Laboratory of Apiculture and Social Insects

Annual Report January 2011

University of Sussex

LASI
LABORATORY OF APICULTURE AND SOCIAL INSECTS

Contents

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Mission statement and goals

Research

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

Teaching

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

Community

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

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Overview of 2010

Having set up the Laboratory of Apiculture and Social Insects in 2008 and 2009, the past year has been one of consolidation and further expansion. As the LASI team has grown, the newly refurbished laboratory facilities soon reached capacity, but thanks to a donation from the late David Read and his family in 2010 we were able to add two new offices to the main lab, expand the workshop, enlarge the main apiary and in the next few months we will add additional laboratory rooms. In addition we have three new workshop facilities, one at LASI, one at our second on-campus apiary and one at Wakehurst Place. When the work is complete LASI should have the space it needs for the foreseeable future.

Builders constructing the workshop extension, which houses a honey bee extraction facility and a cold store

The most important thing in a laboratory is the people who conduct the research. In 2010 several excellent new researchers joined the LASI team. Jelle van Zweden, from the Netherlands by way of the University of Copenhagen, is doing research on nestmate recognition in honey bees, stingless bees and ants. Gianluigi Bigio, from Italy, started his PhD in April on the project *Breeding disease-resistant 'hygienic' honey bees*. Mihail Garbuzov, from Latvia, started his PhD in June and is working on the project *Helping honey bees and insect pollinators in urban areas*. Hasan Tofalia, from Syria, joined in October and is studying honey bee diseases and foraging. Lee Cooper was with us for six months starting in June as a Junior Research Associate and worked on the project *Decoding waggle dances to determine where honey bees forage*. We also welcomed several new volunteers who freely give their time and expertise to help the LASI team.

It is thanks to many generous philanthropic donations that LASI has become established as one of the UK's leading centres for honey bee research, with a large group of scientists working to improve the health and wellbeing of honey bees. On-going donations from Rowse Honey, Mr Michael Chowen, the Nineveh Charitable Trust, Burt's Bees, the Body Shop Foundation, Waitrose, and the British Beekeepers Association are helping to fund this important research.

In 2010 we achieved a great deal in terms of research, outreach and teaching. LASI's research output was very impressive with a number of articles published in refereed scientific journals, which is the recognized benchmark of scientific productivity. Everyone is focused on their work and the projects recently initiated within the *Sussex Plan for honey bee health and well being* should soon also be resulting in publications in refereed scientific journals. A full list of all LASI publications can be found in Appendix 1.

Outreach activities have increased in number with members of the LASI team giving many talks to beekeepers and other groups, writing numerous articles for beekeepers and the public, and organising hands-on events. We have also been inundated with enquiries from the media, both print and broadcast. TV crews are regular visitors and this has helped us communicate our work to millions of people through appearing on popular national TV programs such as *The One Show* and *Countryfile*. In April 2010 the whole LASI team, with the help of University colleagues, put on a one-day training event about bees called *What's the Buzz.* This was a great success. Building on this, in the coming year we are initiating a series of training workshops and a Bee Science Day.

LASI plays an active part in teaching and training the next generation of scientists. There are seven PhD students based at the lab, plus two Masters students and six BSc students doing their projects at LASI. LASI's collaborative and sociable environment brings out the best in project students, who are supervised by Professor Ratnieks but who also receive additional supervision and advice from one or more LASI researchers whose expertise is in the area of the project.

It is now two and a half years since the builders handed over the keys and science could begin at LASI. With the help of much support from the University of Sussex, from many University colleagues, and our financial benefactors, LASI is doing what we set out to do. It is now a place of first class research on honey bees and social insects. It is training the next generation of scientists. And it has strong links to the community. We are making a difference. The challenge for the future will be to consolidate, sustain and strengthen this.

The LASI team June 2010

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 (Carreck, 2009).

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 Varroa.

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 (Pérez-Sato *et al*, 2009). 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.

Main aim

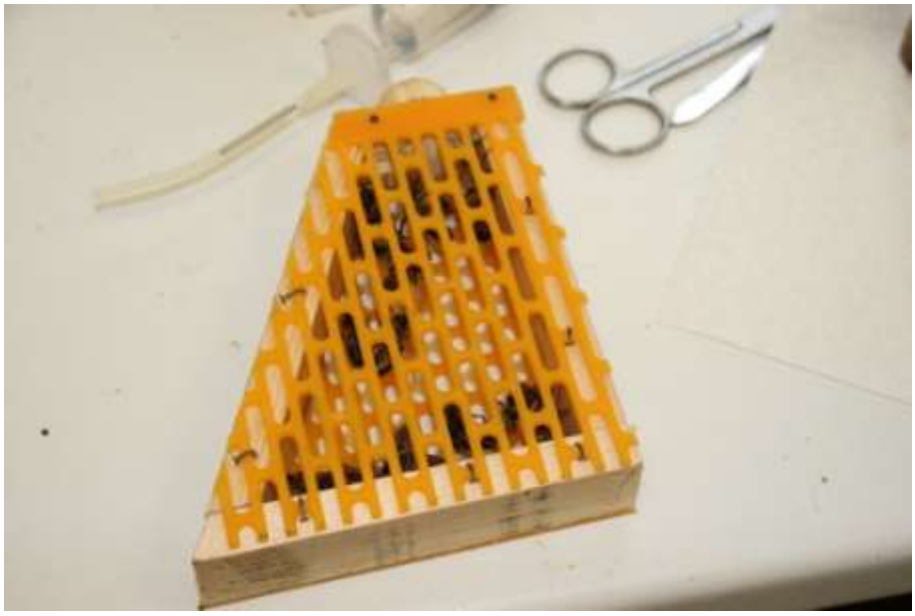
- To selectively breed and then test under UK field conditions, a strain of hygienic honey bees, and to then make this available to UK beekeepers.

Funding

This project is funded by Mr Michael Chowen, Rowse Honey Ltd, the British Beekeepers Association and the Somerset Beekeepers Association.

Progress

In 2008-9, a number of colonies were confirmed to be hygienic, and preliminary observation hive studies were carried out. Sadly the colonies used in the 2009 intracolony selection observation hive studies became queenless during the winter, so the experiment was repeated several times during 2010. Video recordings were made of the behaviour of individual worker bees in dealing with freeze killed brood, and these are being analysed to further understand the different behavioural components of hygienic behaviour.



A cage containing male drones for use in instrumental insemination, August 2010

Throughout 2010, queens have been reared from colonies previously identified as hygienic. Some of these have been open mated in our own apiaries, but in order to increase control, Instrumental Insemination has been used. Michael Collier from the Cornbrook Bee Farm, Shropshire, kindly visited LASI in August to perform the Instrumental Insemination. A donation from the Somerset Beekeepers Association has now enabled the purchase of our own Instrumental Insemination apparatus. Tissue samples for DNA extraction from the observation hive studies and from the reared queens are currently being analysed by Dr Annette Jensen at the University of Copenhagen, Denmark.

A frame of reared queen cells

As mentioned last year, we remain concerned that we have only a limited gene pool available to us, so we have sought beekeepers throughout Europe who are maintaining the dark European honey bee *Apis mellifera mellifera*. Contact has been made with members of the Bee Improvement and Bee Breeders Association (BIBBA) and the Societas Internationalis Pro Conservatione Apis melliferae melliferae (SICAMM). During 2010, queens have been obtained from the Island of Colonsay, Scotland, and from Galtee, Ireland. In 2011 we have been promised queens from Læsø, Denmark and from West Cornwall. Colonies headed by these queens will be compared with colonies headed

by our own queens, and incorporated in the breeding programme if they prove suitable. Norman Carreck has contributed to a major review on bee diversity in Europe as part of the COST Funded 'Prevention of honey bee COLony LOSSes' (COLOSS) network which currently consists of 217 scientists, representing 55 countries worldwide.

