

What's The Buzz Bees, Plants and Humans

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Seminar 1

What are Bees and Why are they Important in Nature and to Humans?

Background on Bees

What are Bees?

Bees are specialized wasps—hairy wasps

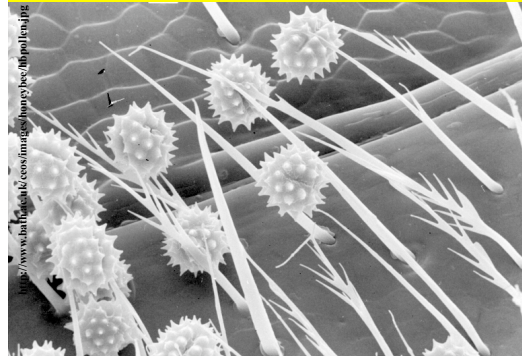
Switch from carnivory (prey) to herbivory (pollen)

Branched “plumose” hairs help collect pollen

Bees are in the insect order Hymenoptera

Specifically the hymenopteran sub-order Aculeata

Worker Honey Bee Plumose Hairs & Pollen



Ants Are Also Specialized Wasps



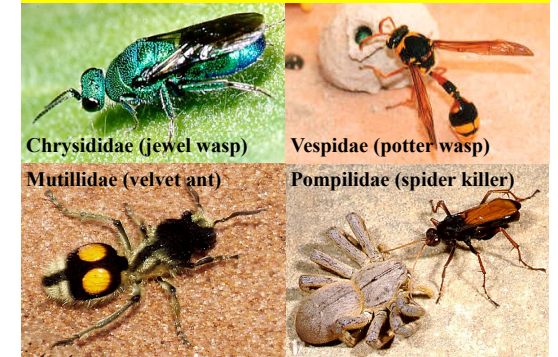
Ants are eusocial wasps with wingless workers

Some Parasitic Wasps (Not Aculeata)



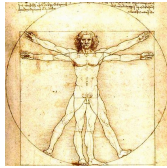
Above: Ichneumonidae wasps. Below: Chalcidoidea wasps; left: fig wasps; right: *Nasonia vitripennis* ovipositing on fly pupa.

Some Aculeata Wasps: Distant Bee Relatives



Bees Are Evolved Relatively Recently

The Earth	4540 million years
Life on Earth	3500 million years
Insects	400 million years
Termites	150 million years
Ants	120 million years
Bees	100 million years
Eusocial Bees	70 million years
Dinosaurs	230-65 million years ago
Modern humans	c. 0.2 million



Oldest Fossil Bee Known

100 million years
Fossil in amber
From Burma
Now extinct
“Intermediate”, with
some wasp-like
characteristics

Poinar & Danforth
2006 Science

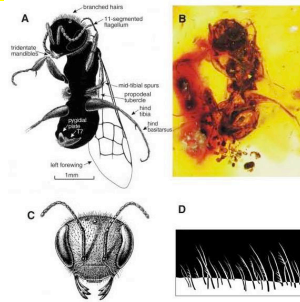


Fig. 1. *Melittophorus burmensis*. (A) Ventral view of fossil with key features labeled. (B) Photograph of fossil as seen in ventral view. (C) Reconstruction of head based on details visible in fossil and information from modern bees. (D) Morphology of branched hairs on the hind femur.

Oldest Fossil Bee Known



Bees: A Successful Way of Life

“Adaptive radiation”: many species from one origin

Coevolution with flowering plants (angiosperms)

c. 17,000 described species worldwide; estimated 30,000 total;
c. 250 species in Britain (222 species recorded in Surrey)

Most are “solitary”. Mother bee builds a small nest.

New life styles

“Cuckoo” bees: lay eggs in another bee’s nest

Eusociality: living in a colony with queen & workers

“Vulture” bees: scavenge for dead meat, fruit

Solitary Bees: Mother Built Nests



Mason bee and Leafcutter bee (Megachilidae). In both cases the female builds and provisions a nest. This is called parental or subsocial behaviour, and is the precursor to eusociality in bees, wasps and ants.

Eusocial Bees

Eusociality has evolved c. 5 times in bees

Only c. 10% bee species are eusocial, but most bees at flowers
bees are eusocial (i.e., worker bees).

3 times in Halictidae sweat bees

1 time in Apidae (bumble bees, honey bees, stingless bees)

1 or more times in Anthophoridae

Eusociality had also evolved 1 time in termites, 1 time in ants,
1 or 2 times in wasps

Apidae Bees: Four Subfamilies



Inside a Leurotrigona Stingless Bee Nest



Guards Tetragonica angustula Stingless Bee



Eusocial Sweat Bee (Halictidae)



Lasiosglossum zephyrum. A eusocial halictine bee species much studied by in the USA by Charles Michener & colleagues. The nest is below ground. Each larva develops on a provision mass of pollen and nectar in a cell. Mature nests are small, with just 6-20 females.

