3rd European Congress on Social Insects

St. Petersburg, Russia, 22–27 August 2005

PROCEEDINGS

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International Union for the Study of Social Insects
Russian Language Section

3rd European Congress on Social Insects

(Meeting of European Sections of the IUSSI)
St. Petersburg, Russia, 22–27 August 2005

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Edited by
Vladilen E. Kipyatkov

Euro IUSSI ~ 2005

St. Petersburg
2005

Euro IUSSI - 2005

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Dear Colleagues,

We are happy to welcome you at the 3rd European Congress on Social Insects (Meeting of European Sections of the IUSSI) in St. Petersburg University – the eldest University in Russia, founded in 1724 under the decree of Peter the Great along with Russian Academy of Sciences and the Academic Gymnasium. The Congress will be held in *The University Conference Centre* which is situated next to the Main Building of the University (see the map on the next page). The building of the Centre houses the conference hall, the restaurant (open until 20:00), bar (open until 20:00), café (open until 18:00) and student canteen (open until 18:00). The opening of the Congress and the first session on Monday 22 August will take place in the conference hall on the second floor of the University Centre.

The Congress will traditionally include plenary invited lectures, symposia organised by leading experts, sessions of offered talks, evening session and poster presentations, as well as many social events including welcome party, concert, excursions and banquet. Special everyday programme for accompanying persons and optional post congress excursions will be also organised.

We would like to thank all the people who have helped us to organise and to carry out this meeting. The Organising Committee hopes that you will have an enjoyable week at the Congress and have an opportunity to see interesting sites of St. Petersburg and its environs.

Vladilen Kipyatkov and Elena Lopatina, Main Organisers

International Organising Committee

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Information for contributors

The invited plenary lectures will be 50 minutes long plus 5 minutes for questions and discussion. The symposia talks will be 15–25 minutes long including time for questions and discussion according time allocation between speakers elaborated by symposia organisers (see Programme). The talks offered for open sessions will be 20 minutes long plus 5 minutes for discussion. The PC computer digital projectors will be available in each lecture hall. The computers will read standard CDs with MS Power Point XP 2002 or earlier presentations.

We request all speakers come to the main lecture hall of the University Conference Centre (second floor) during dinner time (19:00–20:00) the previous day before their talks to put their presentations on the computer and to do a technical check.

Poster presentations. The space allowed for each poster is 100 cm wide and 125 cm high (sufficient for A0 paper). Pins will be provided. Posters will be on display during the entire meeting but special poster session will be organised on Wednesday 24 August from (see p. 11). The poster numbering in the List of Poster Presentations corresponds to the numbers of poster boards provided. Please, set your poster on the board with corresponding number. Poster authors are requested to stay near their posters during the poster session.

Social Events

- **Guided Bus Tour** all over the city of St. Petersburg and to local attractions. Monday 22 August, 14:30–17:30.
- **Concert of an Ensemble of Russian Folk Instruments.** Monday 22 August, 18:00–19:00, Main Lecture Hall of the University Conference Centre (on the second floor).
- **Welcome Party.** Monday 22 August, 19:00–22:00, at the restaurant of the University Conference Centre. At 22:00 the buses will depart from the University Conference Centre to get the participants back to their hotels and hostels
- **Joint photographing of the participants.** Wednesday 24 August, 14:10. Near the monument to Mikhail Lomonosov (*No 1 on the map of St. Petersburg University Campus, see p. 6*).
- **Congress Banquet.** Friday 26 August, 19:30–23:00. The Russian Folk Restaurant "Podvorye" (Pavlovsk). The cost of the banquet is 50 EUR including the costs of bus transportation of the participants from the congress venue to the restaurant and from the restaurant to the accommodation places after the banquet. Banquet will be accompanied by a remarkable performance of a Russian folklore ensemble. According to an old Russian tradition the quantity of alcohol drinks (Russian vodka, white and red wines) served during the banquet will be unlimited. Note, please, that you may order additional dishes from the restaurant carte at your own expense. The buses will depart from the University Conference Centre to transport the participants to Pavlovsk at 18:00. At 23:00 the buses will depart from the restaurant to get the participants back to their hotels and hostels. Tickets for the banquet will be on sale in the Secretariat until the lunch time of Thursday 25 August.
- **Post Congress Tours:**

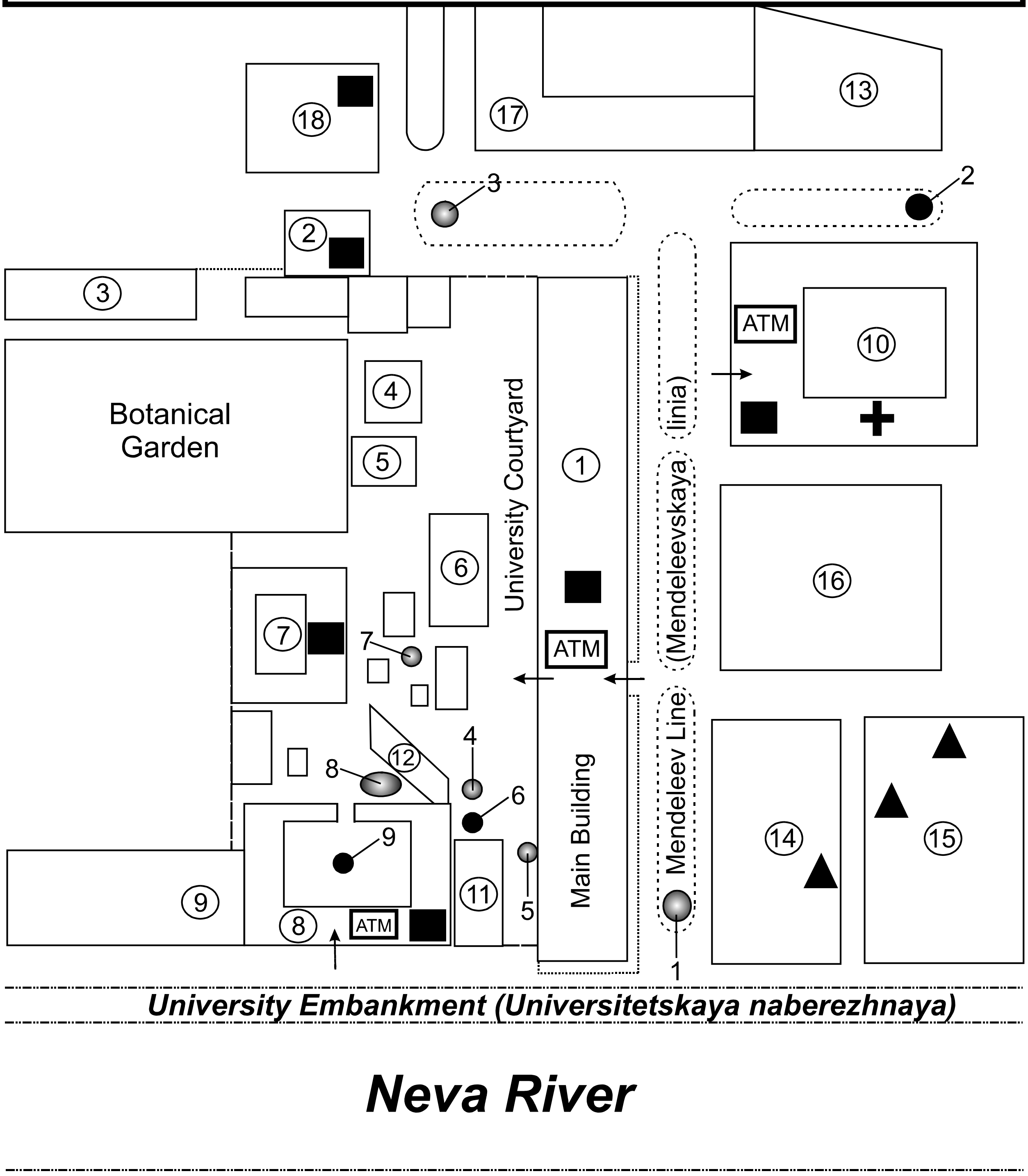
Saturday 27 August – Full-day tour to the suburb town Peterhof (so-called *Russian Versailles*), visits to Grand Palace built for Peter the Great in 1715 and to beautiful parks with numerous fountains, sculptures, smaller palaces and pavilions.

Sunday 28 August – Full-day tour to the suburb town Pushkin (old name *Tsarskoye Selo*), a residence of Russian Emperors. An excursion to Catherine Palace with recently restored Amber Room, to Catherine Park and other attractions.

Monday 29 August – Full-day tour to the suburb town Pavlovsk, a residence of Russian Emperors, with an excursion to the Royal Palace and the walk all over the old and large park where there are several lakes and ponds with the facilities for rowing and catamaran sailing.

(The tours costs and other details have been described in the *Final Circular*)

St. Petersburg University Campus



■ – Cafes & Canteens

▲ – Restaurants

● – Monuments and Arts

✚ – Medical Service

ATM – Automatic Teller Machine
(Cash machine)

→ – Entrances

See Legend on the next page

St. Petersburg University Campus
(Legend)

University Buildings (1–13):

1 – Main Building (originally Twelve Collegia Building constructed between 1722 and 1742 by Domenico Trezzini to house Russia's supreme government ministries – the Senate and the *collegia* instituted by Peter the Great) – *see the next page for details.*
2 – The University Conference Centre (originally Student Canteen built in 1902 to replace the first student canteen in Russia constructed at the end of XIX century in another place; the building was restored in 1999)
3 – Mendeleev Centre (the former Faculty and Institute of Chemistry)
4 – Department of Genetics
5 – Department of Botany
6 – Faculty of Geology (the former Institute of Physics)
7 – University service offices
8 – Faculty of Philology
9 – Faculty of Oriental Sciences
10 – Faculty of History and Faculty of Philosophy
11 – “Rector's House” (birthplace of Russian poet Alexander Blok)
12 – Department of Physical Training and Sports (originally “Jeu de Paume” – “House for Ball Games”, the first covered construction for sport games in Russia, built in 1793)
13 – Faculty of Psychology

Other Buildings and Museums (14–18):