Karin Alton, Gianluigi Bigio and Norman Carreck marking bees, August 2010

Gianluigi Bigio, with a degree in molecular biology from Italy and plant genetics experience in Ireland, and with a beekeeping background, joined the team in Spring 2010 to study for a PhD funded by the British Beekeepers Association. His project will look at techniques for improving the breeding and rearing of queens. In his first field season he has performed experiments comparing methods of maintaining virgin queens in cages.

Future developments

The next stage of the project, commencing in Spring 2011, will comprise testing queens raised or purchased during 2010 for hygienic behaviour. Further queens then will then be reared from the best colonies, again using intracolony selection. The incidence of Varroa infestation in these colonies will also be monitored.

As before, it must be borne in mind that any breeding programme is open ended, and whatever we succeed in producing at the University of Sussex can only be of benefit to British beekeeping if facilities are available to rear queens in quantity and to then distribute them to beekeepers. The involvement and support of members of the Bee Farmers Association will be essential in order to achieve this.

References

Carreck, N.L. (2009), Varroa tolerant bees: dream or reality, Part 1. *British Beekeepers Association News*, 176, 3-4.

Pérez-Sato, J.A., Châline, N., Martin, S.J., Hughes, W.O.H., Ratnieks, F.W.L., (2009), Multi-level selection for hygienic behaviour in honey bees, *Heredity*, 102, 609-615.

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

Francis Ratnieks, Margaret Couvillon, Fiona Riddell-Pearce

Background

The honey bee is the single most important animal pollinator. In recent years, the proportion of animal-pollinated crops has risen rapidly (>300%); however, some parts of the world are experiencing a concurrent decline in wild and managed bee populations. For example, the number of hives has decreased in England and Wales by approximately 75% since 1910. Globally, this results in agicultural need far outstripping the availability of honey bees, especially since 1991. Reasons responsible for the decline in honey bees are complex and multi-faceted, involving parsites, diseases and viruses. However, the loss of forage is most definitely an important issue. Healthy or sick, bees need to eat. Less available forage translates into insufficient honey stores to see the bees through the winter months.

Why might there be fewer flowers for bees? Less available forage reflects changes in land use. 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. Agricultural land has fewer weeds and wild flowers (Figure 1). All of this results in less nectar and pollen for bees and other pollinators.

Figure 1: Wild flowers growing on chalk downland in Surrey. Intensified farming has resulted in the loss of over 90% of unimproved lowland grasslands. This land, dominated by unsown communities of native wild flowers, is an important source of forage for bees and habitat for other insects, including butterflies and bumble bees (Photo courtesy of Francis Ratnieks).

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: during which months of the year is there less forage for bees? How do the bees respond to forage dearth in their foraging organization? What is the relative contribution of urban and rural landscapes? Which parts of the rural landscape are most attractive to bees?

Here at the Laboratory of Apiculture and Social Insects (LASI), we're working hard to investigate these issues.

How do we know where honey bees forage?

The honey bee is unique in that it is the only animal that tells you where it has been foraging. This is communicated by the waggle dance (Figure 2), which was first decoded by Karl von Frisch in work

that earned him a Nobel Prize in 1973. 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 figure-eights. 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.

By housing colonies in observation hives, we are able to eavesdrop on these conversations. We use video cameras, computers, video software, and a protractor to decode by hand individual waggle dances. This provides an effective means to investigate honey bee foraging ecology.

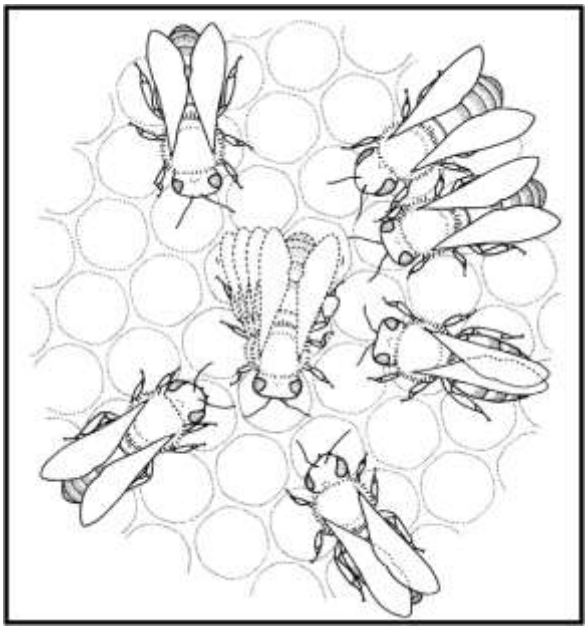


Figure 2: A returning forager performs a waggle dance. This communication informs her nestmates of a foraging location, given in distance and angle relative to the sun. Picture by Lila Morris from video of dancing bee that can be viewed at http://www.sussex.ac.uk/lasi/resources/education/whatbeesdo

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 forager, 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, wild bees, butterflies, and hoverflies, thereby benefiting biodiversity.

What have we learned so far?
We have now analyzed dances for August-October 2009 and March-July 2010. Almost no foraging takes place between November and February. Already we can observe several interesting patterns. The average distance that an individual forager flies varies with month. For hives located in rural East Sussex at the University of Sussex, bees fly the furthest in the summer, averaging over 4km in July and August.

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. This is surprising and probably goes against commonly held perceptions. 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*), which is a common evergreen plant. Ivy typically represents the last nectar flow of the season before the bees begin overwintering.

In March, a majority of foraging flights were at very short distances (<1km). The University of Sussex campus contained many patches of spring bulbs like crocuses and snowdrops (Figure 3). Although these species are not native to Britain, they are both popular garden plants. Therefore, at a time of year when bees need pollen to feed their new brood, urban gardens and parks are important repositories of food.

Figure 3: A honey bee collects pollen from a crocus on 1 March, 2010. Spring bulbs are popular garden plants and an important source of springtime pollen for bees (Photo courtesy of Francis Ratnieks).

We saw a great deal of foraging in the surrounding urban and suburban areas of Brighton and other small towns. Interestingly, a higher proportion of urban visits happened in summer compared to spring. Therefore, at a time of year when forage is less available, the bees are able to find nectar and pollen in urban environments. It is likely that parks, gardens and cemeteries provide a wide variety of plants. Having many different species of plants ensures a more constant supply of nectar and pollen, as each plant will bloom at different times. In this way, urban environments might show less fluctuation in forage availability than a more rural landscape dominated by monocrops.

A large number of dances were decoded to local nature reserves like Stanmer Park, which is located NW of campus, and Castle Hill National Nature Reserve, which is SE of campus. Upon investigation, we found a local park and the neighbouring farms to be covered with pastures of white clover. We found the bees will fly many kilometres to visit these ‘clover leys’. Additionally, Castle Hill NNR has several fields abundant with wild flowers.

By graphing individual dances with colour-coded dots for each month, we are able to pinpoint which areas are visited during different seasons (Figure 4). This method of visualization provides a powerful tool. We can identify at a glance what areas are key foraging locations. Additionally, we see which sections of the landscape are relatively untouched. For example, there were no dances indicating north-east of campus for August 2009. This land is mostly farmland. It will be interesting to monitor over the next year if this specific pattern remains and to determine what is growing there. In contrast, during that same month, bees were heavily visiting north-west of campus. The foraging range includes part of the South Downs, the city of Brighton, and smaller villages.