Pollination

Rewards to Bee: Nectar & Pollen



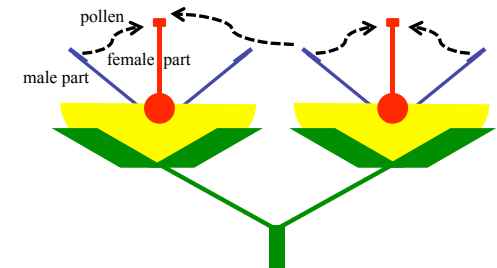
Downland Flowers



Hampton Court Flower Show

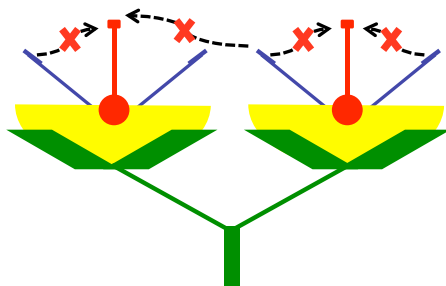


Self Pollination: Pollen From Same Plant



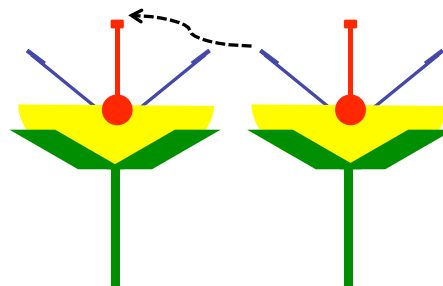
Many plants will accept pollen from the same plant or cultivar (e.g., apple variety). This is known as self compatibility. Bees can be important in moving pollen from the male part of the flower to the female part. Plants that do not accept their own pollen are "self incompatible".

Self Incompatibility



Many plants will not accept pollen from the same plant or the same cultivar (e.g., apple variety). This is known as self incompatibility, and prevents self pollination.

Cross Pollination: From Different Plant

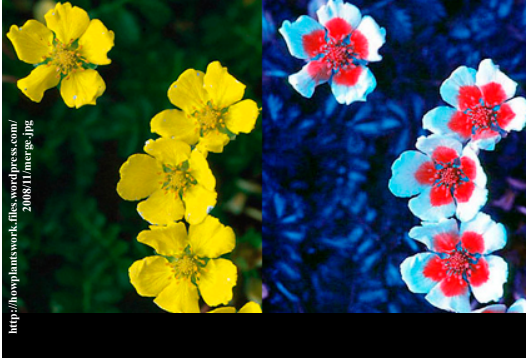


Cross pollination is generally carried out by the wind (e.g., oak trees, grasses) or by animals, usually insects. Wind pollinated flowers are generally inconspicuous. Insect pollinated flowers are brightly coloured.

Nectar Guides: Eyebright



Nectar Guides Visible in UV Light



Plant “Talking to” Bees



Horse Chestnut: Cream = Nectar, Red = None



Bee Orchid: Plant Cheating Bees

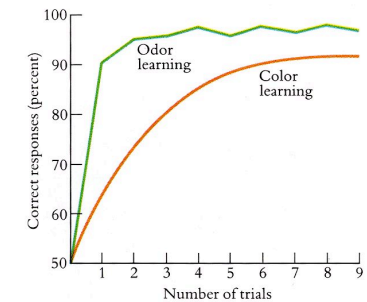


Female Kiwi Fruit Plant: Plant Cheating Bees



In the centre of the flower are the stigmas, part of the female sexual parts. Around these are the male parts, with many stamens with pollen. The pollen is non-functional. Each grain is an empty husk that is sterile and of no nutritional value to the bee.

Honey Bees Learn Colours & Odours Quickly



A typical odor is learned much faster than an average color.

Honey Bees & Crop Pollination

Wild Flower Pollination



A honey bee worker visiting a bramble flower. The honey bee, *Apis mellifera*, is a native British species and pollinates wild flowers as well as garden flowers and crops.

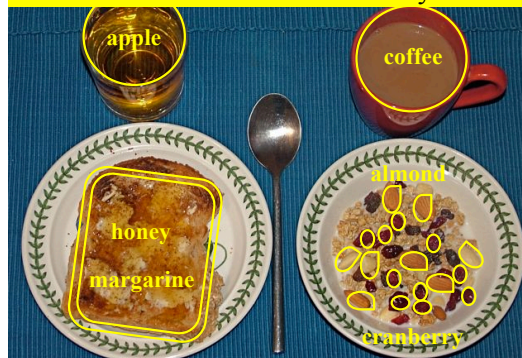
Crop Pollination: California Almonds



Some Honey Bee Pollinated Fruits



Breakfast Thanks to the Honey Bee



Honey Bee: Pollination in Britain

Crop	% role of bees in pollination	Value of bee pollination £M
Oil Seed Rape	8	24.6
Field Bean	8	4.2
Broad Bean	8	0.3
Runner & Dwarf	40	7.8
Apple	90	85.5
Pear	30	3.3
Other Orchard	15	5.7
Raspberry	30	19.5
Strawberry	10	11.1
Other soft fruit	15	3.8
Total		165.7

ADAS / Agriculture in the UK 2006

Honey Bee Pollination Worldwide

USA: c. \$10-15 billion

Worldwide: c. \$40 billion

Bee pollinated crops an increasing component of our diet

Honey bees also produce c. 1.3 million tons of honey p.a.

Honey Bees & Humans

Honey: Sweetness

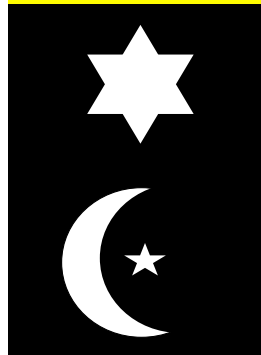


Honey comb (as produced by the bees) and extracted honey

Honey: Sweetness



Religion



...unto a land flowing with milk and honey;

Exodus 3: 8
King James Bible

Your Lord inspired the bee saying: "Build your homes in the mountains, in the trees, and in the hives which men shall make for you. Feed on every kind of fruit, and follow the trodden paths of your Lord."

From its belly comes forth a fluid of many hues, a medicinal drink for men. Surely in this there is a sign for those who would give thought.

Surah *The Bee*, the Qu'ran

Honey: Fermentation



Beeswax: Light



Are You Named "Bee"

Deborah bee, Hebrew

Melissa bee, Greek

Rupert Brooke



The Old Vicarage, Grantchester

Say, is there Beauty yet to find?
And Certainty? and Quiet kind?
Deep meadows yet, for to forget
The lies, and truths, and pain?... oh! yet
Stands the Church clock at ten to three?
And is there honey still for tea?