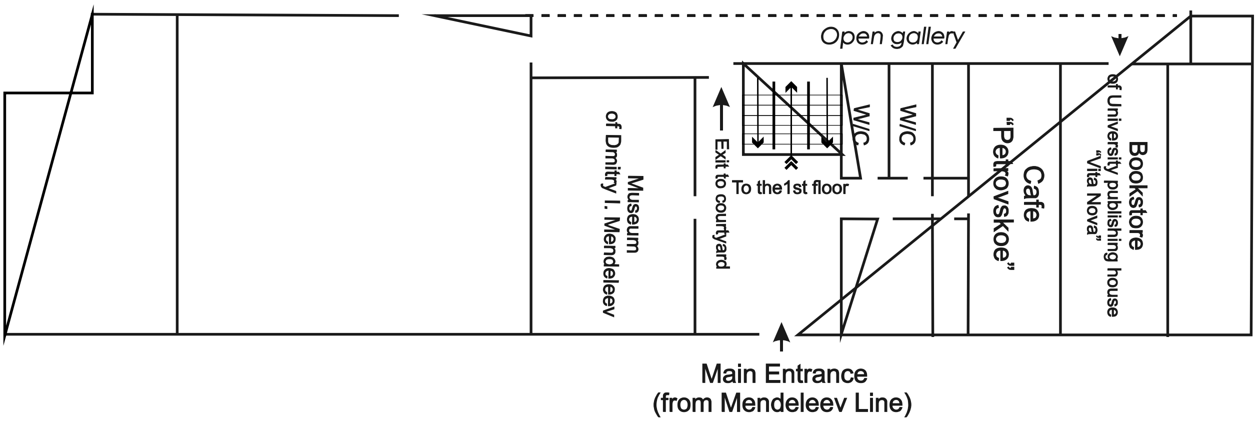
14 – Main Building of Russian Academy of Sciences in St. Petersburg
15 – Museum of Anthropology and Ethnography (the former Kunstkammer found by Peter the Great)
16 – Institute of Gynaecology
17 – Library of Russian Academy of Sciences
18 – State Institute of Optics

Monuments and Arts (1–9):

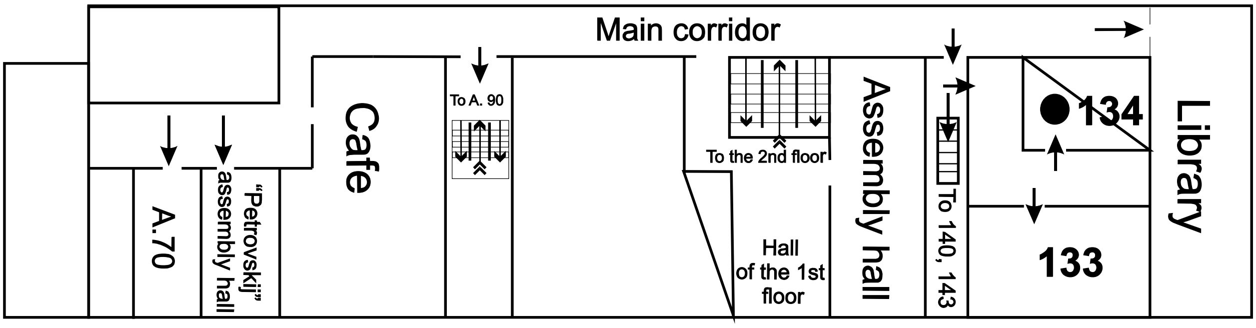
1 – Monument to Mikhail Lomonosov (1711–1765, the first Russian student of natural sciences, member of Russian Academy of Sciences, eminent poet, historian, painter etc.)
2 – Monument to Ivan Pavlov (1849–1936, the world-famous Russian physiologist)
3 – Monument to Andrei Sakharov (1921–1989, the “Farther” of Soviet H-bomb and the modern democratic developments of the late Soviet times)
4 – Monument to the University Members perished during the Second World War
5 – Monument to the Victims of Soviet Political Repressions in the University
6 – Garden of Hefsimania (scriptural place)
7 – Monument to Cat (erected by thankful physiologists of the University)
8 – Labyrinth (made of stones presented by the universities from all over the world), Unicorn, Canons etc.
9 – The courtyard of the Faculty of Philology with a lot of sculptures and modern arts

Main Building of St. Petersburg University

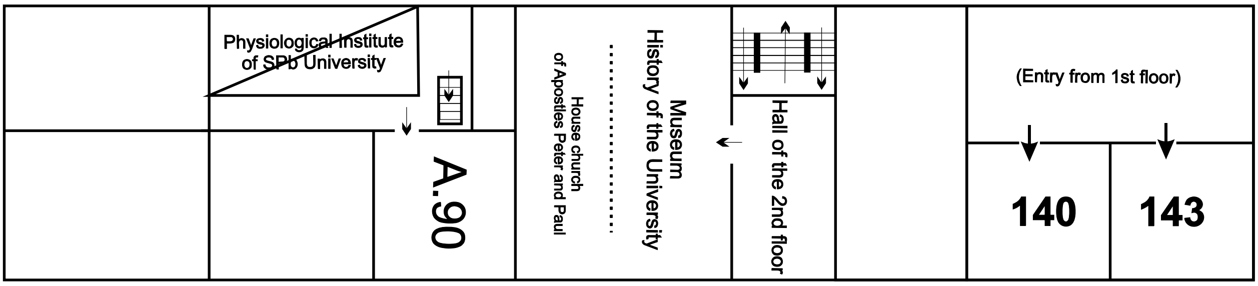
Ground floor



First floor



Second floor



Lecture Halls: 133, 140, 143

● - Congress Secretariat
(Room 134)

3rd European Congress on Social Insects

St. Petersburg, Russia, 22–27 August 2005

St. Petersburg State University

PROGRAMME

Monday 22 August

	The University Conference Centre
9:00–9:30	**Opening ceremony**
9:30–10:25 *Plenary lecture*	**Adrian M. Wenner** (*University of California*): Odor and honey bee exploitation of food crops . . . . p. 33
10:25–11:05	***Coffee Break***
11:05–13:00 *Plenary lecture*	**Sumio Tojo, Sintaro Nomakuchi, Mantaro Hironaka & Lisa Filippi** (*Saga University*): Physiological and behavioural adaptation of a subsocial shield-bug, *Parastrachia japonensis*, that allow it to survive on the drupes of its sole host plant available only two weeks a year . . . . p. 35
13:00–14:15	***Lunch***
14:30–17:30	Guided bus tour all over the city of St. Petersburg
18:00–19:00	Concert: Ensemble of Russian Folk Instruments
19:00–22:00	Welcome Party
22:00	*The buses will depart from the University Conference Centre to get the participants back to their hotels and hostels*

Tuesday 23 August

	The University Conference Centre
8:45–9:40 *Plenary lecture*	**Mandyam Srinivasan, Shaowu Zhang, Judith Reinhard & Javaan Chahl** (*Australian National University*): Small brains, smart minds: Vision, navigation and 'cognition' in honeybees . . . . p. 37
9:40–10:20	***Coffee Break***

Main Building:	**Lecture Hall 133**	**Lecture Hall 140**
10:20–12:50 *Two symposia concurrently*	**S1:** Learning and memory in social systems (*first part*)	**S2:** The molecular bases of social behaviour and sociality

	The University Conference Centre
12:50–14:00	***Lunch***
14:00–14:55 *Plenary lecture*	**Mark J. F. Brown** (*Trinity College, Dublin*): The ecology of social insects and their parasites . . . . p. 37
14:55–15:50 *Plenary lecture*	**Jozef Šimúth, K. Bíliková, S. Hennig & H. Lehrach** (*Institute of Molecular Biology, Bratislava*): Functional genomics of royal jelly proteins and antimicrobial peptides of honeybee *Apis mellifera* L. . . . . p. 38
15:50–16:30	***Coffee Break***

Main Building:	**Lecture Hall 133**	**Lecture Hall 140**	**Lecture Hall 143**
16:30–19:00 *Three symposia concurrently*	**S1:** Learning and memory in social systems (*second part*)	**S3:** The multifaceted functions of cuticular hydrocarbons in social insects	**S4:** Biodiversity of honeybees (16:30–18:00) **Open Session 1:** Contributed oral presentations (18:10–19:00)

19:00–20:00	***Dinner*** *(At the University Conference Centre)*

Wednesday 24 August

	The University Conference Centre
8:45–9:40 *Plenary lecture*	**Yves Roisin** (*Université Libre de Bruxelles*): Origin, function, and ecological significance of termite workers . . . . p. 40
9:40–10:20	***Coffee Break***

Main Building:	**Lecture Hall 133**	**Lecture Hall 140**	**Lecture Hall 143**
10:20–12:50 *Three symposia concurrently*	**S5:** Aspects of termite phylogeny and evolution (*first part*)	**S6:** Perception, 'cognition', and social behaviour (*first part*)	**S7:** Thermoregulation of honeybee colony (10:20–11:35) **S8:** Multiplication of honeybee colonies by swarming (11:35–12:50)

	The University Conference Centre
12:50–14:00	***Lunch***
14:00–14:20	Joint photographing

Main Building:	**Lecture Hall 133**	**Lecture Hall 140**	**Lecture Hall 143**
14:25–15:40 *Three symposia concurrently*	**S5:** Aspects of termite phylogeny and evolution (*second part*)	**S6:** Perception, 'cognition', and social behaviour (*second part*)	**S9:** Optimisation and regulation of work in social insects (*first part*)
15:40–16:30	***Coffee Break*** *(At the University Conference Centre)*		
Main Building:	**Lecture Hall 133**	**Lecture Hall 140**	**Lecture Hall 143**
16:30–19:00 *Three symposia concurrently*	**S10:** Honeybee as new model for functional genomics	**S11:** Conservation biology of social insects	**S9:** Optimisation and regulation of work in social insects (*second part*)
19:00–20:00	***Dinner*** *(At the University Conference Centre)*		

Thursday 25 August

	The University Conference Centre		
8:45–9:40 *Plenary lecture*	**Susanne Foitzik, Miriam Brandt, Birgit Fischer-Blass** (*Ludwig Maximilians Universität München*): Patterns of coevolution and local adaptation in slavemaking ants . . . . p. 42		
9:40–10:20	***Coffee Break***		
Main Building:	**Lecture Hall 133**	**Lecture Hall 140**	**Lecture Hall 143**
10:20–12:50 ***Three symposia concurrently***	**S12:** Visually guided behaviour in social insects	**S13:** Diseases and parasites in social insects	**S14:** Ecology of social insects
	The University Conference Centre		
12:50–14:00	***Lunch***		
14:00–14:55 *Plenary lecture*	**Gennady Dlussky** (*Moscow State University*): Paleontological history of ants and the evidences of Afrotropical origin of Myrmicinae . . . . p. 43		
14:55–15:20 *Invited talk*	**Kazuo Ogata, M. Kubota, C. Suzuki, T. Takahashi & K. Masuko** (*Kyushu University*): Ants from Cretaceous amber of Japan . . . . p. 124		
15:20–19:00	Poster session (*tee and coffee will be served*)		
18:00–19:00	***Dinner***		
19:00–22:00 *Evening Session*	Episodes in the History of Insect Sociobiology: Directed Reminiscences (*led by Christopher Starr, University of the West Indies*) (Russian beer and soft drinks will be served during the session)		