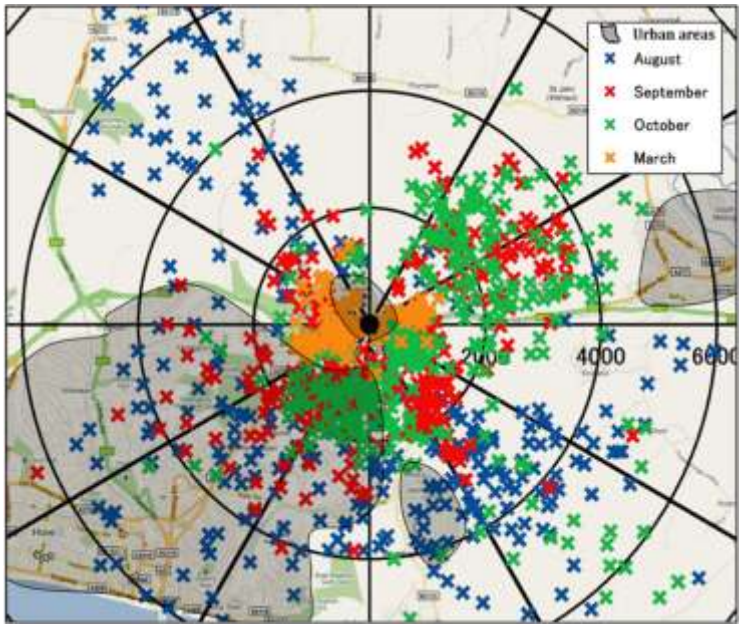


Figure 4: Patterns of individual dances varied with month (August, September, October 2009 and March 2010). Bees forage on a variety of habitats, including urban (gardens, cemeteries) and suburban (parks and nature reserves), agricultural, and unimproved grassland.

Who funds our research?

This project is supported by three major donors: 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, Waitrose, a leading supermarket with a strong commitment to social responsibility, and Nineveh Charitable Trust, which is an agricultural charity promoting the preservation of the countryside. These independent support schemes are complimentary in that Nineveh and Waitrose predominantly have hired the project's personnel and Burt's Bees has funded equipment. The project is critically dependent on all three.

Where do we go from here?

In August, the project completed its first year of data collection. However, we are nowhere near finished. For scientific research to be published in peer-reviewed journals, it is important to demonstrate replication. Therefore, we must monitor dances for a minimum of two years to allow for pattern comparison between 2009-2010 and 2010-2011.

Additionally, this next year will include some 'ground work' in which we visit decoded locations to determine what specific plants are present. These new areas will require microscopy and keys to identify what species' pollen is being collected. If possible, we plan to integrate the use of Global Positioning Systems (GPS) and to collaborate with geographers who already are versed in land-use databases.

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 have enlisted the help of Plumpton Agricultural College. Located an ideal 2-7km from LASI, Plumpton College will plant for us large patches of borage that should be very attractive to bees. These patches will be located in 2-3 distances from LASI. To calibrate for shorter distances, we will train bees to nearby feeders. When bees visiting either the borage or the feeders return to the hive and dance, we will then obtain the necessary information to tweak our mathematical function to reflect our very own bees.

3. **Honey bee foraging in novel environments**
   Francis Ratnieks, Margaret Couvillon, Fiona Riddell-Pearce

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 blooming of heather in autumn.

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.

Funding
Thanks to a donation from Waitrose, to fund PhD student Fiona Riddell-Pearce for three years, research at LASI is able to focus on this important aspect of honey bee welfare.

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.

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 of the bees per minute at these different times throughout the day.
- **Forager success:** A successful returning nectar forager contains nectar in her crop. We collected ten 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 the percentage of successful returning

nectar foragers per hive three times a day. This is the percentage of nectar foragers returning successfully (i.e. with nectar) from a foraging trip.

- **Nectar quality:** Using the regurgitated nectar from the ten nectar foragers, we tested the concentration of sugar using a refractometer. We obtained a reading for the percentage of sucrose in the nectar for each successful returning nectar forager from both Resident and Moved hives three times a day. These readings were used to calculate the average percentage of the sucrose. Higher percentage 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.

This investigation has so far been carried out in late summer (August) and again in autumn (mid October). It will also be repeated in spring (April) and early summer (June). This will allow the foraging behaviour to be tested under a number of different conditions

Preliminary results

So far we have found little difference in the foraging behaviour of Moved and Resident colonies. Both groups lost mass steadily during both August and October trials, suggesting foraging conditions were poor. Relative rate of loss still needs to be calculated to indicate any differences between groups. Trials in spring and summer may show different effects as hives are expected to gain mass during this time due to good foraging conditions. We may also see a clearer difference in the foraging success between groups when foraging conditions are so different from autumn.

Beekman & Ratnieks (2000), Long-range foraging by the honey bee, Apis melifera L. *Functional Ecology*. 14, 490-496

Grüter et al (2008), Informational conflicts created by the waggle dance. *Proceedings of the Royal Society B*, 275, 1321-1327

Frisch, Karl von (1967), *The Dance Language and Orientation of Bees*, Cambridge, Mass. The Belknap Press of Harvard University Press

4. **Helping honey bees and insect pollinators in urban areas**
   Francis Ratnieks and Mihail Garbuzov

This is a new project within the Sussex Plan and is linked to the waggle dance decoding project as both projects are focused on what is probably the most crucial of all things for bees: food.

The Body Shop Foundation has funded a three year PhD to work on this project. After advertising the project in early 2010, an unprecedented number of enquiries and applications were received. The applicant chosen was Mihail Garbuzov, who had just graduated from the University of Sussex. Mihail began work on the project in June 2010, initially as a Summer Bursary Student, and registered as a doctoral student in October 2010. Because he was able to start in June a full season of field work was achieved, and as a result the project has got off to a good start. Work has already begun on three sub-projects as follows, gathering preliminary data and developing methods and research sites.

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.

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 is the most attractive plant for honey bees. Overall, 22% of the insects attracted were honey bees, 56% bumble bees, 5% other bee species, 19% hover flies, and 1% butterflies. The project will continue in 2011 and 2012. It will be expanded to compare thirty-two different varieties of plants, with one site at the University and another at Wakehurst Place. The plants will be grown in permanent beds in the ground, each plant replicated in two 1x1 metre beds at each of the two sites.

Mihail Garbuzov and Francis Ratnieks with Simon Charlesworth of Downderry Nursery taking delivery of lavender plants, June 2010

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

This project is examining the effect that lattice fencing and hedging have on the flight paths taken by forager bees when departing or returning to their hive. In particular, we hope to show that by forcing the bees to fly above head height, a 2m lattice fence or hedge will reduce the number of bees that bump into or even sting people near to the hives. This will provide 'best practice' guidance for keeping bee hives in urban areas and will give councils and landowners an incentive to encourage beekeeping. We have set up a suitable lattice fence around our apiary in the nursery garden at Wakehurst Place. The fence can easily be removed, allowing bee flight paths with and without fencing or temporary hedging to be studied. The project will continue in 2011 until we have sufficient data to finish the study. We will continue working at Wakehurst Place and may also use a second apiary.