Rupert Brooke (1887-1915) 1912

Winnie the Pooh



Seminar 2

What are the Problems
Facing Bees and Other
Pollinators?

Challenges to the Honey Bee

Challenges to the Honey Bee in Britain

From c.1,000,000 to 250,000 hives in past century

Causes of the Reduction

Fewer flowers in countryside/habitat loss/intensification

Honey bee diseases

Insecticides

Urbanization

Global climate change

GMOs

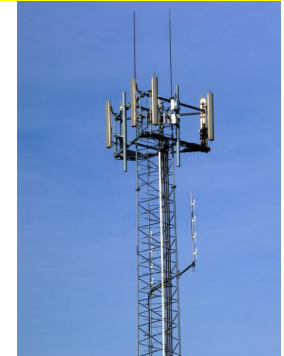
Mobile Phones

F1 hybrid plants

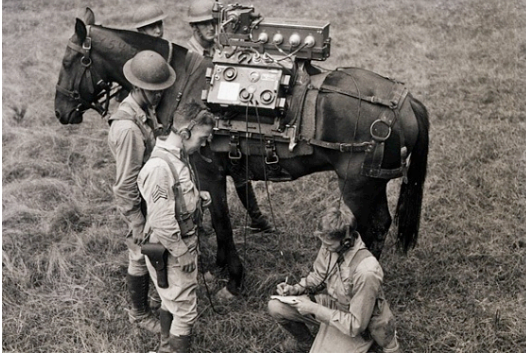
Nanotechnology.....HFCS.....etc.

Non-Problems But Good
Stories

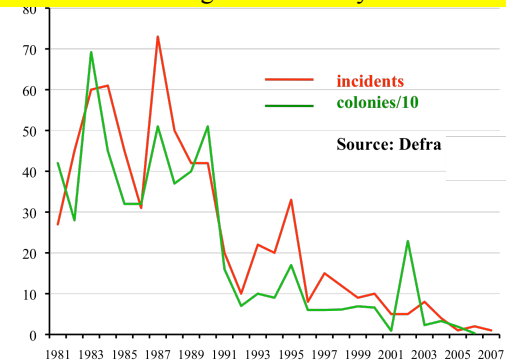
Mobile Phones: Almost Certainly Not a Problem



Radio Waves & Mobile Phones Not New

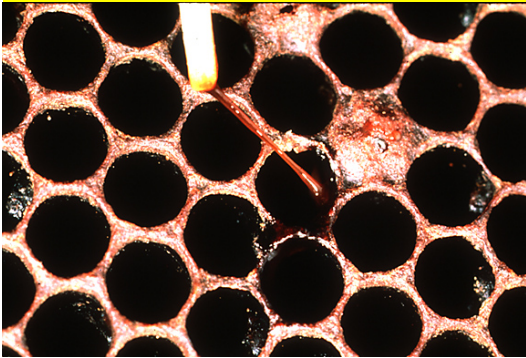


Pesticide-Poisoning British Honey Bee Colonies



Definite Problem
Pathogens & Pests
Honey Bee Specific
New & Old

Old Pathogen: American Foulbrood



Old Pathogen: Chalk Brood



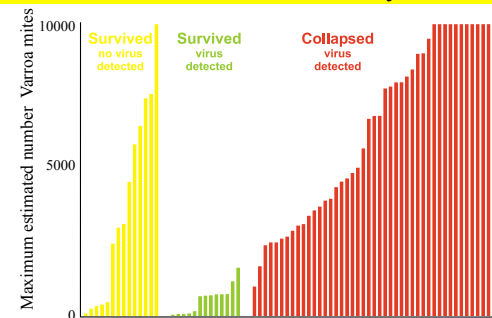
Old Pathogen: Deformed Wing Virus



New Pest: Mother Varroa on Drone Larvae



Varroa + Virus Causes Colony Death

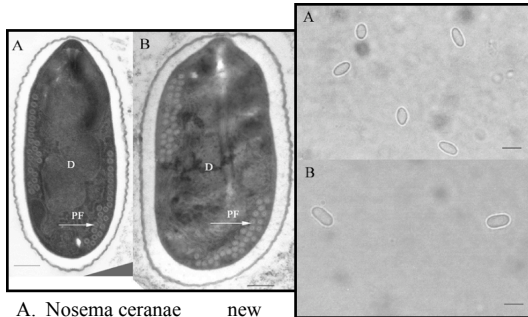


Carreck, Ball & Martin, 2010, J Apicult Res

Apistan: Varroa Now Resistant



Old & Very New Pathogen: Nosema



A. *Nosema ceranae* new
B. *Nosema apis* old

Pest of the Future?: Small Hive Beetle



Small hive beetle, *Aethina tumida*

CCD: Colony Collapse Disorder

Large scale losses of honey bee colonies are not new!

1868	Kentucky, Tennessee, USA
1891, 1896	Colorado, USA
1872	Australia
1906	UK
1910	Australia
1915	Portland, Oregon, USA
1915	Florida to California, USA
1917	USA
1917	New Jersey, USA; Canada
1960s	Louisiana, Texas, USA
1963-64	Louisiana, USA
1964	California, USA
1970s	Mexico
1970s	Seattle, Washington, USA
1974	Texas, USA
1975	Australia
1977	Mexico
1978	Florida, USA
1995-1996	Pennsylvania, USA
1999-2000	France
2002	Alabama, USA
2002-2003	Sweden, Germany, etc.