Friday 26 August

	The University Conference Centre		
8:45–9:40 *Plenary lecture*	**Dave Goulson** (*University of Southampton*): Decline and conservation of bumblebees . . . . p. 44		
9:40–10:20	***Coffee Break***		
Main Building:	**Lecture Hall 133**	**Lecture Hall 140**	**Lecture Hall 143**
10:20–12:50 *Three symposia concurrently*	**S15:** Exploitation of food sources in social insects: foraging, recruitment, and communication mechanisms (*first part*)	**S16:** Social insects and their macroparasites	**S17:** Can European honeybees coexist with *Varroa* mites?
12:50–14:00	***Lunch*** *(At the University Conference Centre)*		
Main Building:	**Lecture Hall 133**	**Lecture Hall 140**	**Lecture Hall 143**
14:00–16:00 *Three symposia concurrently*	**S15:** Exploitation of food sources in social insects: foraging, recruitment, and communication mechanisms (*second part*)	**Open Session 2:** Contributed oral presentations	**S18:** Honey bees and social insects on the web (*round table discussion*)
16:00–18:00	"Technological break" – for the participants who wish to get back to their hotels to drop their bags and get changed for the banquet Meanwhile tee and coffee will be served *from 16:30 to 17:30* in the University Conference Centre for those who prefer to stay at the University		
18:00	*The buses will depart from the University Conference Centre to transport the participants to Pavlovsk*		
19:30–23:00	***Congress Banquet in the Russian Folk Restaurant "Podvorie" (Pavlovsk)***		
23:00	*The buses will depart from the restaurant to get the participants back to their hotels and hostels*		

Saturday 27 August & Sunday 28 August

Post Congress Tours

(see p. 5)

List of Plenary Lectures

Monday 22 August, 9:30–13:00 **Chair: Vladilen Kipyatkov**

Adrian M. Wenner (*University of California, USA*): Odor and honey bee exploitation of food crops .... p. 33

Sumio Tojo, Sintaro Nomakuchi, Mantaro Hironaka & Lisa Filippi (*Saga University, Japan*): Physiological and behavioural adaptation of a subsocial shield-bug, *Parastrachia japonensis*, that allow it to survive on the drupes of its sole host plant available only two weeks a year ...... p. 35

Tuesday 23 August, 8:45–9:40 **Chair: Adrian M. Wenner**

Mandyam Srinivasan, Shaowu Zhang, Judith Reinhard & Javaan Chahl (*Australian National University*): Small brains, smart minds: Vision, navigation and 'cognition' in honeybees .... p. 37

Tuesday 23 August, 14:00–15:50 **Chair: Dave Goulson**

Mark J. F. Brown (*Trinity College, Dublin, Ireland*): The ecology of social insects and their parasites .... p. 37

Jozef Šimúth, K. Bíliková, S. Hennig & H. Lehrach (*Institute of Molecular Biology, Bratislava, Slovakia*): Functional genomics of royal jelly proteins and antimicrobial peptides of honeybee *Apis mellifera* L. .... p. 38

Wednesday 24 August, 8:45–9:40 **Chair: Anne-Geneviève Bagnères**

Yves Roisin (*Université Libre de Bruxelles, Belgium*): Origin, function, and ecological significance of termite workers .... p. 40

Thursday 25 August, 8:45–9:40 **Chair: Yves Roisin**

Susanne Foitzik, Miriam Brandt, Birgit Fischer-Blass (*Ludwig Maximilians Universität München, Germany*): Patterns of coevolution and local adaptation in slavemaking ants .... p. 42

Thursday 25 August, 14:00–14:55 **Chair: Vladilen Kipyatkov**

Gennady Dlussky (*Moscow State University, Russia*): Paleontological history of ants and the evidences of Afrotropical origin of Myrmicinae .... p. 43

Friday 26 August, 8:45–9:40 **Chair: Mark J. F. Brown**

Dave Goulson (*University of Southampton, UK*): Decline and conservation of bumblebees ...... p. 44

List of Symposia & Sessions

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Organiser: Randolf Menzel (*Freie Universität, Berlin*)
S2: The molecular bases of social behaviour and sociality . . . . p. 16
Organiser: Guy Bloch (*The Hebrew University of Jerusalem*)
S3: The multifaceted functions of cuticular hydrocarbons in social insects . . . . p. 16
Organiser: Abraham Hefetz (*Tel-Aviv University*)
S4: Biodiversity of honeybees . . . . p. 17
Organiser: Yaacov Lensky (*Hebrew University of Jerusalem*)
S5: Aspects of termite phylogeny and evolution . . . . p. 17
Organisers: Anne-Geneviève Bagnères (Université de Tours), Corinne Rouland-Lefèvre (*BioSol Centre IRD d'Ile de France*) & Paul Eggleton (*The Natural History Museum, London*)
S6: Perception, 'cognition', and social behaviour . . . . p. 18
Organisers: Judith Reinhard & Andrew Barron (*Australian National University*)
S7: Thermoregulation of honeybee colony . . . . p. 19
Organisers: Yaacov Lensky (*Hebrew University of Jerusalem*) & Alexander Komissar (*National Agricultural University, Kiev*)
S8: Multiplication of honeybee colonies by swarming . . . . p. 19
Organiser: Yaacov Lensky (*Hebrew University of Jerusalem*)
S9: Optimisation and regulation of work in social insects . . . . p. 20
Organisers: Karl Crailsheim & Thomas Schmickl (*Karl-Franzens-Universität, Graz*)
S10: Honeybee as new model for functional genomics . . . . p. 20
Organiser: Jozef Simuth (*Institute of Molecular Biology, Bratislava*)
S11: Conservation biology of social insects . . . . p. 21
Organisers: Mark Brown (*Trinity College, Dublin*) & Robert Paxton (*Queens University, Belfast*)
S12: Visually guided behaviour in social insects . . . . p. 21
Organisers: Misha Vorobyev (*University of Queensland*) & Natalie Hempel de Ibarra (*Freie Universität, Berlin*)
S13: Diseases and parasites in social insects . . . . p. 22
Organiser: Ingemar Fries (*Swedish Agricultural University, Uppsala*), Mark Brown (*Trinity College, Dublin*) & Robert Paxton (*Queen's University, Belfast*)
S14: Ecology of social insects . . . . p. 23
Organiser: John Breen (*University of Limerick*)
S15: Exploitation of food sources in social insects: foraging, recruitment, and communication mechanisms . . . . p. 24
Organisers: Stefan Jarau (*University of Ulm*) & Michael Hrncir (*University of Vienna*)
S16: Social insects and their macroparasites . . . . p. 25
Organiser: Patrizia D'Ettorre (*Universität Regensburg, Germany*)
S17: Can European honeybees coexist with *Varroa* mites? . . . . p. 26
Organiser: Ingemar Fries (*Swedish Agricultural University, Uppsala*)
S18: Honey bees and social insects on the web: global communication, regional networks, high school and university education (round table discussion)
Organiser: Malcolm Sanford (*University of Florida*)
S19: Palaeontology and evolution of ants . . . . p. 26
Organisers: Keiichi Masuko (*Senshu University*) & Vladilen Kipyatkov (*St. Petersburg University*)
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Evening Session: Episodes in the History of Insect Sociobiology: Directed Reminiscences . . p. 27

Programmes of Symposia and Sessions

Symposium 1

Learning and memory in social systems

Organiser: Randolf Menzel (*Freie Universität, Berlin*)
Tuesday 23 August – Main University Building: Lecture Hall 133

First Part

10:20–10:30 **Randolf Menzel**: Introduction to the symposium

10:45–11:00 **Thomas Collett, R. Harris, N. Hempel & P. Graham** *(University of Sussex)*: Wood ants use feeding state for the selective priming of navigational memories . p. 46

11:00–11:30 **Galina Udalova** (*Research Centre of Ecological Safety RAS*) **& Anna Karas:** On the capability to conditioned switching in higher social insects .... p. 46

11:30–12:00 **Brian Smith** *(Columbus, USA)*: Inattention and inhibition in honeybee learning

12:00–12:30 **Uli Müller** (*Saarland University*): Memory in honeybees: A network of parallel acting signaling cascades .... p. 47

Second Part

16:30–17:00 **Dorothea Eisenhardt & Nicola Stollhoff** (*Free University of Berlin*): Memory formation after acquisition and retrieval in the honeybee (*Apis mellifera*) . . p. 48

17:00–17:30 **Bernd Grünewald** *(Freie Universität Berlin)*: Ion Channels and Modulations. The cellular physiology of neurons involved in honeybee olfactory learning . . . p. 48

17:30–18:00 **Irene V. Ryzhova, N. G. Lopatina, E. V. Savvateeva, T. G. Zachepilo & E. G. Tchesnokova** (*Pavlov Institute of Physiology RAS*): Excitatory amino acids in memory formation and retention of the honeybee ***(Apis mellifera L.)***: ontogenetic and genetic aspects .... p. 49

18:00–18:30 **Randolf Menzel & Paul Szyszka** (*Freie Universität Berlin*): Watching the bee brain when it learns .... p. 50

Related Poster Presentations (numbers according to the List of Poster Presentations on p. 28):

10. **Anja Froese, M. Karrenbrock & D. Eisenhardt** *(Freie Universität Berlin)*: AmCREB in memory consolidation of the honeybee *(Apis mellifera)* .... p. 139

Symposium 2
The molecular bases of social behaviour and sociality

Organiser: Guy Bloch (*The Hebrew University of Jerusalem*)
Tuesday 23 August – Main University Building: Lecture Hall 140

10:20–10:50	**Charles W. Whitfield, Y. Ben-Shahar, C. Brillet, I. Leoncini, Y. Le Conte, S. Rodriguez-Zas & G. E. Robinson** (University of Illinois): Genomic dissection of behavioral maturation in the adult worker honey bee, *Apis mellifera* ...... p. 51
10:50–11:20	**H. Michael G. Lattorff, Robin F. A. Moritz** *(Martin-Luther-Universität Halle-Wittenberg)* **& R. M.Crewe:** The role of the "thelytoky" locus for reproductive dominance in honeybees Christina M. Grozinger (North Carolina State University): Genomic response to pheromones in the honey bee brain .... p. 51
11:20–11:50	**Christina M. Grozinger** *(North Carolina State University)* Genomic response to pheromones in the honey bee brain .... p. 52
11:50–12:20	**Jana Schlenstedt** (University of Potsdam)**, A. Baumann & W. Blenau**: Molecular and pharmacological characterization of honeybee serotonin receptors ... p. 52
12:20–12:50	**Guy Bloch** (The Hebrew University of Jerusalem): Molecular underpinnings of socially mediated plasticity in circadian rhythms in the honey bee *Apis mellifera* .... p. 53