Ivy: its importance to honey bees and other insects
Ivy is a common native plant and produces a profusion of flowers in autumn. It is found commonly in both towns and in the countryside. It is the last of our native plants to bloom and appears to be an important nectar sources for bees and other insects. This sub-project is quantifying the ivy bloom period, insect visitors, and (by collecting pollen samples from returning forager bees) the proportion of honey bee pollen collected in the autumn that is from ivy. Data were collected in the autumn of 2010 at locations around the university. The results so far show that ivy is visited by a wide range of insects, especially wasps, bees and flies. We also observed the ivy bee, *Colletes hederae*. This is a bee that has recently colonized Britain from the Continent and is spreading in the south.

A honey bee visits an ivy plant in autumn 2010

This project has links to many people and organizations outside the University. In 2010 our main partners were Wakehurst Place and Downderry Nursery. In 2011 we will continue working with them and will also begin working with Bee Happy Plants of Somerset, a plant nursery specializing in herbs, and Dr Danahar of Dorothy Stringer School in Brighton who will help with a project investigating honey bee foraging in urban areas by dance decoding In addition to research, in July 2011 a workshop will be held to explore which garden plants are best for bees. It is aimed at gardeners, growers, garden centre workers, conservationists, land managers, parks departments, teachers, beekeepers and others who want to make gardens more bee and insect friendly. Those attending will learn how to identify common pollinating insects and determine which plant varieties are most attractive to them.

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 masters 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.

Undergraduate students gathering data for a guarding project

Other members of the LASI team, including Maragret 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 minutes' walk from the main Life Sciences buildings, this greatly helps link undergraduate students to LASI.

Outreach and public communication

The past year has been busy at the Laboratory of Apiculture and Social Insects, with our outreach and public communication programme expanding throughout the year.

Representatives from the regional business, education and farming communities joined LASI academics to discuss how to help the British honey bee at a special 'bee summit' at the University of Sussex in April 2010. The event, entitled 'What's the buzz? Bees, land use and the community', focused on the decline of honey bees and the impact of this on land use and the community at large. Seminars and hands-on demonstrations in the lab, followed by discussion forums, provided ample opportunity for lively debate, networking and for sharing ideas on how to help the honey bee. Strong links with the South Downs National Park, Royal Botanic Gardens, Wakehurst Place and Downderry Lavender Farm were forged. The event was a success, with calls for a repeat in 2011. For more details, photos and course material visit http://www.sussex.ac.uk/lasi/newsandevents/whatsthebuzzz

We have continued to strengthen our bonds with local schools, and a visit from St Joseph's Catholic Primary School in May enthused pupils to learn more about honey bees, ants and the natural world. Students from Brighton College were treated to a demonstration at LASI in June, and in May, Sam Jones took colonies of ants to show pupils at St David's College in West Wickham.

A group of visitors from the Country Land and Business Association learning to decode waggle dances

Not only have groups such as the Country Land and Business Association experienced demonstrations of our research at the lab, but LASI members have also attended events such as the official opening of National Insect Week at Butterfly World in St Albans in June, the opening of the Railway Lands Project on the outskirts of Lewes and a visit to Knepp Castle, a wild-land conservation project near Horsham.

In March the television presenter, Jimmy Doherty, organised a Science Festival weekend at his farm near Ipswich, Suffolk, to highlight the importance of science in farming and food production. Karin Alton took an observation hive to the festival to emphasise the vital role that honey bees play in agriculture and to highlight our current research at the University. It was a great success with over 5,000 visitors. LASI has been invited to take part again in 2011.

Karin Alton demonstrating with an observation hive at Jimmy's Farm

LASI's portable observation hive has also visited family days such as The Wildlife Day in July at Stoneywish Nature Reserve and the Apple Day, a celebration of the Community Orchard in Scrase Valley Nature Reserve which is being restored by the Haywards Heath Transition Town Group.

Norman Carreck and Karin Alton are both involved with instructing and training beekeepers. Norman teaches on the National Diploma in Beekeeping course and, in conjunction with Central Sussex Beekeepers Association, Karin instructed a 'Beekeeping for beginners' course and taught hands-on practical work at the Association's apiary during the summer months.

Throughout the year members of the LASI team have given many talks to a wide variety of audiences all over the UK. These include many beekeeping groups, the WI, farmers' and land-managers' groups, science festivals and environmental groups. These talks, mainly given to a lay audience, along with all the activities highlighted above, play an important part in the public communication of science, which is becoming an increasingly important issue for the scientific community.

All the scientists at LASI attend national and international academic conferences, giving talks and presenting papers on their research. At the 4th European Bee Research Conference in Turkey, both Norman Carreck and Karin Alton gave presentations. Karin's focused on the importance of public communication of honey bee research with examples of the extension work carried out by LASI. Our approach of involving the business and community world in our work far exceeds any other university in Europe, and our efforts were highly commended. At the Rank Prize Fund Mini-symposium on Sensory Aspects of Insect Pollination in Grasmere, Margaret Couvillon gave a talk on her work on honey bee foraging. Francis Ratnieks has given numerous presentations both in the UK and overseas, for example a course of lectures at the University of São Paulo, Brazil.

A full list of all academic and popular talks given in the past year can be found in Appendix 2.

The LASI website (www.sussex.ac.uk/lasi) has continued to grow and has now over 55 pages of information, not only for the benefit of students and academics, but also the general public. Social networking sites such as Facebook and Twitter are utilised to disseminate our research and broadcast events and news occurring in the lab. During the month of December 2010, the website attracted nearly 1500 page views.

Media engagement

During 2010 there was once again a great deal of media interest in the problems facing honey bees. The research being conducted at LASI was featured in the national and regional press, magazines and periodicals, online articles, radio and television programmes. Increasingly Professor Ratnieks and the LASI team are the first journalists and presenters turn to for comment on honey bee issues..

Throughout the year LASI has hosted various journalists, and radio and film crews, for programmes such as *The One Show* and *Countryfile*. Ainsley Harriott recorded an episode for the new BBC programme, *The Great British Food Revival*
http://www.sussex.ac.uk/lasi/newsandevents/index?id=51655

The LASI team with Ainsley Harriott during filming for The Great British Food Revival

Below is a list of just some of the items in which Professor Ratnieks or members of the LASI team were featured

Bee Colony Collapse May Have Several Causes
Francis Ratnieks talks to online magazine Wired Science about colony collapse and why it is unlikely to be down to a single cause. *Wired Science*, *08.01.10*

Loss of forage biggest long-term threat to bees
Francis Ratnieks disputes the theory that pesticides are the main cause of colony collapse in honey bees. *The Ecologist, 08.01.10*

Clarity on Honey Bee collapse
Francis Ratnieks' (Biology) study on Honey Bee mortality published in the journal *Science*. *Science, 08/01/10*

BBKA funds honey bee research at Sussex University
An unnamed DPhil student will benefit from a donation of £6,000 to help further research into the health of bees. *Bee Craft, 01.02.10*

Norman Carreck gives an interview to French television at LASI about “sniffer bees”. *France 2 Londres Groupe France Télévisions, 01.04.10*

Lab plays host to BBC Radio Sussex Breakfast Show
Presenter Neil Pringle visited the lab to learn more about Dr Margaret Couvillon's Sussex Plan project – deciphering bee waggle dances to determine where bees are foraging in the landscape. *BBC Radio Sussex, 10.03.10*

Spotlight on honey bee colony losses
LASI bee scientist Norman Carreck was filmed for BBC TV's Spotlight South West programme while he was attending a beekeepers' meeting in Devon on "coping with honey bee colony losses", organised as part of Defra's 'Healthy Bees Plan'. *BBC South West TV, 20.03.10*