Adapted from Underwood & Van Engelsdorp, 2007

Definite Problem

Fewer Flowers in the Countryside

Affects Many Species

Land Use Changes

Reduction in hay meadows

Reduction in flower rich pasture

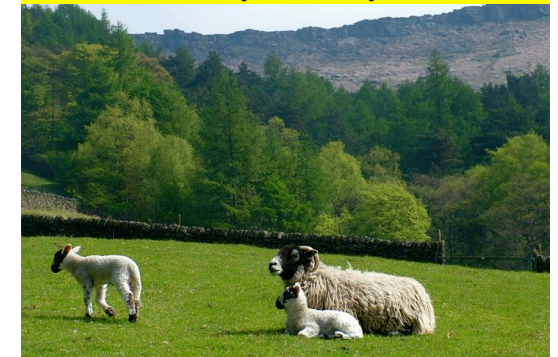
Fewer weeds in arable fields

Conversion of heathland into arable land, development

Increasing urbanization Etc. Etc.

Overall effect is to reduce forage and habitat for bees

British Countryside—Any Flowers?



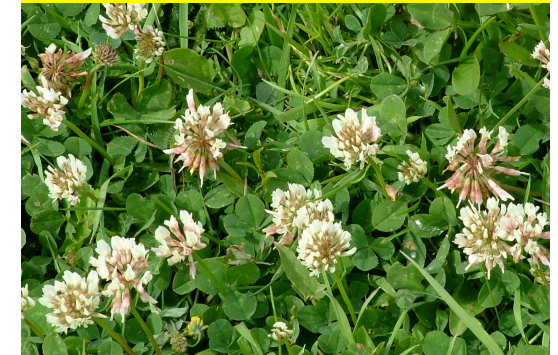
Intensification: Loss of Heather



Fewer Flowers in Grazing Land



Less Clover More Chemical Fertilizer



Fewer Weeds: Poppies in Oil Seed Rape



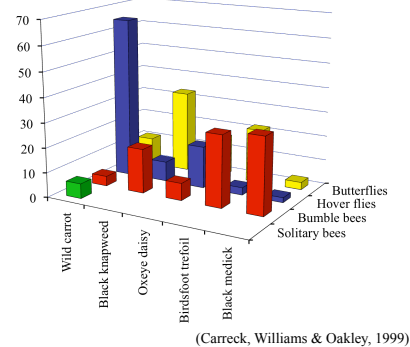
New Crops with Flowers: Rape



Wheat Field With Buffer Strip



Insects on Grass + Wild Flower Mixture



Seminar 3

What Can We Do to Help Bees and Pollination: Scientists and the Public

Laboratory of Apiculture & Social Insects

Sussex University

LASI, Sussex University, Founded June 2008



LASI Researchers Spring 2010

Lab Leader		<div>Bees ** 100% * part</div>
Prof. Francis Ratnieks		
Postdocs & Researchers		
Dr. Karin Alton**	Denmark/England	
Dr. Margaret Couvillon**	USA	
Dr. Christoph Grüter*	Switzerland	
Dr. Jelle van Zweden*	Netherlands	
Mr. Norman Carreck**	England	
PhD Students		
Mr. Gianluigi Bigio**	Italy	
Mr. Tommy Czaczkas	England	
Mr. Sam Jones	England	
Mr. Martin Kärcher**	Austria	
Ms. Fiona Riddell**	Scotland	
Undergraduate Project Students & Volunteers Amanda Kuepfer, Laura Rosario, Buffy Harris-Jones, Samantha MacKenzie**, Thomas Durance, Keeley Taylor, Sarah Hudson** (volunteer)		

LASI Goals

- Research**
To carry out basic and applied research on honey bees and social insects.
- Teaching**
To train the next generation of honey bee and social insect scientists.
- Community**
To extend knowledge to beekeepers and others.
To play an active role in the public communication of science.
- Conservation**
To help honey bees and other social insects.

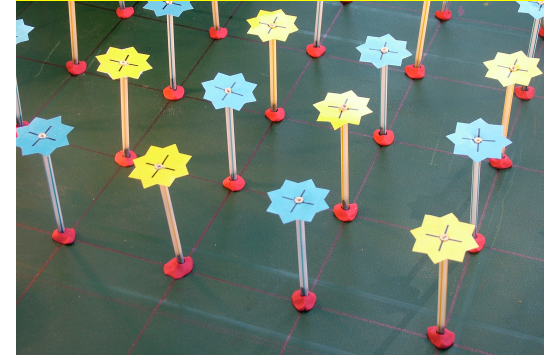
Training Bee Scientists: Undergrads



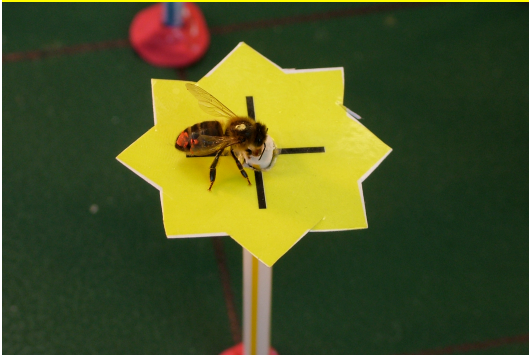
Undergraduate Project: Flower Constancy



Undergraduate Project: Flower Constancy



Undergraduate Project: Flower Constancy



Training Bee Scientists: PhD Students



Training Bee Scientists: Postdocs



Media Links



Bee Farmers Association Visit



Bryanston School, Dorset



St. Joseph's Kindergarten, Brighton



Friends of Kew Gardens



Caroline Lucas MEP



And You!

How can the people here today help?