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37. **Piyamas Nanork** *(Chulalongkorn University, Bangkok, Thailand)*, **J. Parr, N. C. Chapman, S. Wongsiri & B. P. Oldroyd**: Reproductive competition among queenless workers of dwarf honey bee *Apis florea* .... p. 163

Symposium 3
The multifaceted functions of cuticular hydrocarbons in social insects

Organiser: Abraham Hefetz (*Tel-Aviv University*)
Tuesday 23 August – Main University Building: Lecture Hall 140

16:30–16:55	**Abraham Hefetz** (*Tel Aviv University*): The multifaceted role of cuticular hydrocarbons in social insects .... p. 54
16:55–17:20	**Margaret Couvillon & Francis Ratnieks** (*The University of Sheffield, UK*): Sniffing Bees: Universal rejection of wasp intruders by honey bee guards supports hypothesis of overlapping recognition cue distributions between nestmate and non-nestmate bees .... p. 57
17:20–17:45	**Mamiko Ozaki** *(Kyoto Institute of Technology)*, **A. Wada-Katsumata, K. Fujikawa, M. Iwasaki, F. Yokohari, Y. Satoji, T. Nisimura & R. Yamaoka**: Nestmate and non-nestmate discrimination by a CHC-sensitive sensillum in a Japanese carpenter ant .... p. 54
17:45–18:10	**Patrizia D'Ettorre** *(University of Copenhagen*): Queen signal and pheromonal parsimony in a ponerine ant .... p. 55
18:10–18:35	**Stephanie Dronnet & Anne-Geneviève Bagnères** *(University of Tours)*: Genetic and cuticular hydrocarbon variations among and within colonies of a non-aggressive subterranean termite .... p. 56

18:35–19:00 **Katrin Kellner** *(University of Regensburg)*, **P. D'Ettorre, J. Heinze & M. Ayasse**: The metamorphosis of the queen's chemical signature in the ant *Pachycondyla villosa* .... p. 57

Related Poster Presentations (numbers according to the List of Poster Presentations on p. 28):

8. **Christine Errard** *(Université de Tours, France)*, **A.-M. Le Guisquet, J.-P. Christides & A. Hefetz**: Early learning of volatiles chemical cues leads to interspecific tolerance between two ant species .... p. 137

45. **Shiri Shnieor, T. Katzav-Gozansky & A. Hefetz** *(Tel Aviv University)*: Social regulation of reproductive and pheromone plasticity in worker honeybees .... p. 170

Symposium 4
Biodiversity of honeybees

Organiser: Yaacov Lensky (*Hebrew University of Jerusalem*)
Tuesday 23 August – Main University Building: Lecture Hall 143

16:30–16:55 **Ibrahim Çakmak** *(Uludag University, Bursa- Turkey)***:** The biodiversity of honeybee races in Turkey .... p. 58

16:55–17:20 **Alexey Nikolenko** *(Institute of Biochemistry and Genetics, Ufa Scientific Centre of RAS Russia)***:** Gene pool of Black European bee *Apis mellifera mellifera* L. in Ural region .... p. 60

17:20–17:45 **Alexander Komissar** *(National Agricultural University, Kyiv)*: Races of honey bees, human nations and religions .... p. 61

Symposium 5
Aspects of termite phylogeny and evolution

Organisers: Anne-Geneviève Bagnères (Université de Tours), Corinne Rouland-Lefèvre (*BioSol Centre IRD d'Ile de France*) & Paul Eggleton (*The Natural History Museum, London*)
Wednesday 24 August – Main University Building: Lecture Hall 133

First Part

10:20–10:50 **Paul Eggleton, D. Inward & D. Jones** *(The Natural History Museum, London)*: The evolution of termite functional diversity: a global phylogenetic perspective p. 62

10:50–11:10 **Sarah Donovan** *(Plymouth University)*: Phylogenetic information in worker termite gut characters .... p. 65

11:10–11:30 **Daegan Inward** *(The Natural History Museum, London)*: Aspects of termite biology as revealed by a comprehensive new phylogenetic reconstruction .... p. 179

11:30–11:40 Break for discussion

11:40–12:00 **Thomas Lefebvre & C. Rouland-Lefèvre** (*Université Paris XII*): In search of coevolution between *Nasutitermes* and their actinomycete digestive flora .. p. 62

12:00–12:20 **Corinne Rouland-Lefèvre, E. Miambi, F. Rinaut & J. Nguedegbe** *(Laboratoire d'Ecologie des Sols Tropicaux):* Macrotermitinae/fungi co-evolution: new data on other fungi than *Termitomyces* .... p. 65

12:20–12:40 **Natalia V. Belyaeva & Ilya G. Dovgobrod** *(Moscow State University)*: New diagnostic characteristic for the species identification of termites .... p. 63

Second Part

14:25–14:55 **Judith Korb** *(University of Regensburg)*: Workers of lower termites: no altruists, but hopeful reproductives .... p. 63

14:55–15:15 **Laurianne Leniaud, S. Dronnet, M. Kutnik, S. Dupont & A.-G. Bagnères** *(Université François Rabelais de Tours)*: How flexibility of breeding systems in subterranean termites explains their invasive success .... p. 64

15:15–15:35 **Anne-Geneviève Bagnères** *(University of Tours)*, **M. Kutnik, S. Dupont & E. Vargo:** Postglacial recolonization of southwestern Europe by subterranean termites: Genes tell complex story .... p. 66

15:35–15:40 Discussion and the end of symposium

Related Poster Presentations (numbers according to the List of Poster Presentations on p. 28):

29. **Thomas Lefebvre** *(Université Paris XII)*, **N. Châline & A.-G. Bagnères**: Phylogeography of an insular subspecies of termite *Reticulitermes lucifugus corsicus*: from origins to recent expanses on continental coasts .... p. 156

Symposium 6

Perception, 'cognition', and social behaviour

Organisers: Judith Reinhard & Andrew Barron (*Australian National University*)
Wednesday 24 August – Main University Building: Lecture Hall 140

First Part

10:20–10:45 **Matthew Collett** (*Ludwig-Maximilians Universität*) **& Thomas S. Collett:** Integration of multiple sources of information by desert ants navigating familiar routes .... p. 67

10:45–11:10 **Paul Graham & Thomas S. Collett (***University of Sussex***)**: The interaction between spatial memories in the wood ant .... p. 67

11:10–11:35 **Vladimir Kartsev, T. Oganesov & D. Kalinin** (*Moscow State University*): Learning at consequential stages of orientation in bumblebees and paper wasps ... p. 68

11:35–12:00 **Shaowu Zhang** *(The Australian National University):* The learning of rules and concepts by the honeybee .... p. 69

12:00–12:25 **Johannes Spaethe** (University of Vienna), **A. Brockmann & L. Chittka**: How size limits sensory capabilities in bumblebees and why it matters for colony organisation .... p. 70

12:25–12:50 **Andrew B. Barron** *(The Australian National University)*, **R. Maleszka & G. E. Robinson**: Neurochemical dissection of the honeybee dance language .... p. 71

Second Part

14:25–14:50 **Sarah M. Farris** *(West Virginia University):* Insect mushroom bodies and the evolution of sociality: insights from scarab beetles? .... p. 72

14:50–15:15 **Hideaki Takeuchi** *(The University of Tokyo):* Gene expression in honeybee mushroom bodies and its gene orthologues in non-social insects/invertebrates .... p. 72

15:15–15:40 **Charles Claudianos** *(The Australian National University)* **H. Ranson, J. Oakeshott, S. Biswas, J. Reinhard, R. Maleszka & R. Feyereisen***:* Life history and behaviour shape honeybee genome evolution .... p. 73

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14. **Daphna Gottlieb** *(Department of Entomology, The Volcani Center, Israel)*, **A. R. Harari, Y. Lubin, A. Bouskila**: Local mate competition in the female palm stone borer beetle .... p. 143
28. **Alexander Komissar** *(National Agricultural University, Kiev)*: The peculiarities of the honeybee perception of two-coloured near entrance marks .... p. 155

Symposium 7

Thermoregulation of honeybee colony

Organisers: Yaacov Lensky (*Hebrew University of Jerusalem*) & Alexander Komissar (*National Agricultural University, Kiev*)
Wednesday 24 August – Main University Building: Lecture Hall 143

10:20–10:45 **Marco Kleinhenz, B. Bujok, S. Fuchs & J. Tautz** *(University of Würzburg)*: Brood nest incubation strategies in honeybees p.76

10:45–11:10 **Julia Jones** *(University of Sydney)*, **P. Helliwell, M. Beekman, R. Maleszka & B. P. Oldroyd:** Thermoregulation and the effects of rearing temperature on developmental stability and learning and memory in the honey bee, *Apis mellifera* .... p. 77

11:10–11:35 **Alexander Komissar** *(National Agricultural University, Kiev)*: Thermoregulation of honey bees in winter by means of vertical movement in the hives with vertical gradient of temperature .... p. 78

11:35–12:00 **Yaacov Lensky** *(Hebrew University, Israel)*: Thermoregulation of honeybee (*Apis mellifera* L. Spin.) colonies during summer and winter in the Subtropics .. p. 74

Symposium 8

Multiplication of honeybee colonies by swarming

Organiser: Yaacov Lensky (*Hebrew University of Jerusalem*)
Wednesday 24 August – Main University Building: Lecture Hall 143

11:35–12:00 **Ibrahim Çakmak** *(Uludag University, Bursa- Turkey)*: Swarming of honeybee colonies in Turkey .... p. 79

12:00–12:25 **Zbigniew Lipiński** *(Poland)*: Emotional nature of adaptive nest abandonment by honeybee swarms .... p. 80

Symposium 9

Optimisation and regulation of work in social insects

Organisers: Karl Crailsheim & Thomas Schmickl (*Karl-Franzens-Universität, Graz*)
Wednesday 24 August – Main University Building: Lecture Hall 143

First Part

14:25–14:50 **Matthias Fürst** *(University of Regensburg)* **& Patrizia D´Ettorre:** Behavioural plasticity in ant queens of the *Pachycondyla villosa* complex .... p. 81

14:50–15:15 **Thomas Schmickl & Karl Crailsheim** *(Karl-Franzens-University Graz)*: Simulating the regulation of task selection in honeybees .... p. 81

15:15–15:40 **Jaw-Jinn Jong & How-Jing Lee** *(National Taiwan University)*: Temporal division of labor in the Gray-black Spiny Ant, *Polyrhachis dives* .... p. 82

Second Part

16:30–16:55 **Kerstin Fröhle & Flavio Roces** *(University of Würzburg)*: Regulation of chamber size in nests of leaf-cutting ants .... p. 82

16:55–17:20 **Ronald Thenius, T. Schmickl & K. Crailsheim** *(Karl-Franzens-University Graz)*: Modeling multiple transfer and nektar flow in honeybees? .... p. 83