Norman Carreck talked to the BBC Asian Network radio about mobile phone signals and the possibility that they are wiping out bees – apparently the plot of a new Bollywood movie. *BBC Asian Network, 30.03.10*

Professor Francis Ratnieks (LASI) talked about the bee crisis. *'Farming Today' BBC Radio 4, 28.04.10*

Experts make beeline for uni meeting
A 'bee summit', with representatives from business, farming and community join academics at the University of Sussex. *The Argus 29.04.10*

Norman Carreck talked to BBC Five Live about Colony Collapse Disorder, the crisis facing bees and what can be done about it. *BBC Five Live, 02.05.10*

What's happening to our Honeybees?
How can science help the honeybee? Science feature in which Francis Ratnieks and Margaret Couvillon from LASI describe their work on the Sussex Plan for Honey bee health. *Eureka magazine, The Times 06.05.10*

Bee talk
Francis Ratnieks (Biology) gives the lowdown on the honey bee as the BBC launches a Springwatch campaign for bees. *BBC Radio Sussex, 18.05.10*

Bee aware and start counting every one
Francis Ratnieks (Biology) and Brighton mayor Ann Norman join forces with Dorothy Stringer secondary school, Brighton, to promote bee conservation as part of the council's Big Nature project.
Brighton Argus, 17.05.10
Brighton and Hove leader, 20.05.10
Brighton Argus, 21.05.10

Swarm's beeline for new home at uni
Picture story describes how a bee swarm took up residence in the Laboratory for Apiculture and Social Insects. *Brighton Argus, 20.05.10*

Researchers are sweet on the honey bee
Francis Ratnieks (biology) describes the work being carried out by his research team in an opinion piece devoted to honey bees. *Brighton Argus, 31.05.10*

Themed ball raises cash for bee fund
Sussex RAG students raised £3,000 for LASI through their Stanmer House bee ball.
Brighton Argus, 03.05.10

What's Buzzing?
A major article focusing on Francis Ratnieks and LASI's link-up with Kew Garden's Wakehurst Place facility. *Kew Magazine, 01.06.10*

Bee experts unravel mystery of the dance
Report on Waitrose's donation to support LASI research into decoding the honey bee waggle dance. *The Daily Telegraph, 25.06.10*

Waitrose's cash will bee very useful
Report on Waitrose donation to the University's Laboratory of Apiculture and Social Insects. *Brighton Argus, 29.06.10*

New danger for bees
Front-page lead highlights LASI call to action to save bees
West Sussex Gazette, 02.06.10

Why we need our bees
Cover-story article announcing £67,500 donation by Waitrose to LASI at Sussex.
Waitrose Weekend (free magazine distributed at tills nationwide), 24.06.10

Is there honey still for tea?
Major feature and interview with Francis Ratnieks about LASI's honey bee research. *Saga Magazine, June 2010*

Waitrose funds 'bee dance' research
Report on Waitrose's research funding for LASI.
International Supermarket News, 29.06.10

University of Sussex - Waggly tale
News of Waitrose's £70,000 donation to Project 2 of the Sussex Plan - waggledance decoding – reported in the Times Higher.
Times Higher magazine, 08.07.10

Norman Carreck talked about breeding hygienic bees and the Sussex Plan on Radio 4's Material World. *Material World, Radio 4, 29.07.2010*

Scientists square off on evolutionary value of helping relatives
Professor Francis Ratnieks (Biology and Environment) argues against the methodology of creating the 'inclusive fitness', theory, which attempts to explain why relatives play a role in raising offspring. *The New York Times 31.08.10*

LASI and the Sussex Plan are the subject of a special report on BBC 1's Sunday teatime show Countryfile. *Countryfile, BBC1, 15.08.10*

Urban bees fare better due to varied diet, research reveals
Professor Francis Ratnieks (Biology) and Environmental Science) is studying the value of different species of garden plants for honey bees and other pollinators. *The Guardian, 17.08.10*

Professor Frances Ratnieks interviewed about the plight of the bees. *ITN News, 25.08.10*

Buzz about bees
Professor Francis Ratnieks spoke at an event at Arundel Town Hall supported by Arundel Greening Campaign. *The Argu,s 04.09.10*

Bees stung by 'climate change-linked' early pollination
Francis Ratnieks suggests caution when linking climate change to decline in bees. *The Ecologist, 07.09.10*

The buzz is back
Professor Francis Ratnieks (Biology and Environmental Science) explains why the grocery industry needs to help restore bee numbers. *The Grocer 11.09.10*

Francis Ratnieks and Margaret Couvillon gave an interview to the BBC Radio 4 programme Saving Species on the work of LASI. *Saving Species, Radio 4, 12.10.10*

A run for your honey
An interview with donor Rowse Honey makes mention of the company's donation to honey bee research at LASI. *Food Manufacture, 01.11.10*

Top scientist warns against 'hype' as EU sets out bee rescue plan
Francis Ratnieks quoted in story about declines in honey bee populations being reported in a number of EU member states, but warns that data is patchy.
Euobserver.com 06.12.10
http://euobserver.com/885/314355

Conservation expert calls on garden centres to stock insect-friendly bedding plants
Francis Ratnieks calls on garden centres and bedding breeders to consider bees and butterflies when breeding bedding plants**.** *Horticulture Week, 10.12.10*

British research offers hope in varroa battle
Francis Ratnieks advises caution in news about varroa research
New Zealand Herald, 23.12.10
http://www.nzherald.co.nz/science/news/article.cfm?c_id=82&objectid=106962033

2011 is the year to bring insects in from the cold
Francis Ratnieks quoted in an article by flowers expert Sarah Raven about plants that are good for bees and insects.
Telegraph Lifestyle, 01.01.11
http://www.telegraph.co.uk/gardening/gardeningadvice/8229738/2011-is-the-year-to-bring-insects-in-from-the-cold.html

Pesticides could be behind honeybee demise
Norman Carreck quoted in an article about the effects of neonicotinoid pesticides on honey bees
The Telegraph Earthnews, 25.01.11
http://www.telegraph.co.uk/earth/earthnews/8271659/Pesticides-could-be-behind-honeybee-demise.htmll

Funding

Research at LASI on The Sussex Plan for honey bee health and well-being is entirely funded by philanthropic donations. These donations have come from a wide variety of sources including companies, trusts and foundations, beekeepers' associations and individuals. The commitment shown by LASI donors to this vital research is crucial to finding evidence-based solutions to the problems facing the honey bee, solutions that will also impact positively on all pollinators. It is essential that the Laboratory continues to attract generous funding to ensure that the research continues to help the honey bee

Generous donations have come from young and old alike; from benefactors who have a personal or professional interest in honey bees and from organisations and individuals with a wider interest in conservation and the environment. Between January and December 2010 over £515,000 has been received and pledged to fund research at LASI, including Gift Aid and HEFCE Matched Funding. Added to this is the commitment made by the University of Sussex in supporting the laboratory facility and employing Professor Ratnieks. All the other scientists and their research are funded by charitable donations

As well as continuing support from Rowse Honey Ltd. Burt's Bees, the Nineveh Charitable Trust and Mr Michael Chowen, we were delighted this year to receive donations from The Body Shop Foundation, the British Beekeepers' Association and Waitrose, all of whom are funding PhD students to conduct honey bee research for three years. All the donors who have made a commitment to LASI over several years are of particular value to this research project, as evidence-based scientific research takes place over the long-term and relies on the ongoing support of donors. We very much hope that this support will continue in the future.