Helping Honey Bees The Sussex Plan for Honey Bee Health & Well Being

www.sussex.ac.uk/lasi

Sussex Plan

started October 2008

4 projects, 2 started

6 additional personnel so far

3 researchers

1 PhD student

2 PhD students to start in next few months

also 5 undergraduates & 1 volunteer

Full Cost c. £2 million

Raised c. £750,000 (all from benefactors)

Funding for the Sussex Plan



c. 40 Donors & Benefactors

Major Donors

Rowse Honey Ltd.

Burt's Bees

Waitrose

Nineveh Charitable Trust

Body Shop Foundation

BBKA

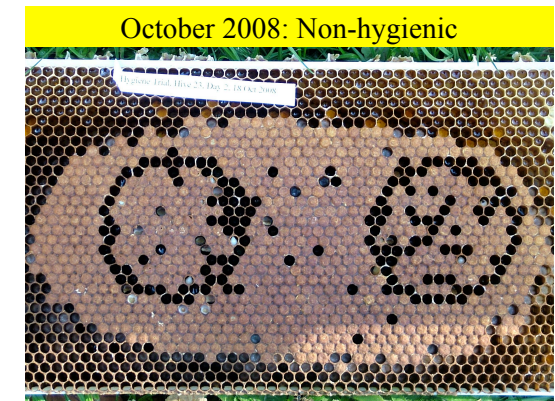
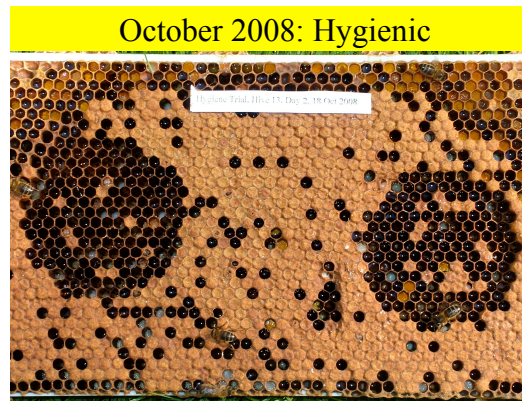
Mr. Michael Chowen

Mr. David Reed

Bee Health

Screening Hives for Hygiene





Screening of Hives Trial 3 July 2009



How Will the Project Help

Disease resistance
Brood diseases
Varroa

Breeding stock for beekeepers

Conservation on native honey bee

Initiate honey bee breeding in general

Apistan Resistant Varroa Mites



Some Other Varroa Control Methods

Method	Time of Year to Apply
Hygiene	when requeening
Trapping in drone cells	spring
Essential oils (e.g., thymol)	summer
Organic acids	
formic acid	summer
oxalic acid	autumn

3-Factor Test of Varroa Control Methods

Trapping	Thymol	Oxalic acid	No. hives
Yes	Yes	Yes	10
Yes	Yes	No	10
Yes	No	Yes	10
No	Yes	Yes	10
Yes	No	No	10
No	Yes	No	10
No	No	Yes	10
No	No	No	10
Total			80

Aim: to determine which combinations of methods are collectively effective at keeping Varroa at low levels

Bee Well Being

How Good is the British
Countryside for Honey Bees?

Decoding Dances to Determine
where Worker Honey Bees are
Foraging

Worker Honey Bee on Borage



Waggle Dance



Observation Hive & Video Camera



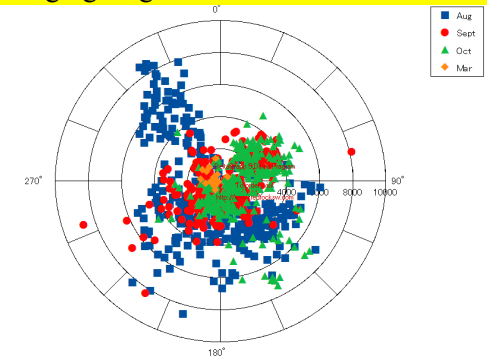
Decoding Dances Using iMovie



University & Surroundings



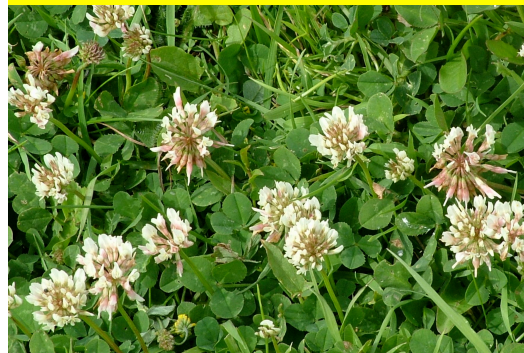
Foraging Aug-Oct 2009 & March 2010



English Towns—Lots of Flowers?



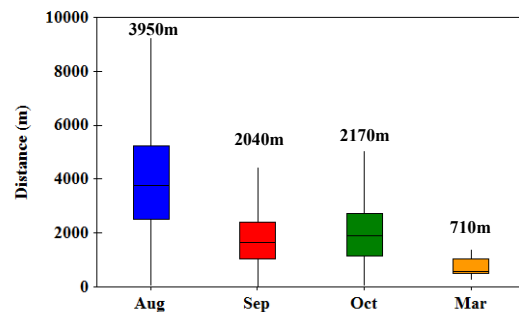
Pasture with Clover



March: Early Garden Plants



Foraging Aug-Oct 2009 & March 2010



How Will the Project Help

Information for people who can help honey bees and insects

Land managers, farmers, parks departments, gardeners etc.
Wildlife friendly farming schemes

Distance

Months when forage is more or less abundant

Locations

The bees tell us the habitats they favour
Urban v Rural
Different types of farmland

Benefits to other species

Where honey bees forage so do other bees and insects

Bee Well Being

Helping Honey Bees in Urban Areas

Helping Honey Bees in Urban Areas

PhD Studentship

Funded by Body Shop Foundation; Mr. Mihail Garbuzov to start July

Aims

Which garden and park plants are good for honey bees & other insects
compare lavender varieties
see what is already grown and which is good forage
trees

Develop an apiary design that minimizes contact with neighbours
keeping bees in gardens, allotments

Links

Local park departments (e.g., Brighton & Hove)
Plant nurseries (e.g., Downderry Nursery)
Kew/Wakehurst etc.