17:20–17:45 **Chris Georgiadis & Anastasios Legakis** *(University of Athens)*: Preliminary experiments on the foraging activity of *Messor* ants from Greece .... p. 83

17:45–18:10 **Oliver Mitesser** *(University of Würzburg)* **& Hans-Joachim Poethke**: Evolution of activity patterns in an annual eusocial insects .... p. 84

18:10–18:35 **Jelle van Zweden** *(Universität Regensburg)*, **J. Heinze & P. D’Ettorre**: Worker policing: a mechanism to discriminate between worker-laid and queen-laid eggs .... p. 85

Symposium 10

Honeybee as new model for functional genomics

Organiser: Jozef Simuth (*Institute of Molecular Biology, Bratislava*)
Wednesday 24 August – Main University Building: Lecture Hall 133

16:30–17:00 **Jozef Šimúth** (*Institute of Molecular Biology, Bratislava*), **K. Bíliková, H. Lehrach & R. F. A. Moritz**: introduction to Symposium “Honeybee as new model for functional genomics” .... p. 86

17:00–17:30 **Philippe Bulet** *(Atheris Laboratories, Geneva)*: Antimicrobial peptides in insects: structure and gene regulation .... p. 86

17:30–18:00 **Katerine Aronstein & E. Saldivar** *(USDA-ARS-KSARC, Beneficial Insects Research Unit, USA):* Characterization of honeybee Toll related receptor gene *Am18w* and its potential involvement in host immune responses .... p. 87

18:00–18:30 **Michel Solignac** *(Laboratoire Populations, Génétique et Evolution, France)*, **F. Mougel, D. Vautrin, M. Monnerot & J.-M. Cornuet**: The linkage map of the honeybee: present status, use and prospects .... p. 88

Symposium 11

Conservation biology of social insects

Organisers: Mark Brown (*Trinity College, Dublin*) & Robert Paxton (*Queens University, Belfast*)
Wednesday 24 August – Main University Building: Lecture Hall 140

16:30–17:00 **Jonathan S. Ellis, B. Darvill, M.E. Knight & D. Goulson** *(University of Southampton)*: Population genetics of rare bumblebees . . . . p. 90

17:00–17:30 **Jean-Luc Mercier, C. Errard, N. Fresquet, Y. Morizet and A. Lenoir** *(Université de Tours, France)*: A study of *Myrmica sabuleti* (Hymenoptera, Formicidae), the ant host of *Maculinea arion* (Lepidoptera, Lycaenidae), in relation to a beltway construction project . . . . p. 89

17:30–18:00 **Tomás E. Murray** *(Queen's University Belfast)*, **Ú. Fitzpatrick, R. J. Paxton & M. J. F. Brown:** The Role of Habitats in Structuring and Conserving Bumble Bee Assemblages . . . . p. 90

18:00–18:30 **Robert J. Paxton** *(Queen's University Belfast)* **& Fani Hatjina**: The role of social bees in provision of the ecosystem service of pollination in NE Greece . . . . p. 91

18:30–19:00 **Johnny S. C. Chen, J.-H. Shen & H.-J. Lee** *(National Taiwan University)*: Monogynous and polygynous red imported fire ants, *Solenopsis invicta* Buren (Hymenoptera: Formicidae), in Taiwan . . . . p. 89

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20. **Jan Hrcek** *(University of South Bohemia, Czech Republic)*, **M. Janda & Z. Krenova**: Spatial and temporal nest distribution in *Myrmica* ant community, hosting *Maculinea alcon* – preliminary results . . . . p. 148

Symposium 12

Visually guided behaviour in social insects

Organisers: Misha Vorobyev (*University of Queensland*) & Natalie Hempel (*Freie Universität, Berlin*)
Thursday 25 August – Main University Building: Lecture Hall 133

10:20–10:45 **Eric Warrant, A. Kelber, B. Greiner, W. Ribi & W. Wcislo** *(Lund University, Sweden)*: Seeing in the dark: vision and landmark orientation in a tropical nocturnal bee . . . . p. 93

10:45–11:10 **Shaowu Zhang** *(Australian National University)*: Visual cognition in honeybee navigation . . . . p. 94

11:10–11:35 **Rob A. Harris, P. Graham & T. S. Collett** *(University of Sussex, UK)*: Visual memories in wood ants: binding of landmark edges to perceived centre of gravity . . . . p. 95

11:35–12:00 **Misha Vorobyev** *(University of Queensland, Australia)* **& Natalie Hempel de Ibarra**: Do honeybees optimally use optics of their eyes? . . . . p. 96

12:00–12:25 **Natalie Hempel de Ibarra** *(Free University of Berlin)*, **M. Vorobyev & R. Menzel**: How foraging bees are guided by floral displays . . . . p. 97

12:25–12:50 **Marie-Claire Cammaerts** *(Université Libre de Bruxelles)*: Sensitivity of the ant *Myrmica sabuleti* to light intensity . . . . p. 98

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9. **Rikard Frederiksen & Eric J. Warrant** *(Lund University, Sweden)*: Signal-to-noise ratio and information capacity in the eyes of halictid bees . . . . p. 138
15. **Birgit Greiner** *(Lund University, Sweden)*, **W. A. Ribi, T. W. Cronin, W. T. Wcislo & E. J. Warrant**: Polarisation vision in a nocturnal bee . . . . p. 144
18. **Robert A. Harris, P. Graham & T. S. Collett** *(University of Sussex, UK)*: Role of visual centre of gravity for landmark navigation in wood ants . . . . p. 147
19. **Mantaro Hironaka** *(Hamamatsu University School of Medicine, Japan)*, **S. Tojo, S. Nomakuchi, L. Filippi, H. Horiguchi & T. Hariyama**: Round-the-clock visual navigation of a subsocial shield bug, *Parastrachia japonensis* using path integration . . . . p. 148
50. **Jamie Theobald & Eric Warrant** *(Lund University, Sweden)*: Theoretical models of visual summation for night flight in *Megalopta* . . . . p. 173
53. **Anna M. Wertlen** *(Free University of Berlin)*, **N. Hempel de Ibarra, A. A. Cocucci, A. Sersic, W. Kreisch & M. Ristow**: Distribution of colours and sugar rewards in the bee's natural environment . . . . p. 176

Symposium 13

Diseases and parasites in social Insects

Organiser: Ingemar Fries (*Symposium wedish Agricultural University, Uppsala*), Mark Brown (*Trinity College, Dublin*) & Robert Paxton (*Queen's University, Belfast*)
Thursday 25 August – Main University Building: Lecture Hall 140

10:20 Introduction

10:20–10:45 **Malcolm T. Sanford** *(Apis Enterprises, USA)*: History and significance of small hive beetle introduction into the US . . . . p. 99

10:45–11:00 **Mario X. Ruiz-Gonzclez and Mark J. F. Brown** *(University of Dublin):* Testing the haploid susceptibility hypothesis: parasites and social organisation . . . . . . p. 99

11:00–11:10 **Ingemar Fries** *(Swedish University of Agricultural Sciences)* **& J. I. R. Larsson:** *Nosema bombi* - variation or sibling species? . . . . p. 100

11:10–11:35 **Elaine O'Mahony (***Queen's University Belfast***) and Wee Tek Tay:** Intra-genomic variation in the rRNA gene of the microsporidian parasite of the bumble bee, *Nosema bombi* . . . . p. 100

11:35–12:00 **Julia Klee** *(Queen's University Belfast)***:** Prevalence and distribution of the microsporidium *Nosema bombi* in bumble bees (*Bombus* spp.) . . . . p. 101

12:00–12:25 **Jozef J.M. van der Steen** *(Wageningen University and Research Centre)*: Infection routes of *Nosema bombi* in *Bombus terrestris* . . . . p. 102

12:25–12:50 **Oliver Otti & Paul Schmid-Hempel** *(Ecology & Evolution, ETH Zurich)*: Confusing Fitness Effects of *Nosema bombi* (Nosematidae, Microsporidia) in the Bumblebee *Bombus terrestris* . . . . p. 102

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36. **Sandra Mustafa, Julia Klee & Robert J. Paxton** *(Queen's University Belfast)*: High incidence of infection of the microsporidium *Nosema bombi* in the ovaries of spring-caught bumble bee queens (*Bombus terrestris*): a case of vertical transmission? . . . . p. 162

Symposium 14
Ecology of social insects

Organiser: John Breen (*University of Limerick*)
Thursday 25 August – Main University Building: Lecture Hall 143

10:20–10:45 **Ivan Rusin, O. Kryuchkov & L. Rusina** *(Kherson State University)*: Foraging behaviours of three social wasps species in southern Ukraine . . . . p. 103

10:45–11:10 **Elisabeth Brunner, N. Stroeymeyt & J. Heinze** *(University of Regensburg)*: Conflict resolution in insect societies . . . . p. 104

11:10–11:35 **William G. Meikle, N. Holst, G. Mercadier & F. Derouané** *(European Biological Control Laboratory)***:** The use of balances linked to dataloggers to monitor honeybee colonies . . . . p. 105

11:35–12:00 **Audrey O'Grady & John Breen** (*University of Limerick*): Ant communities in Ireland with special reference to those on limestone grassland . . . . p. 105

12:00–12:25 **P. R. Swaran & R. V. Varma** (*Kerala Forest Research Institute, India*): Termite diversity in young eucalypt plantation in the tropical forests of Kerala State (India) . . . . p. 104

12:25–12:50 **Leïla von Aesch & D. Cherix** *(Museum of Zoology, Lausanne)*: Worker confrontations of invasive ants at food sources under laboratory conditions . . . . p. 106

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41. **Veronica Santorum & John Breen** *(University of Limerick, Ireland)*: A comparison of pan traps and transects for the sampling of bumblebees in biodiversity surveys if agricultural landscapes . . . . p. 166
51. **Salvatore Vicidomini & Luigi Sannino** *(C. R. A. Istituto per la Sperimentazione sul Tabacco, Italy)*: Social interactions in *Xylocopa violacea* (L.) nest in post-emersion phase of offsprings (Hymenoptera: Apidae) . . . . p. 174
52. **Salvatore Vicidomini & Luigi Sannino** *(C. R. A. Istituto per la Sperimentazione sul Tabacco, Italy)*: Sex ratio and allocation, founding female investment type per nest, in a South Italian population of *Xylocopa violacea* (L.) (Hymenoptera: Apidae) . . . . p. 175

Symposium 15

Exploitation of food sources in social insects: foraging, recruitment, and communication mechanisms

Organisers: Stefan Jarau (*University of Ulm*) & Michael Hrncir (*University of Vienna*)
Friday 26 August – Main University Building: Lecture Hall 133