At the beginning of 2010, the students at the University of Sussex demonstrated their support for honey bee research by naming the annual Student's Union Rag Ball 'The Bee Ball', which was suitably themed in black and yellow. The students raised over £3,000 towards LASI research. This event was also supported by Burt's Bees.

LASI is continuing to receive valuable support from members of the public who are concerned about the challenges facing honey bees. In April 2010 Melanie Cooke ran the London Marathon, dressed in a bee costume, and donated £500 to honey bee research.

Everyone at LASI would like to thank all our past and present donors for their generosity and hope that they might consider supporting this vital research in the future.

Major donors
The Body Shop Foundation
The British Beekeepers Association
Burt's Bees (UK) Ltd
David Read
Michael Chowen
Nineveh Charitable Trust
Rowse Honey Ltd
Waitrose

Donors
1155
Anna Appelmelk
Bucks County Beekeepers' Association
Dean Forest Beekeepers' Association
Dorchester and Weymouth Beekeepers' Association
Eliot Edmonds, Eleanor Palmer Primary School and 8th Hampstead Scout Group
Elizabeth Boyling
Habitat Aid
Helen Wilson and Ealing and District Beekeepers' Association in memory of John Wilson MBE
High Wycombe Beekeepers' Association
Isobel Ponsford and Jasmin Bannister and Kingsbridge Primary School
Jane Samsworth
Jill Hearn
John Merrill
John Spedan Lewis Foundation
Keith Jones
Margaret Ashworth
Marks & Spencer
Melanie Cooke
Mrs M Crowhurst
Nutley WI
Oak Foundation
Pamela Morton
Philip King Charitable Trust
Shirley Fitch and Fleet Beekeepers' Association in memory of Colin Fitch
Sir Peter Daniell Charitable Trust
St Joseph's RC Primary School
Somerset Beekeepers Association
The Tansy Trust
Vale and Downland Beekeepers' Association and Newbury Beekeepers' Association
Yew Tree WI

Donors in kind
Silver Spoon
Weber Shandwick

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 as a research scientist at Rothamsted Research for nearly twenty years, working on both agronomy and apiculture. He sits on numerous committees for beekeeping associations and trusts, as well as a UK member of the international COLOSS network to investigate the causes of honey bee colony losses. He is also Senior Editor of the Journal of Apicultural Research and Scientific Director of the International Bee Research Association. He is a fellow of the Royal Entomological Society.

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.

Mr. 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 202010 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.

Mr. 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.

Mr. 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.

Mr. 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.

Mr. 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.

Mr. Martin Kärcher
Martin Kärcher is a PhD student 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.

Ms. 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 2010 (University of Sussex authors in bold)

Papers in refereed journals.

Bonckaert, W., Tofilski, A., Nascimento, F. S., Billen, J., **Ratnieks, F.L.W.,** Wenseleers, T. (2010) Co-occurrence of three types of egg policing in the Norwegian wasp *Dolichovespula norwegica. Behavioural Ecology and Sociobiology*. doi: 10.1007/s00265-010-1064-3

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,** 51-84. doi: 10.3896/IBRA.1.50.1.06

Carreck, N.L., Ball, B.V., Martin, S.J. (2010) Honey bee collapse and changes in viral prevalence associated with *Varroa destructor*. *Journal of Apicultural Research* **49,** 93-94. doi: 10.3896/IBRA.1.49.1.13

Carreck, N.L., Ball, B.V., Martin, S.J. (2010) The epidemiology of cloudy wing virus infections in honey bee colonies in the UK. *Journal of Apicultural Research* **49,** 66-71.
doi: 10.3896/IBRA.1.49.1.09

Czaczkes, T.J., Nouvellet, P., Ratnieks, F.L.W. (2010) Cooperative food transport in the Neotropical ant, *Pheidole oxyops*. *Insectes Sociaux*. doi:10.1007/s00040-010-0130-1

Czaczkes, T.J., Ratnieks, F.L.W. (2010) Simple rules result in the adaptive turning of food items to reduce drag during cooperative food transport in the ant *Pheidole oxyops. Insectes Sociaux*. doi: 10.1007/s00040-010-0121-2

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

Couvillon, M.J., Hughes, W.O.H., Perez-Sato, J.A., Martin, S.J., **Ratnieks, F.L.W.** (2010). Sexual selection in honey bees: colony variation and the importance of size in male mating success. *Behavioural Ecology* **21,** 520-525.

Couvillon, M.J., Jandt, J., Duong, N., Dornhaus, A. (2010). Ontogeny of body size distribution in bumble bees (*Bombus impatiens*). *Ecological Entomology* **35,** 424-435.

Couvillon, M.J., Fitzpatrick, G., Dornhaus, A. (2010). Ambient air temperature does not predict body size of foragers in bumble bees (*Bombus impatiens*). *Psyche* (In press).

Couvillon, M.J., Dornhaus, A. (2010). Small worker bumble bees (*Bombus impatiens*) are hardier against starvation than their larger sisters. *Insectes Sociaux* **57,** 193-197.

Couvillon, M.J., DeGrandi-Hoffman, G., Gronenberg, W. (2010). Africanized honey bees are slower learners than their European counterparts. *Naturwissenschaften* 97(2), 153-160.

Dijkstra, M.B., **van Zweden, J.S.**, Dirchsen, M. & Boomsma, J.J. (2010) Workers of *Acromyrmex echinatior* leafcutter ants police worker-laid eggs but not reproductive workers. *Animal Behaviour* **80,** 487-495

El-Showk, S., **van Zweden, J.S.**, d'Ettorre, P. & Sundström, L. (2010) Are you my mother? Kin recognition in the ant *Formica fusca*. *Journal of Evolutionary Biology* **23,** 397-406

Gronenberg, W., **Couvillon, M.J.** (2010) Brain composition and olfactory learning in honey bees. *Neurobiology of Learning and Memory* **93,** 435-443.

Grüter, C., Czaczkes, T.J., Ratnieks, F.L.W. (2010) Decision making in ant foragers (*Lasius niger*) facing conflicting private and social information. *Behavioural Ecology and Sociobiology* online first.

Grüter, C., Kärcher, M.H., Ratnieks, F.L.W. (2010) The natural history of nest defence in a stingless bee, *Tetragonisca angustula* (Latreille) (Hymenoptera: Apidae), with two distinct types of entrance guards. *Neotropical Entomology* (in press).

Grüter, C., Leadbeater, E., Ratnieks F.L.W. (2010) Social learning: the importance of copying others. *Current Biology*, **20,** R683-R685.

Grüter, C., Czaczkes, T.J., Ratnieks F.L.W. (2010) Decision-making in *Lasius niger* foragers facing conflicting private and social information. *Behavioural Ecology and Sociobiology*. doi: 10.1007/s00265-010-1020-2 (in press).