Comparing Lavender Varieties



...and Also Help Other Insects



Working Together to Help Bees

Who is Here & How Can They Help?

Educationalists

Teaching children

Media

Informing the public; debate

Land Managers

Bee friendly plantings in urban areas

Farmers & Growers

Bee friendly plantings in the countryside
Providing plants

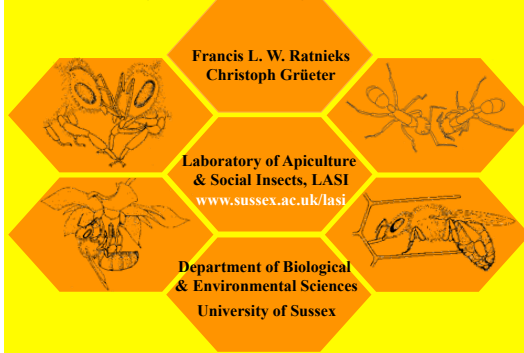
Councils & Government (e.g., South Downs Park; Politicians)

Strategy and resource allocation; "joined up" government

St. Joseph's School, Brighton



Watching Bees Forage and Pollinate



Wild Flower Pollination



A honey bee worker visiting a bramble flower. The honey bee, *Apis mellifera*, is a native British species and pollinates wild flowers as well as garden flowers and crops.

Worker Honey Bee on Borage



Bumble Bee Covered in Pollen



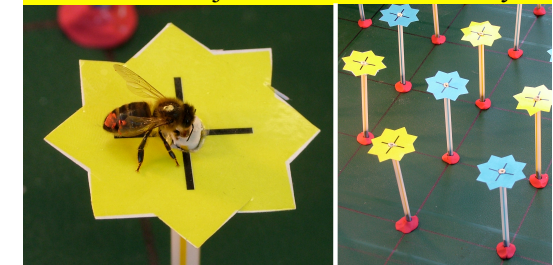
As it forages, a bee's hairy body gets covered in pollen. The bee combs its body with its legs, moving pollen into a storage location. The location varies among bees. In bumble bees and honey bees, it is the pollen basket.

Nectar Guides: Eyebright & Azalea

Many plants have markings, known as nectar guides, that help the bee orient its body to collect nectar, and inadvertently to pollinate the plant. Nectar guides are sometimes in ultra violet, a colour humans cannot see.



Research Project on Flower Constancy



A worker honey bee on an artificial flower in a project on "flower constancy". That is, the tendency of bees to visit only one type of flower. Even a single nectar reward causes the bee to become very constant to the trained colour in its next visits in an array of blue and yellow flowers.

Plants Communicating to Insects Via Colour



Some plants retain pollinated flowers to act as a long range signal or landing platform. The pollinated flowers, which no longer provide nectar, may change colour and bees quickly learn to avoid them. By changing colour, the plant is more attractive as the bees can forage more efficiently. In both Lantana (left) and horse chestnut, yellow/cream means nectar.

Showing Honey Bees Have Colour Vision



New Paper, New Locations. Choose Yellow



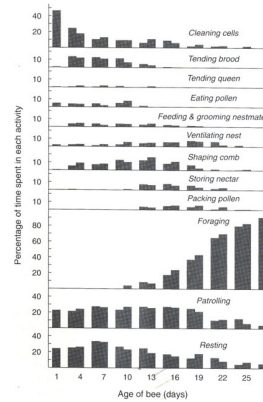
Karl von Frisch showed that bees have colour vision by this simple experiment. A syrup feeder was placed on a coloured background. The feeder was then moved to a new location onto a fresh piece of paper. The bees landed on the new paper in the new location. Grey backgrounds were also used to show the bees recognized colour, not shade of grey.

Honey Bee Behaviour As Seen In An Observation Hive

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Karin Alton

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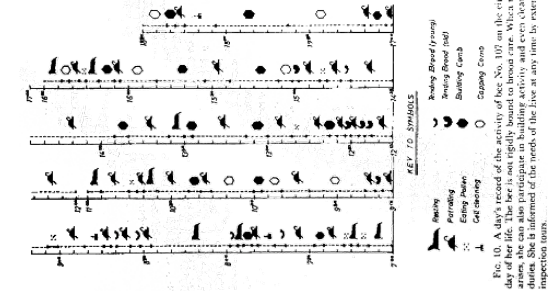


Age & Task in the Honey Bee

Data collected from a group of worker honey bees shows clearly how the work tasks performed change with age. Some clear patterns are:

1. Cleaning cells is the first task
2. Tending brood (nursing) and eating pollen by young bees
3. Somewhat older bees handle food, shape comb
4. Foraging by oldest bees
5. A lot of time spent by bees of all ages in walking round nest (patrolling) and resting

A Day in the Life of a Worker Bee



A day in the life of worker honey bee 107. Lindauer M. 1961. Communication among social bees. Harvard UP.

Queen Honey Bee Laying an Egg



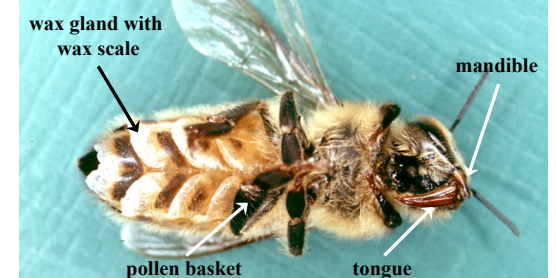
A honey bee queen can lay up to 2000 eggs per day. Before laying an egg, she puts her head into the cell to check the cell size and whether the cell is empty. She then inserts her abdomen (above), and lays an egg which attaches to the hexagonal base of the cell. The queen is surrounded by a court of workers who feed her and monitor her presence.