First Part

10:20–10:50	**Claire Detrain & C. Devigne** *(University of Brussels):* The influence of social context on ants' collective foraging patterns and individual decision-making . . . . p. 107
10:50–11:20	**Elva J. H. Robinson** (*University of Sheffield, UK*), **D. Jackson, M. Holcombe & F. L. W. Ratnieks**: Negative pheromone in an ant foraging trail network . p. 108
11:20–11:50	**Flavio Roces** *(University of Würzburg):* Transport chains in foraging grass-cutting ants: efficient load carriage or improved information transfer? . . . . p. 108
11:50–12:20	**Nicole Saverschek** *(University of Würzburg)*, **H. Herz & F. Roces**: The influence of experience on host plant selection by the leaf-cutting ant *Atta colombica* . p. 109
12:20–12:50	**Keiichi Masuko** *(Senshu University, Japan):* Trophic egg production and prey retrieval by the foundress in the ant *Manica yessensis*: Their contributions to the first worker production . . . . p. 110

Second Part

14:00–14:25	**Veronika M. Schmidt** *(University of Vienna)*, **R. Zucchi & Friedrich G. Barth**: Recruitment in a scent path laying stingless bee to food sources of different profitabilities . . . . p. 111
14:25–14:50	**Michael Hrncir** *(University of Vienna)*, **R. Zucchi & F. G. Barth**: Vibrating food receivers: an optimal transmission of recruitment signals in bees . . . . p. 112
14:50–15:15	**Judith Reinhard, M. V. Srinivasan & S. Zhang** *(The Australian National University)***:** Associative learning and cross-modal recall as "recruitment" mechanisms in honeybees . . . . p. 113
15:15–15:40	**Mick E. Hanley, S. Pichon, B. Darvill & D. Goulson** *(University of Southampton)*: The influence of floral rewards on bumblebee foraging behavior: higher quality pollen means more visits . . . . p. 114
15:40–16:05	**Thomas Eltz** *(University of Düsseldorf):* Tracing bumblebee footprints on natural flowers . . . . p. 114
16:05–16:30	**Jan Šobotník** *(Institute of Organic Chemistry and Biochemistry, Prague)*, **I. Valterová, O. Hovorka & L. Cahlíková**: Age-dependent structure and content of labial glands in males of *Bombus terrestris* . . . . p. 115

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12. **Oliver Geissler & Flavio Roces** *(University of Wuerzburg Am Hubland)*: Crop loading and recruitment behavior in the nectar-feeding ant *Camponotus rufipes* p. 141

24. **Reet Karise** *(Estonian Agricultural University)*, **M. Mänd, M. Ivask, A. Luik & Ants Bender**: Bumble bee pollen forage on different colour morphs of hybrid lucerne (Medicago x varia) flowers . . . . p. 151
31. **Anne-Catherine Mailleux** *(Biological control and spatial ecology, Belgium)*, **C. Detrain & J.-L. Deneubourg**: A behavioural rule of thumb adjusting ants recruitment to aphid productivity . . . . p. 158
55. **Stefan Jarau** (*University of Ulm, Germany*), **Ronaldo Zucchi, Friedrich G. Barth & Manfred Ayasse**: Scent trail marking in stingless bees: it's the labial- not the mandibular gland secretion . . . . P. 178

Symposium 16

Social insects and their macroparasites

Organisers: Patrizia D'Ettorre (*Universität Regensburg, Germany*)
Friday 26 August – Main University Building: Lecture Hall 140

10:20–10:25 **Patrizia D'Ettorre**: Introductory remarks

10:25–11:05 **Alain Lenoir** *(University of Tours, France)*, **S. Devers, P. Marchand, C. Errard, C. Bressac & R. Savolainen**: Microgynous queens in ants: social parasites or dispersal morphs? . . . . p. 116

11:05–11:45 **Carlos Lopez Vaamonde, W. Koning, R. Brown, W. Jordan & A. Bourke** *(Zoological Society of London)*: Intraspecific social parasitism by reproductive bumblebee workers . . . . p. 117

11:45–12:05 **Elisabeth Brunner, A. Trindl, K. Falk, J. Heinze & P. D'Ettorre** *(University of Regensburg):* Reproductive conflict in social insects: male production by workers in a slave-making ants . . . . p. 117

12:05–12:25 **Jeanette Beibl** *(Universität Regensburg)*, **A. Buschinger, S. Foitzik, P. D'Ettorre & J. Heinze**: Phylogeny of the ant genus *Chalepoxenus* . . . . p. 118

12:25–12:45 **Jaclyn Smith** *(Flinders University of SA, Adelaide)*, **S. Tierney, Y. C. Park & M. P. Schwarz**: The evolution of social parasitism: Implications for sympatric speciation based on phylogenetic studies of allodapine bees . . . . p. 119

12:45–12:50 **Patrizia D'Ettorre**: Conclusive remarks

Related Poster Presentations (numbers according to the List of Poster Presentations on p. 28):

48. **Danival J. Souza** *(Université François Rabelais, Tours, France)*, **I. M. F. Soares, T. M. C. Della Lucia & A. Lenoir**: A new social parasite of leaf-cutting ants from Brazil . . . . p. 172
54. **Marion U. Zobel** *(Uni Tübingen, Zool. Institut, Germany)* **& Robert J. Paxton**: Nest usurpation and kinship in the primitively eusocial bee, *Lasioglossum malachurum* . . . . p. 177

Symposium 17

Can European honeybees coexist with *Varroa* mites?

Organiser: Ingemar Fries (*Swedish Agricultural University, Uppsala*)
Tuesday 23 August – Main University Building: Lecture Hall 143
Friday 26 August – Main University Building: Lecture Hall 140

10:20–10:50 **Adrian Wenner** *(University of California):* The exciting potential of remote feral bee colonies for *Varroa* coexistence . . . . p. 120

10:50–11:20 **Ingemar Fries** *(Swedish University of Agricultural Sciences):* Honeybees and *Varroa* mites - natural selection versus directed breeding . . . . p. 121

11:20–11:50 **Peter Rosenkranz** *(University of Hohenheim, Germany)*: Population dynamics of bees, brood and *Varroa* mites in honey bee colonies selected for tolerance to *Varroa* infestation . . . . p. 122

11:50–12:20 **Malcolm T. Sanford** *(Apis Enterprises, USA):* The use of soft chemicals to control *Varroa* mites in the US and Canada . . . . p. 123

12:20–12:50 **Jozef J. M. van der Steen, A. C. M. Cornelissen, L. A. Gerritsen and T. Blacquière** *(Wageningen University and Research Centre, the Netherlands)*: Integrated control of *Varroa* in the Netherlands . . . . p. 123

Related Poster Presentations (numbers according to the List of Poster Presentations on p. 28):

1. **Anatoly Anisimov & S. I. Razumovsky** *(St. Petersburg State Agrarian University)*: *Varroa* mite and honeybee mortality after treatments by two chemicals preparation (laboratory tests) . . . . p. 131
27. **Vladimir Kiryushin** *(Shmalhausen Institute of Zoology, Kiev)*: Dynamics of *Varroa destructor* mites drops from honey bees belonging to different rases . . . . p. 154
40. **Stanislav Razumovsky & A. I. Anisimov** *(St. Petersburg State Agrarian University)*: *Varroa* mite and honeybee mortality after treatments by two chemicals preparation (tests in apiary) p. 165
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Palaeontology and evolution of ants

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Abstracts

Odor and honey bee exploitation of food crops

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Keywords: honeybees, odors, learning, recruitment, wind, pollination

In 330 BC, Aristotle wrote (in part): "…for instance, bees and [ants] detect [food] at a distance, and they do so recognizing it by smell." Recent studies confirm that honeybees (*Apis mellifera*) are what some scientists view as the "ultimate generalist forager" (polylectic, not oligolectic). That is, no one seems to have yet found a "natural attractant" for honeybees, although some apparent exceptions exist. At times, searching bees will investigate the odor of honey and of wax. During swarm relocation, scout bees will orient toward Nasonov gland emissions. Drones in flight will fly toward airborne objects and attempt to mate with any object that has queen odor.

Flower scents, with their pleasant odors (pleasant to us, that is) have long been considered to attract "scout" bees. However, attempts to use such odors, their constituent chemicals, or Nasanov gland compounds to entice bees to pollinate crops have not proven successful.

To our senses, flower odors seem simple (e.g., rose, citrus, jasmine), but an analysis of such perfumes reveals that an entire suite of chemicals emanates from such blossoms. Some specific chemicals (e.g., citronella) occur across different flower species, but no pattern has yet been found to exist. We encounter, instead, a remarkable diversity of chemical combinations in the scents of various flowers.

Besides the fact that blossoms in a single flower species likely have a complex combination of odors, we who experiment must contend with the fact that each specific locality in nature also has a suite of odors that can define that locality. Consider, for example, any particular site in an open field. Weeds at that site may differ from an apparently similar site nearby. Establishing a feeding station can involve trampling on grass or weeds and contribute to the specific suite of odors at that site. Also, molecules from some odor source upwind can drift down to the station and cling to the body hairs of foragers. Although we human beings may not smell distinctive odors in the area, we have little evidence about which and how many odors honeybees might perceive. We can only determine that by experimentation.

Hypothesis: *Bees rely on a suite of odors, as well as on visual and other cues, but do not necessarily rely on a single chemical at any one time.*

Learning (conditioned response) in honeybees has not received the attention it should have received this past half century. Consider two comments that von Frisch published in 1950, statements that deserved more consideration back then (only slightly paraphrased here): A) When the feeding dishes became empty, only from time to time would one of [the foragers] fly out to the feeding place to see if anything was to be had. B) If we now refilled the dish at the more distant site, then … the first gatherers to return with full stomachs aroused chiefly bees from the group that had previously visited the distant feeding place. But when we offered sugar water at the nearer site, then the [returning foragers] aroused mostly bees that had previously been feeding there."

In the 1960s we obtained experimental results similar to those von Frisch had published but noticed that his results could occur even when returning successful bees did not dance. Today many of us would recognize that situation as an example of learning (conditioned response) behavior. Experienced foragers do investigate known nectar or pollen sources after they cease to yield a reward. When reward again becomes available, those investigating foragers feed and return to their colony. They carry odors on their bodies of the food and of the specific locality they frequented. Idled experienced foragers in the colony recognize from that particular set of odors that food is once again available. They then fly out to sites where they had previously had success. An exponential buildup of experienced foragers at profitable food sources thus occurs at similar sites in the entire region. We termed this type of recruitment, "communication by means of conditioned response." To test that behavior, we let the dishes remain empty and later merely injected the training odor into the hive; experienced bees then soon arrived at the empty dishes on the basis of an odor cue alone.

