bee Health & Well Being* at Somerset Beekeepers Association AGM (FR).
12/3/11	Talk to SE Hants Beekeepers Spring Convention (MC).
15/3/11	*Darwin's difficulty: worker insects.* Departmental seminar, University of Paris 13, France (FR).
19/3/11	*Bee research - past, present and future* to Medway Beekeepers Association, Rochester, Kent (NC).
19/3/11	*The Sussex Plan for Honey Bee Health & Well Being* to Gloucestershire Beekeepers Association AGM (FR).
23/3/11	*Honey bee: the amazing life of a common British insect.* Keynote talk and demonstration to "Aim Higher" (school pupils), at University of Sussex (FR).
26/3/11	Exhibition at the Eco fair, Ardingly Village, West Sussex (KA).
26/3/11	*Colony losses - some explanations* to Welsh Beekeepers Convention, Builth Wells (NC).
15, 16/4/11	*The Honey Bee: Gateways to discoveries in biology* (2 talks) and *The Sussex Plan for Honey Bee Health & Well Being* at British Beekeepers Association Spring Convention, Stoneleigh, Warwickshire (FR).
18/4/11	*Honey bee foraging, navigation and pheromones* to Central Sussex

Beekeepers Association, Horsham (KA).

28/4/11 *Plants and bees* to Central Sussex Beekeepers Association, Horsham (KA).

17/5/11 Talk and demonstration about honey bees with observation hive to pupils of the Priory School, Lewes, at the Linklater Pavilion, Lewes (FR).

18/5/11 Briefing talk on bees at pollination at Tuesley Farm, Godalming, Surrey, as part of a Bee Day arranged by Waitrose for fruit farmers (FR).

19/5/11 Talk on the honey bee at the Arts & Science meeting, Sheffield University (FR).

21,23/5/11 Two *Hygienic Behaviour* Training Workshops, LASI, University of Sussex (KA, GB, NC, FR)

11/6/11 *The honey bee: an amazing Lewesian insect* and *Honey bee: the amazing life of a common British insect* (4 talks) at the Linklater Pavilion, Lewes, as part of the Bee The Buzz event and the unveiling of the observation hive (FR).

15/6/11 *Honey bees and why scientists study them* to school pupils visiting the University of Sussex for the Aim Higher scheme (FR).

17, 18/6/11 Two *Honey Bee Waggle Dance* Training Workshops LASI, University of Sussex (KA, MC, FR-P, FR).

29/6/11 Bees, honey bees and farming at College Farm, Duxford, Cambridgeshire at the Bee Day for farmers arranged by Waitrose (FR).

15, 16/7/11 Two *Finding out which plants are best for bees* Training Workshops, LASI, University of Sussex (KA, MG, FR).

15/7/11 Exhibition at the 'Connect with the countryside' event, South of England Agricultural Society, run for schools in Sussex, attended by 2400 children and teachers (KA).

16/7/11 *Honey bee: the amazing life of a common British insect* at the Open Day at Dorothy Stringer School, Brighton (FR).

18/7/11 *The amazing honey bee: gateway to science, honey maker and pollinator* Café Scientifique, The Keystone pub, Guildford, Surrey (FR).

19/7/11 *Breeding honey bees for varroa tolerance* to National Diploma in Beekeeping Advanced Beekeeping Course, Fera, York (NC).

21/7/11 *Honey bee decline and LASI honey bee research* to Ardingly Women's Institute (KA).

24/7/11 Talk at Hungerford Arts Festival, Berkshire (MC).

27/8/11 *Honey bee research at LASI* at Wildlife Weekend, Alderney, Channel Islands (KA).

22/9/11 *Honey bee winter losses in England, 2007-10* at XVIIth International Apicultural Congress, Buenos Aires, Argentina (NC).

1/10/11 Exhibition at Apple and Honey Fair, Ardingly, West Sussex (KA).

7/10/11 *Honey bees and the research at LASI* at UWC Atlantic College, St Donat's Castle, Llantwit Major, Wales (KA).

13/10/11 *The honey bee* to A level pupils at Portslade Aldridge Community Academy (FR).

15/10/11 *Bee research at LASI and the Sussex Plan for Honey Bee Health & Well Being* to Weald Beekeepers Group, Smarden, Kent (FR).

26/10/11 *What can humans learn from honey bees?* Invited talk at Supper with the Generals (dinner and talk to 25 generals and equivalent in the UK armed forces), London (FR).

2/11/11 *The Sussex Plan for Honey Bee Health & Well Being* and *Helping honey bees and pollinators in urban areas* to the Body Shop Foundation, Littlehampton, West Sussex (FR).

3/11/11 Talk in Biology Department Seminar Series, University of York (MC).

3/11/11 *Making healthy environments.* Sussex Conversation at The Royal Institution, London. Member of panel (FR).

8/11/11 *Progress on finding the causes of colony losses* to Andover Beekeepers Association, Hampshire (NC).

12/11/11 Talk at Sussex Beekeeper's Association (MC).

15/11/11 *Colony Collapse Disorder - fantasy, fact and fiction* to Chichester BKA (NC).

26/11/11 *Honey bee research at LASI* to Central Association of Bee-Keepers' Autumn Conference, Stratford upon Avon, Warwickshire (KA).

8/12/11 *Conserving bees* to Natural England conservation advisors, Basingstoke, Hampshire (NC).