Kärcher, M.H., Ratnieks, F.L.W. (2010) Honey bee guards recognise allospecific intruders via "different odours" not "harmful-intruder odours". *Journal of Apicultural Research* **49,** 270-277. doi: 10.3896/IBRA.1.49.3.07

Martin, S.J., Ball, B.V., **Carreck, N.L.** (2010) Prevalence and persistence of deformed wing virus (DWV) in untreated or acaricide treated *Varroa destructor* infested honey bee (*Apis mellifera*) colonies. *Journal of Apicultural Research* **49,** 72-79.
doi: 10.3896/IBRA.1.49.1.10

Neumann, P., **Carreck, N.L.** (2010) Honey bee colony losses. *Journal of Apicultural Research* **49,** 1-6. doi: 10.3896/IBRA.1.49.1.01

Ratnieks, F.LW., Carreck, N.L. (2010) Clarity on honey bee collapse? *Science* **327,** 152-3. doi: 10.1126/science.1185563
Ratnieks, F.L.W., Foster, K. R., Wenseleers, T. (2010) Darwin's special difficulty: the evolution of "neuter insects" and current theory. *Behavioural Ecology and Sociobiology*. doi: 10.1007/s00265-010-1124-8
Stroeymeyt, N., Guerrieri, F.J., **van Zweden, J.S.,** d'Ettorre, P. (2010) Rapid perceptual decision making with side-specific odour processing in ants, *PLoS One* 5, e12377
van Zweden, J.S., Brask, J.B., Christensen, J.H., Boomsma, J.J., Linksvayer, T.A., d'Ettorre, P. (2010) Blending of heritable recognition cues among ant nestmates creates distinct colony gestalt odours but prevents within-colony nepotism. *Journal of Evolutionary Biology* 23, 1498-1508

Book chapters, reports, conference proceedings, etc.

Couvillon, M.J., Riddell Pearce, F.C., Ratnieks, F.L.W. (2010). How good is the British Landscape for honey bees? Decoding waggle dances to determine where bees forage? *Rank Prize Fund Mini-symposium on Sensory Aspects of Insect Pollination, Grasmere, UK, 24-27 May, 2010*
Alton, K.L., Carreck, N.L., Ratnieks, F.L.W. (2010) Public communication of honey bee research. *Proceedings of 4th European Conference of Apidology, METU, Ankara, Turkey, 7-9 September 2010.* 107.
Carreck, N.L. (2010) Threats to bees. In *Abstracts of Royal Society of Medicine Meeting "Bees, food and human health". Royal Society of Medicine, London, 30 September 2010.* 12.
Carreck, N.L., Alton, K.L., Jensen, A.B., **Ratnieks, F.L.W.** (2010) Intra-colony selection for hygienic behaviour in the dark European honey bee. In *Proceedings of 6th COLOSS Conference - Prevention of Honey bee COLony LOSSes, Hacettepe University, Ankara, Turkey, 5-6 September 2010.* 29.
Carreck, N.L., Alton, K.L., Ratnieks, F.L.W. (2010) Intracolony selection of honey bee colonies for disease resistance. In *Abstracts of Royal Entomological Society Annual Meeting "Ento' 10", Swansea University, UK, 26-28-7/10.* 19.
Carreck, N.L., Alton, K.L., Ratnieks, F.L.W. (2010) Intracolony selection of the Dark European honey bee for disease resistance. In *Proceedings of 4th European Conference of Apidology, METU, Ankara, Turkey, 7-9 September 2010.* 52.
Carreck, N.L., Jones, S.L., Cooper, R.A. (2010) Bee products in human medicine - the need for standardisation. In *Proceedings of 4th European Conference of Apidology, METU, Ankara, Turkey, 7-9 September 2010.* 79.
Couvillon, M.J., Dornhaus, A. (2010) The hows and whys of size variation in worker bumble bees *Bombus impatiens*. In *Abstracts of XVIth International Union for the Study of Social Insects Congress, 8-14/8/10, Copenhagen, Denmark.* 188.
Czaczkes, T.J., Grüter, C., Jones, S., Ratnieks F.L.W. (2010) Keep on truckin' - a novel role for ant trail pheromones as a 'keep on walking' signal in the ant *Lasius niger*. In *Abstracts of XVIth International Union for the Study of Social Insects Congress, 8-14/8/10, Copenhagen, Denmark.* 285.
Ernst, U., Cardoen, D., **Ratnieks, F.L.W.,** deGraaf, D., Schoofs, L., Verleyen, P., Wenseleers, T. (2010) Is there specialism in policing in the honey bee *Apis mellifera*? In *Abstracts of XVIth International Union for the Study of Social Insects Congress, 8-14/8/10, Copenhagen, Denmark.* 117.
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,* (in press).
Grüter, C., Ratnieks, F.L.W. (2010) Honey bee foragers increase their use of waggle dance information when using private information becomes unrewarding. In *Abstracts of XVIth International Union for the Study of Social Insects Congress, 8-14/8/10, Copenhagen, Denmark.* 244.
Helanterä, H., Ratnieks, F. L. W. (2010) Worker - worker conflict and worker policing. In: *Breed M.D and Moore J. (Eds). Encyclopedia of Animal Behaviour.* Academic Press; Oxford, UK. pp 621-628.
Kärcher, M.H., Ratnieks, F.L.W. (2010) Killing the wrong kind of eggs - the cost of worker policing. In *Abstracts of XVIth International Union for the Study of Social Insects Congress, 8-14/8/10, Copenhagen, Denmark.* 153.
Ratnieks F.L.W. (2010) Adaptive shifts in the acceptance thresholds of honey bee guards. In *Abstracts of XVIth International Union for the Study of Social Insects Congress, 8-14/8/10, Copenhagen, Denmark.* 318.
Riddell, F.C., Couvillon, M.J., Ratnieks, F.L.W. (2010) Decoding waggle dances to determine foraging patterns of honey bees throughout the year. In *Abstracts of XVIth International Union for the Study of Social Insects Congress, 8-14/8/10, Copenhagen, Denmark.* 299.
van Zweden, J.S., d'Ettorre, P. (2010) Nestmate recognition in social insects and the role of hydrocarbons. In *Insect Hydrocarbons: Biology, Biochemistry and Chemical Ecology*. Eds. Blomquist, G.J. & Bagnères, A.-G., Cambridge, Cambridge University Press, pp. 222-243
van Zweden, J.S., Brask, J.B., Christensen, J.H., Boomsma, J.J., Linksvayer, T.A., d'Ettorre, P. (2010) Direct vs. indirect genetic effects of recognition cues in ants. In *Abstracts of XVIth International Union for the Study of Social Insects Congress, 8-14/8/10, Copenhagen, Denmark*. 315.

Popular articles.

Bigio, G. (2011) Progress on the BBKA PhD studentship at the University of Sussex. *British Beekeepers Association News* (in press).
Carreck, N.L. (2010) How were the BBKA Honey Bee Research priorities decided? *British Beekeepers Association News* **181,** 5-6.
Carreck, N.L. (2010) What is the Coloss Network? *British Beekeepers Association News* **182,** 1,4.
Carreck, N.L. (2010) What is new at the International Bee Research Association? *British Beekeepers Association News* **186,** 13.
Carreck, N.L. (2010) What is new at the International Bee Research Association? *Bee Culture* (in press).
Carreck, N.L. (2010) Honey bee colony losses - towards a better understanding of the causes? *Bee World* **87(1)**, 10-11.
Carreck, N.L. (2010) Science and the novice beekeeper. *Bee World* **87(2),** 27-8.
Carreck, N.L. (2010) Only one queen in the hive? *Bee World* **87(3),** 50-1.
Carreck, N.L. (2010) What about toxic pollen and nectar? *Bee World* **87(4),** 75-6.
Carreck, N.L. (2010) COLOSS and EurBee in Turkey, 2010. *Bee World* **87(4),** 86-87.
Carreck, N.L. (2010) Welcome back *Bee World*! *Journal of Apicultural Research* **49(2),** 223.
MJ Couvillon, M.J. and **Ratnieks. F.L.W**.(2010), How good is the British countryside for our honey bees? Decoding waggle dances to determine where bees forage. (Accepted) *Beekeepers Quarterly*
Grüter, C. (2010) Der Schwaenzeltanz in neuem Licht. *ADIZ/Die Biene/Imkerfreund* **3,** 18-19 [in German].
Neumann, P., **Carreck, N.L.** (2010) Honey bee colony losses. *Beekeepers Quarterly* 102, 44-47.
Neumann, P., **Carreck, N.L.** (2010) Pérdidas de colonias de abejas. *Actualidad Apicola* **1,** 6-9. [in Spanish]
Ratnieks, F.L.W. (2010) Researchers are sweet on the honey bee. *The Argus*, 31/5/10. p 8.