Hypothesis: *Recruitment of experienced bees each day can be explained by conditioned response, a recruitment to wherever* *the odor of similar food sources exists in the region.*

One must therefore distinguish between the behavior of experienced foragers and newly recruited bees. Experienced foragers, upon perceiving a familiar odor, fly immediately out to previously yielding sources. By contrast, newly recruited bees receive a "reward" from a waggle dancer, obtain an impression of a suite of odors (of food and of locality) from that successful forager, and then instantly learn (become conditioned) to search for the same food source. On that point, von Frisch wrote in 1937, "the [recruited] bees first seek in the neighborhood, and then go farther away, and finally search the whole flying district."

Consider an experiment with a constant number of marked foragers that make round trips between the feeding station and their colony. One can then continually capture and tally all unmarked bees as they arrive at the feeding station that has scented food. Each day experienced foragers will build up exponentially after initial provision of food. Recruits, by contrast, will not begin to arrive in numbers until an hour after regular foragers begin their trips. The increase in number of recruits captured per 15 minutes will be linear, not exponential, during a several hour experiment. If one repeats the experiment and then switches to unscented food half way through a preset time period, recruits will suddenly cease to arrive. That type of result matches what von Frisch wrote in 1937: "I succeeded with all kinds of flowers with the exception of flowers without any scent. When the collecting bee alights on the scented flowers to suck up the food, the scent of the flower is taken up by its body-surface and hairs, and when it dances after homing … the interested bees perceive the specific scent on its body and know what kind of scent must be sought…"

Hypothesis: *Without odor, recruited bees cannot find a food source.*

It is difficult to conduct completely odor-free experiments, since foraging bees function essentially as "flying dust mops" (Jerry Bromenshenk's term). In normal circumstances, not only do they bring back to their colony odor of the food source but also the odor of the specific locality in which they forage. Bromenshenk's experiments have revealed that bees can perceive molecular concentrations in parts per billion or parts per trillion.

Winds complicate the study of recruitment to food sources, a fact little appreciated until recently. Odor molecules can only travel downwind; hence, recruitment of bees to food sources located any great distance downwind from a colony becomes difficult. On the other hand, in most places wind directions shift daily and also shift from day to day as weather fronts pass through an area. In those cases, foraging can occur in all directions from a colony. In other places, wind can have a relatively constant direction during a season, and foraging occurs primarily in one direction.

From all of the above, it would appear that we might be on the verge of a breakthrough for a new era in studies of pollination. Anyone who has attempted to train bees to an artificial feeding station must have at times encountered difficulty. For instance, during a major nectar flow the odor of that incoming nectar accumulates in the colony. If one then attempts to train bees to a feeding station, the odor of the prevailing nectar flow overrides whatever small amount of odor one uses in sugar solution at a test feeding station.

In the 1930s and early 1940s, Gubin, Romashov, Kapustin, and Gataulin in Russia and von Frisch in Germany reported some success in "scent directing bees" to get them to forage on particular crops. Although some questions have been raised as to whether they really had achieved success, our own results suggest that a full application of current knowledge about odor, conditioned response, how to saturate colonies with target odor, and the importance of wind direction could well lead to important practical application.

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Physiological and behavioural adaptation of a subsocial shield-bug, *Parastrachia japonensis*, that allow it to survive on the drupes of its sole host plant available only two weeks a year

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Keywords: subsociality, provisioning, monophagous, aggregation, reproductive diapause

Progressive provisioning behavior, in which adults continue to provide food until the young are able to acquire and assimilate it on their own has been rarely reported in insects outside of Hymenoptera and Isoptera, and in only a few species in Hemiptera (Filippi et al., 2001). Field surveys on this subsocial behavior in Hemiptera were conducted almost exclusively in the shield bug, *Parastrachia japonensis* (Hemiptera: Parastrachiidae).

Synchronization of reproduction with its food plant. The sole food source of *P. japonensis* is drupes of the deciduous tree, *Shoepfia jasminodora*. In Saga (33_N) Kyushu, Japan, the northern boundary of this bug's range, females and males enter the reproductive stage from late April to middle May, when *S. jasminodora* blooms and produces drupes (Tsukamoto and Tojo, 1992; Filippi-Tsukamoto et al., 1995; Filippi et al., 2000). Inseminated females move to *S. jasminodora* in late May where they feed on the unripe drupes, their first food-uptake since adult emergence ten months earlier. They feed for about 10 days, until their eggs mature and then nest under leaf litter where they oviposit a round egg mass containing about 100 eggs. The females guard the egg mass for two weeks by keeping it suspended on the end of stylets. Rainy season generally start from early June and ends in mid-July. Their nests are distributed 5-15m away from host trees, because the vicinity of the host trees is not suitable for nesting due to higher possibility of flooding, predation and intraspecific competition (Tsukamoto and Tojo, 1992; Filippi-Tsukamoto et al., 1995a; Filippi et al., 2001).

Provisioning of good-quality drupes to young. After eggs hatch, the female guard the nymphs and forages for ripe drupes with well developed endosperm that have fallen on the ground, which are available during a brief period of nearly two weeks from mid-June to early July (Nomakuchi et al., 1998; Filippi et al., 2000a). Nymphs can mature to adults only by feeding on drupes with good-quality (well-developed endosperm), and none can grow beyond the second stadium on those with poor-quality (Filippi et al., 2000, 2001).

The female is attracted to volatiles emitted from the skin of ripe drupe, judges the quality of the endosperm through probing (Nomakuchi et al., 1998b; Filippi et al., 2001) and, if the drupe is high in quality, provisions it to her own nest. Provisioning continues all day and night, and success in returning to the nest primarily depending on sun and polarized light compasses and finally on chemical cue. The detailed story on the homing behavior and the structure of compound eyes adapted for the behavior will be presented by Mantaro Hironaka at this Congress (*Poster:* Mantaro Hironaka, S. Tojo, S. Nomakuchi, L. Filippi, H. Horiguchi and T. Hariyama "Round-the-clock visual navigation of a subsocial shield bug, *Parastrachia japonensis* using path integration" – see p. 148).

The guarding and provisioning behaviors of the female greatly enhance the survival of the young, especially in early stadia, as the food resource fluctuate greatly each year. Most drupes are poor in quality, resulting in severe intraspecific competition for good-quality drupes, and the forest environment is too severe for the fragile young to forage, due to wet ground rich in predators and covered with leaf litter and many obstacles that interfere with access to the drupes (Nomakuchi et al., 1998; Filippi et al., 2000a, 2001, 2002).

Provisioned young typically remain in the nest until the third stadium when the female dies, after which they leave the nest and feed in aggregations under a host tree. They molt to adults after the fifth stadium by late July (Filippi et al., 2001, 2002).

Aggregation during reproductive diapause. The newly emerged adults soon enter reproductive diapause, forming aggregations of a few to several thousand individuals that are suspended from the leaves and branches of non-host broad-leaf evergreen trees or ferns until the reproductive season comes around again the following spring, although they aggregate close to the ground on hot summer days and underground in winter from December to February (Tsukamoto and Tojo, 1992; Filippi et al., 2000b).

The adults, ca 2 cm long, have conspicuous black and red color pattern. When quails eat the bug, they come to avoid eating one again for up to several days, although they continues to eat *Erthesina fullo* adults which exhibit protective coloration. Thus, the color pattern of *P. japonensis* seems to function as warning coloration against predators, which is expected to be enhanced by aggregate formation. Works are now going on to elucidate the structure of chemicals which exist both in *P. japonensis* and the drupe of *S. jasminodora*, and function as deterrents to the quail (Ritsuo Nishida et al., unpublished).

Clusters are not sex-biased, and aggregation pheromone is involved in aggregate formation (Mantaro Hironaka, unpublished). Oxygen consumption is greatly reduced in the adults during reproductive diapause, and further reduced to nearly half by physical contact with other individuals (Tojo et al., in press).

Contribution of symbiotic bacteria on uric acid recycling. The adults live for at least nine months, many bugs for another year, before becoming reproductively active, surviving on a diet of water with no supply of nitrogen. Recent surveys support that uric acid is recycled as nitrogen source in diapausing adults with the aid of symbiotic *Erwinia*-like bacteria, which exist exclusively in the gastric coeca, and that uricase of the bacteria functions as a key enzyme for this recycling (Kashima et al., submitted).

Thus, we conclude that unreliable food resource being limited in a brief period had led to the evolution of behavioural and physiological adaptations in *P. japonensis* to synchronize reproduction with it sole host plant, and to effectively detect and provision good-quality food items to young. Further, aggregate formation and symbiotic relationship with bacteria greatly contribute to energy conservation and prolonged survival in diapausing adults.

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Small brains, smart minds: Vision, navigation and 'cognition' in honeybees

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Insects, in general, and honeybees, in particular, perform remarkably well at seeing and perceiving the world and navigating effectively in it, despite possessing a brain that weighs less than a milligram and carries fewer than 0.01% as many neurons as ours does. Working together with our colleagues, we have been trying to unravel the secrets of their success.

Although most insects lack stereo vision, they use a number of ingenious strategies for perceiving their world in three dimensions and navigating successfully in it. For example, distances to objects are gauged in terms of the apparent speeds of motion of the objects' images, rather than by using complex stereo mechanisms. Objects are distinguished from backgrounds by sensing the apparent relative motion at the boundary. Narrow gaps are negotiated by balancing the apparent speeds of the images in the two eyes. Flight speed is regulated by holding constant the average image velocity as seen by both eyes. Bees landing on a horizontal surface hold constant the image velocity of the surface as they approach it, thus automatically ensuring that flight speed is close to zero at touchdown. Foraging bees gauge distance flown by integrating optic flow: they possess a visually-driven "odometer" that is robust to variations in wind, body weight, energy expenditure, and the properties of the visual environment.

Recent research on honeybee perception and cognition is beginning to reveal that these insects may not be the simple, reflexive creatures that they were once assumed to be. For example, bees can learn rather general features of flowers and landmarks, such as colour, orientation and symmetry, and apply them to distinguish between objects that they have never previously encountered. Bees exhibit "top-down" processing: that is, they are capable of using prior knowledge to detect poorly visible or camouflaged objects. They can navigate through labyrinths by learning path regularities, and by using symbolic signposts. They can learn to form complex associations and to acquire abstract concepts such as "sameness" and "difference". Bees are also capable of associative recall: that is, a familiar scent can trigger recall of an associated colour, or even of a navigational route to a food location. All of these observations suggest that there is no hard dichotomy between invertebrates and vertebrates in the context of perception, learning and 'cognition'; and that brain size is not necessarily a reliable predictor of perceptual capacity.

Finally, some of the above principles – especially those that relate vision and navigation – are offering novel, computationally elegant solutions to persistent problems in machine vision and robot navigation. Thus, we have been using some of the insect-based strategies described above to design, implement and test biologically-inspired algorithms for the guidance of autonomous terrestrial and aerial vehicles.