Emerging Worker Honey Bee



A worker honey bee emerging from her cell. She is silvery in colour. The first job she does is cell cleaning. In the honey bee cells are reused.

Wax Glands of Worker Honey Bee



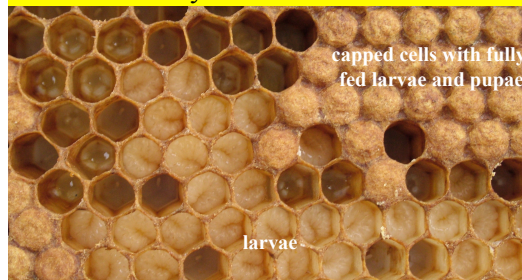
A worker honey bee has four pairs of wax glands on the underside of the abdomen. These can be seen as V-shaped light coloured bands. In this bee, the wax glands have thick scales of wax, ready for use. This photo also shows the bee's pollen basket, tongue and mandibles.

Undertaker Bee



Some tasks, such as undertaking (above: removing worker corpse from nest) are not performed by all workers because there is little work to do.

Honey Bee Worker Cells



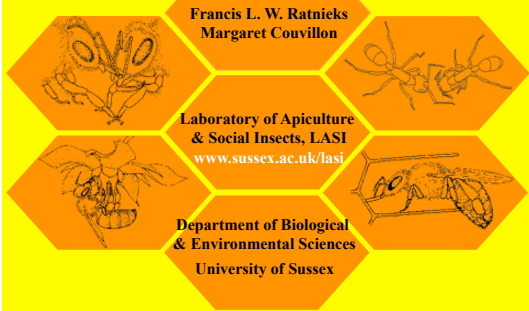
Honey bee cells can be used for rearing brood and storing food (nectar, honey, pollen). The cells above contain nectar, eggs, larvae, and pupae. When a larva is fully fed, the worker bees cap the cell with wax.

Water Collecting Worker Honey Bee



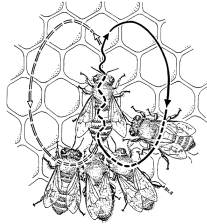
An African honey bee worker from Brazil collecting water. The tongue compound eyes, antennae, pollen basket and hairs can be seen.

The Honey Bee Dance Language (Bees Telling You Where They Are Foraging)



Karl von Frisch: Honey Bee Waggle Dance

Dancing bee (a successful forager)

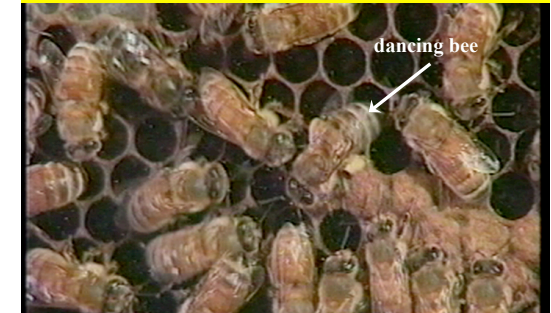


Dance following bees (unemployed foragers)



Karl von Frisch, an Austrian scientist who worked for many years at the University of Munich, discovered the honey bee waggle dance. In 1973 he was awarded the Nobel Prize for Physiology for this discovery.

Waggle Dance



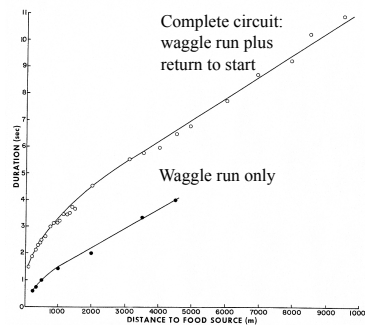
Dancing bee, with pollen on legs, and dancer followers on vertical comb. Not all foragers dance. Only those who are working a good food source.

Observation Hive & Video Camera



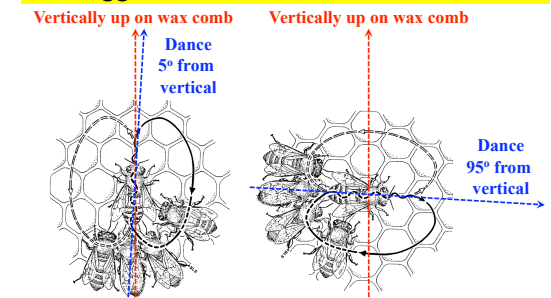
An observation hive with camera and monitor. The bees forage outside, via a plastic pipe. An observation hive has only one layer or comb versus several in a natural nest, to see everything going on. An observation hive is normally managed to have a smaller population than in a normal hive.

Waggle Dance: Distance Information



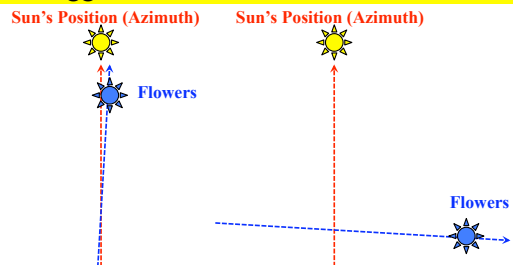
The slower the dance, the greater the distance to the patch of flowers being advertised by the dance. The distance information is encoded in the "waggle run" part of the "figure of 8" dance. A dancing bee may make from 1 to 100 dance circuits. The better the food source she has discovered, the more circuits she makes. Only the foragers working good patches dance.