Appendix 2

Talks given in 2010

29/1/10	*Losses of honey bees - some explanations* to Crop Advisors Independent Alliance Annual Conference, Sutton Scotney, Hampshire (NC).
3/2/10	*Why should we care about bee viruses?* to Reigate Beekeepers Association, Surrey (NC).
4/2/10	*The hows and whys of size variation in bumble bees* to University of Sussex Seminar Series (MC).
10/2/10	*Bee diseases and causes* at Rural Enterprise Gateway meeting: "Honey bee Health and Management" at Royal Agricultural College, Cirencester, Gloucestershire (NC).
11/2/10	*Mechanisms of guarding and nestmate recognition in honey bees and stingless bees* to Worthing Beekeepers Association, Sussex (MC).
20/2/10	*Clarity on colony losses?* at Surrey Beekeepers Association "Surrey Bee Day", Ewell (NC).
2/10	Social Insects Course of 10 x 50 minute lectures, University of São Paulo at Riberão Prêto, Brazil (FR).
28/2/10	*Strength in Numbers; emergence in bees and ants* at Brighton Science Festival "Life, the Universe & Everything: How life emerged from chaos, and how chaos never went away" (FR).
8/3/10	*The Haig hypothesis for genomic imprinting* at University of Sussex, meeting of researchers studying imprinting and methylation (FR).
11/3/10	*Basic and applied honey bee research at the Laboratory of Apiculture & Social Insects, University of Sussex* at Fera National Bee Unit, Sand Hutton, York (FR).
13/3/10	*Research at the University of Sussex* to Cheshire Beekeepers Association (NC).
16/3/10	*Bees and bee populations* to Hampshire Arable Systems Annual Conference, Basingstoke (NC).
20/3/10	*The interaction of Varroa and viruses* to Healthy Bees Plan South West Regional Workshop: "Combating colony loss", Tiverton, Devon (NC).
24/3/10	*Darwin's Difficulty: worker insects* at Department of Ecology & Evolution, University of Lausanne, Switzerland (FR).
25/3/10	*The honey bee: Gateway to biology, cultural icon and agricultural helper* at Jodrell Lecture Theatre, Royal Botanic Gardens, Kew, London (FR).
29/3/10	*The honey bee: Gateway to biology, cultural icon and agricultural helper, and what we are doing at Sussex University to help the honey bee* to Women's Institute Bee Ambassadors' Conference, Ferris Room, Denman College (FR).
16/4/10	Debate: *Queen problems* at British Beekeepers Association Spring Convention, Stoneleigh (NC).
21/4/10	*Breeding bees for hygienic behaviour* to Mid Bucks Beekeepers Association, Wendover (NC).
23/4/10	*The evolution of extreme altruism in insect societies and the roles of kinship and coercion* at School of Biosciences, Falmouth Campus, University of Exeter (FR).
24/4/10	*Bees and bee conservation* to Horsham Transition Towns Group, Friends' Meeting House, Horsham (NC).
25/4/10	*The amazing honey bee* at Callington Town Forum, Cornwall (FR).
28/4/10	*What are bees and why are they Important in nature and to humans?* (FR), *What are the problems facing bees and other pollinators?* (NC), *What can we do to help bees and pollination: scientists and the public* (MC) at RLU meeting "What's the buzz? Bees, land use and the Community, University of Sussex.
25/5/10	*How good is the British Landscape for honey bees? Decoding waggle dances to determine where bees forage?* at Rank Prize Fund Mini-symposium on Sensory Aspects of Insect Pollination, Grasmere, UK (MC).
5/6/10	*CCD and bee health problems* and *Honey bee research at the University of Sussex* to Avon BKA, Chew Magna, Somerset (NC).
12/7/10	*The honey bee and Sussex Research* at University of Sussex, Continuing Education (FR).
15/7/10	*The honey bee - one of the little things that we depend on* at Café Scientifique, Latest Music Bar, 14-17 Manchester Street, Brighton,BN2 1TF(FR).
26/7/10	*Intracolony selection of honey bee colonies for disease resistance* at Royal Entomological Society Annual Meeting Ento '10, University of Swansea (NC).
2/8/10	*Neural correlates of nestmate recognition in social insects* to Insect Olfaction Group, University of Konstanz, Konstanz, Germany (JvZ)
9-10/8/10	*Adaptive shifts in the acceptance thresholds of honey bee guards* (FR) and *Keep on truckin' - a novel role for ant trail pheromones as a 'keep on walking' signal in the ant* Lasius niger (TC) at XVIth International Union for the Study of Social Insects Congress, Copenhagen, Denmark.

7-9/9/10	*Intracolony selection of the Dark European honey bee for disease resistance* (NC), *Bee products in human medicine - the need for standardisation* (NC) *Public communication of honey bee research* (KA) at 4th European Bee Research Conference (EurBee), METU, Ankara, Turkey.
9/9/10	*The honey bee: our best insect friend and bee research at the University of Sussex to help honey bees and pollinators* at Waitrose Food Technology Conference (FR).
9/9/10	*The honey bee - one of the little things that we depend on and research at Sussex University to help it* at Arundel Greening Campaign, Arundel Town Hall (FR).
15/9/10	*The honey bee* at Adur Festival, "All things bright and beautiful", StMary de Haura Church, Shoreham-by-Sea (FR).
18/9/10	*Using intracolony selection to breed hygienic bees* and *Is the honey bee native to the British Isles?* to West Cornwall Beekeepers Association, Truro (NC).
21/9/10	*The honey bee, foraging and flowers* at West Hove & District Horticultural Society (FR).
30/9/10	*Threats to honey bees* to Royal Society of Medicine Meeting "Bees, food and human health", Royal Society of Medicine, London (NC).
16/10/10	*Bee Research at Sussex University: The Sussex Plan for Honey Bee Health & Well Being* at Wiltshire Beekeepers Association Honey Show (FR).
19/10/10	*The amazing honey bee, our best insect friend, and Sussex University research to help it* at Friends Meeting House, Ship St, Brighton (FR).
10/11/10	*The honey bee: background, farming and research* at Waitrose Technical Conference, Aylesford, Kent (FR).
11/11/10	*Nestmate recognition and within-colony kin recognition in two species of Formica ants* to Laboratoire d'Ethologie Expérimentale et Comparée (LEEC, University of Paris 13, Paris, France (JvZ).
17/11/10	*How good is the British Landscape for honey bees? Decoding waggle dances to determine where bees forage* at Wildlife Gardening Forum, Royal Horticultural Society Halls, London. (MC).
17/11/10	*Charles Darwin, bumble bees, cats, mice and old maids* to London Beekeepers Association (NC).
26/11/10	*Basic research on honey bee biology at the Laboratory of Apiculture & Social Insects at Sussex University: Nestmate recognition and worker policing*. Annual Rosina Clark memorial lecture to Twickenham Beekeepers Association, Middlesex (FR).
10/12/10	*How good is the British Landscape for honey bees? Decoding waggle dances to determine where bees forage?* to International Union for the Study of Social Insects (IUSSI) Northwest Section Meeting, Natural History Museum, London. (MC).