Waggle Dance: Direction Information



Bees dance on the vertical comb. If a bee makes a waggle run vertically up on the comb, this means that the flowers are in the direction of the sun. Bees give direction relative to the sun.

Waggle Dance: Direction Information



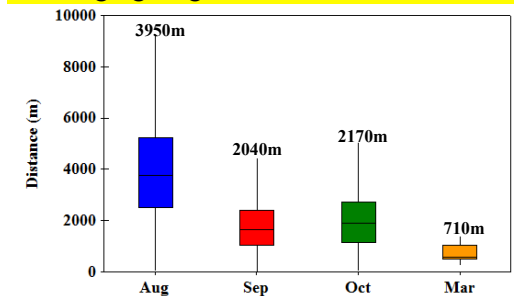
When the dance following bees leave the nest, they use the dance information to tell them the direction and distance to the flowers. The direction is given by translating the angle of the dance relative to vertical, to the angle of the flowers relative to the sun.

Decoding Dances Using iMovie



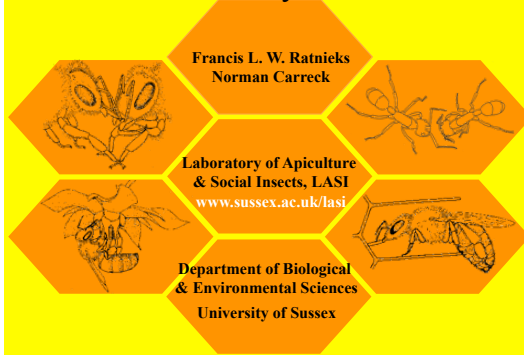
Decoding dances takes a lot of time. Dances are decoded from videos downloaded to computers using. We use the length of the waggle run to give the direction information. We decode four waggle runs per dance. We measure the angle of the dance with a protractor. Plumb lines on the observation hives give vertical lines that are easily seen on the video.

Foraging Aug-Oct 2009 & March 2010



Our results so far show that honey bees have to travel greater distances to find flowers in the summer than in autumn or spring.

Bee Biodiversity & Structure

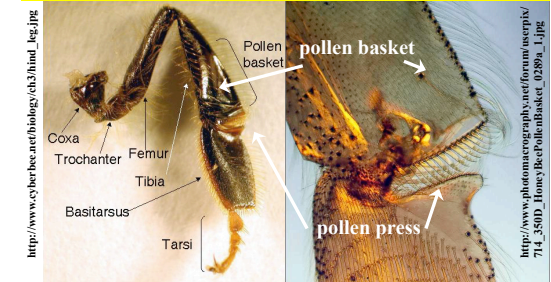


Families of British Bees

- Colletidae**
- Andrenidae**
Mining bees
- Halictidae**
Sweat bees*
- Megachilidae**
Leaf cutter bees, mason bees
- Anthophoridae**
Wool carder bee
- Apidae**
Honey bee**, bumble bees**

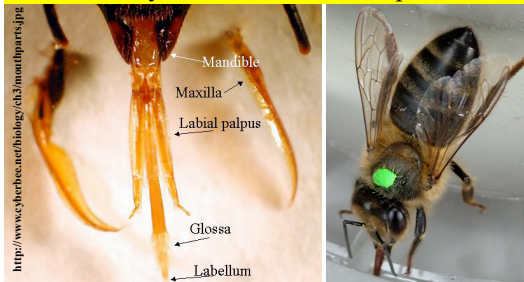
All eusocial**, some eusocial* (= colony with queen and workers)

Honey Bee Worker Hind Leg



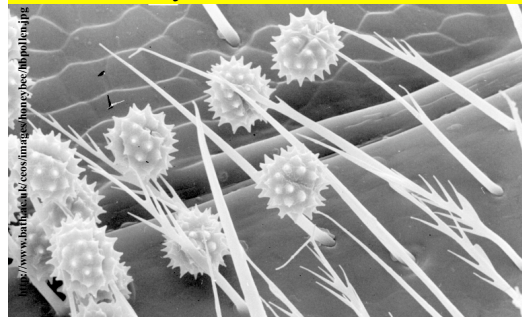
A honey bee worker has two pollen baskets, one on each hind leg. The basket or corbula is on the tibia, which is flattened and surrounded with long setae (hairs). Queen and drone honey bees do not have a basket. The pollen press pushes pollen combed from the body into the basket.

Honey Bee Worker Mouthparts



A honey bee worker has a long tongue, glossa, and other mouthparts. The jaws, mandibles are used for picking things up, biting, and for fashioning wax into cells. Tongue length in pollinating insects varies greatly, and affects the plants from which the insect can collect nectar.

Worker Honey Bee Plumose Hairs & Pollen



Some of the hairs on the body of a worker honey bee. The hairs are branched, plumose, and pollen grains become trapped in the hairs.

Megachilidae: Scopa Under Abdomen



A bee in the family Megachilidae. In these bees the pollen storage organ, scopa, is on the underside of the abdomen and comprises long hairs.

Halictidae: Halictus scabiosae



A bee in the family Halictidae. The pollen storage area, scopa, is extensive, both on the underside of the abdomen and on the hind legs.

Anthophoridae: Anthidium manicatum



The wool carder bee *Anthidium manicatum*, family Anthophoridae. This is a spectacular solitary bee. Males are larger than females and guard flowers that the females visit. Females have to mate with the male to forage. The lambs ear plant, *Stachys byzantia*, is attractive to the wool carder bee. It has flowers, and plant hairs for nest building.

Andrenidae: Andrena fulva



There are over 60 species of *Andrena* bees, family Andrenidae, in Britain. Known as mining bees, they build nests in the ground often in aggregations. The tawny mining bee *Andrena fulva* is common in spring. It is larger than a honey bee, and almost bumble bee like in appearance.