The ecology of social insects and their parasites

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Parasites are increasingly being recognised as playing a key role in the ecology and evolution of social insect societies. However, the ecological impact of parasites on social insects at the colony level remains unclear. High levels of redundancy in social insect colonies and patterns of division of labour all act to reduce the apparent ecological cost of parasitism. However, recent work suggests that understanding the context of host-parasite interactions may elucidate the true ecological cost of parasitism. In this talk I will discuss the interaction between social insects and their parasites from the perspective of social insect life-history, focussing on key periods of host-stress and drawing on examples from bumble bees, honey bees and ants.

Functional genomics of royal jelly proteins and antibiotics peptide of honeybee *Apis mellifera* L.

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Introduction

Royal jelly (RJ) is considered a unique nutrient developed in nature in the process of evolution. Female honeybee larvae can differentiate into the queens or workers, depending on the food and care given them during the early larval stages. This is a case of insect polyphenism regulated by differential nourishment. The compositions of the RJ fed to the two castes are similar but have shown to be non-identical. RJ is a complex biological matrix, which structure comprises a multitude of specific protein-protein as well as protein-fatty acids interactions (Šimúth, 2001). The electron scan microscopic examination of the RJ layer showed relatively large spherical particles in the range from 20 to 100 µm mutually interconnected by a system of fibrous filamentous channels. We have found that apalbumin 1 has an ability to form self-assembled structures, which determine the textural properties of RJ.

The gap between full scientific understanding and the real structure and functions of RJ is still so wide that an approach at molecular level is needed to both complement and test inferences from the molecular networking to genomics organizations.

The important ingredients of RJ are proteins and peptides. The proteins secreted by honeybee into its products have different functions in establishment of optimal development of honeybee colony and may be defined as a specific phenotypic characteristic of honeybee colony, as well as extracellular mediators of gene expression predominantly during early larval development.

Proteomics of of royal jelly proteins

In contrast to already available detailed analysis of sugars and fatty acids, the precise analysis of individual RJ proteins started with one exception only a few years ago. A substantial part of RJ is made of proteins, which form about 50% of its dry mass (Šimúth, 2001). The *mrjp* gene family, encoding at least eight closely related MRJPs, has been described at the cDNA level. The first RJ peptide characterized was royalisin (Fujiwara et al., 1990). We have started a targeted study of all RJ proteins at molecular level by characterization of the main RJ protein (Hanes and Šimúth, 1992). Major proteins accounting for 90% of total RJ proteins with molecular masses of 49-87 kDa are assigned to one protein and gene family (Hanes and Šimúth, 1992; Ohashi et al., 1997; Schmitzová et al., 1998; Malecová et al., 2003).

We suggested to term this group MRJP (for Major Royal Jelly Protein) before knowing their physico-chemical properties. Later we have established (Šimúth, 2001) that these proteins have physico-chemical properties similar to those of ovalbumin (storage egg-white protein) or serum albumin (major protein of serum) which are typical albunoid proteins and therefore we have proposed to rename major royal jelly proteins as apalbumins. Thus, apalbumin-1 will be designated as MRJP1, apalbumin-2 as MRJP2, and so on. Basing on their functions, exogenous proteins and peptides secreted by honeybee into its products could be classified as:
1) Enzymes that are involved in transformation of nectar to honey: α-glucosidase, glucose oxidase, catalase and amylase. They are the so-called technological enzymes; *2) Nutritional proteins* that are secreted into larval diet as the main source of protein nutrition of the honeybee larva; *3) Protective proteins and peptides* that are secreted by honeybee into its products and protect mainly the developing brood against pathogens; *4) Physiologically active proteins and peptides* that have various immunostimulatory effects in the honeybee colony and influence processes in tissue cultures of animal cells *in vitro* conditions.
Recently, the availability of the honeybee *Apis mellifera* genome and transcriptome stimulated new effort in investigating the protein composition of the RJ by proteomics approach for the study of various physiological functions of RJ proteins (Sano et. al., 2004).

Physiomics of RJ proteins

Certain properties of the RJ proteins might play a role in cytokine-induced activation of genes important for immune response of honeybees and humans. It was corroborated by many experiments that in these processes TNF-α could play a pivotal role as the factor participating in regulation of important cellular processes such as cell proliferation and inflammation. The question is, which components of RJ could participate in these processes? We have found that apalbumin-1, apalbumin-2, and apisimin induce release of TNF-α in mouse macrophages (Šimśth et al., 2004). We have also demonstrated that these proteins are regular components of honey and honeybee pollen. Thus, honeybee secretes RJ proteins into their own food that could induce self-defense mechanisms in honeybees mainly during larval development. It implies that RJ proteins function as stimulators of physiological processes, rather than as active substances. Apalbumin-1 is likely to promote liver regeneration and may have a cytoprotective action on hepatocytes. It was shown that apalbumin-3 could exhibit potent immunoregulatory effects *in vitro* and *in vivo* (Okamoto et al., 2003). The minor part of RJ proteins is composed of proteins and peptides with different functions including antimicrobial and antifungal properties (Fujiwara et al., 1990; Bķlikovį et al., 2001; Bķlikovį et al., 2002). Proteins and peptides of RJ can participate in defense mechanisms of honeybee against microbial pathogens by means of a direct inactivation of microrganisms occurring in honeybee products, as well as through induction of cytokine production that participate in regulation of transcription of protective proteins and peptides. Thus, antibiotic peptides present in RJ could be the important factor for elimination of bacterial infection of honeybee larva (Bķlikovį et al., 2001). Induction of the immune response was found to be linked to NF-κB and interleukin-type response elements upstream of the immune genes. Honeybees have to survive in colonies laden with pathogenic bacteria and fungi. Yet, perhaps the most interesting aspect of this ecosystem is not the expected staggering losses from susceptibility to infection, as much as the survivability by honeybees in spite of infection. The resilience may be attributed to the presence of a repertoire of host defense system.

Genomics of RJ proteins

The organized annotation and analysis of the honeybee genome has been started (http://listserv-public.bcm.tmc.edu/archives/honeybee-genome.html). The Baylor College of Medicine Human Genome Sequencing Center has released the v. 2.0 assembly of the *Apis mellifera* genome. These assemblies were generated using 7.5-fold genome coverage of small insert whole genome shotgun sequences. Our participation in the annotation of gene coding of RJ proteins in the framework of “*Honeybee Genome Project Analysis Plan*” is based on the data concerning the study of proteomics and genomics of the family of major RJ proteins. We have started with characterization the genomic clone containing the entire *mrjp1* gene and determined its sequence (Malecová et al. 2003). Seven mismatches between the *mrjp1* gene sequence and two previously independently published cDNA sequences were found, however these differences did not lead to any change in the deduced amino acid (aa) sequence of apalbumin-1. Putative promoters were predicted upstream of all *mrjp* genes (including *mrjp1*). *Mrjp1*’s genomic locus was predicted to encode an antisense transcript, partially overlapping with five *mrjp1* exons and entirely overlapping with the putative promoter and predicted transcriptional start point of *mrjp1*. This finding may shed light on the mechanisms of regulation of *mrjp*s expression. Although apalbumins and the yellow protein of *Drosophila melanogaster* share a certain degree of similarity in aa sequence and although it has been shown that they share a common evolutionary origin, neither structural similarities in the gene organization, nor significant similarities between intron sequences of *mrjp1* gene and fourteen *yellow*-like genes of *Drosophila melanogaster* were found .

The honeybee genome sequencing data allows to assume that purposeful international scientific cooperation will result in elucidation of functional genomics of RJ proteins and thus to contribute to scientifically substantiated utilization of the honeybee products for human health.

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Origin, function, and ecological significance of termite workers

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Advanced eusociality appeared once at the origin of Isoptera, with the onset of the sterile soldier caste. This caste is present in all termite lineages, except for a few apical branches where it has obviously been lost. By contrast, the history of the second eusocial caste, the workers, is not as simple. A "true" worker caste is deemed to be present whenever social tasks (food collection, nest building, brood care…) are accomplished by a specialized category of individuals, permanently excluded from the developmental pathway leading to the imago stage (alate). Whenever these tasks are done by individuals remaining ontogenetically totipotent, i.e., retaining the possibility to transform ultimately into several categories of individuals including alates, such individuals will be called pseudergates (literally "false workers"). True workers are present in the Mastotermitidae, Hodotermitidae, Termitidae, and most Rhinotermitidae. Pseudergates are known from the Termopsidae, Kalotermitidae.and some Rhinotermitidae (review in Roisin, 2000). Are true workers derived from specialized pseudergates, or are they ancestral while pseudergates were secondarily selected for their flexibility ? Plotting presence/absence of true workers on the most recent cladogram of termites does nor resolve this question unambigously. Either hypothesis requires several transitions between the two models of social organization. However, I will point out that the life history and ecology of present-day termites with pseudergates (small colonies located within a single piece of wood on which they feed in confinement) are very likely to represent the ancestral termite condition. On the contrary, termites with workers attain large colony sizes, often forage outside their nest, and may exploit sources of food other than wood. I will therefore argue that ancestral termite colonies most likely possessed pseudergates, which implies that true workers appeared at least three times during the evolution of the Isoptera (Noirot and Pasteels, 1988). The evolution of workers was accompanied by a more complex foraging behaviour allowing colonies to exploit sources of food outside the nest itself, and thus to grow far beyond the size permitted by the original piece of nesting wood.

One could however wonder which adaptation, true workers or external foraging, gave the impulse to the diversification of termites with workers. Few taxa infringe upon the rule "pseudergates ó confined environment", but the genus *Prorhinotermes* (Rhinotermitidae) is one of them. When short of food, *P. inopinatus* colonies explore their environment in the open despite the lack of true workers. Exploration of unknown areas is initiated by soldiers, soon followed by pseudergates. When food is discovered, a long-lasting trail becomes collectively established between the nest and the food, along which soldiers and pseudergates travel, but also neotenic reproductives. After several days, the trail is sheltered by a wood carton tunnel. A large part of the colony, including reproductives, may move into the new food source. These observations suggest that, in the Rhinotermitidae, foraging evolved because it allowed the extension of the home range of a colony, rather than as a way of gathering food to bring it back to the nest. This evolution was made possible by the development of a populous soldier caste endowed with chemical weapons, able to forage without cover and to protect other individuals efficiently. Further experiments, still in progress, indicate that the castes of *Prorhinotermes* show little physiological response to food shortage. By contrast, in *Cryptotermes secundus* (Kalotermitidae), when food approaches exhaustion, pseudergates tend to proceed to the alate stage and disperse on the wing rather than to forage on the ground (Korb and Lenz, 2004). By its foraging and reproductive strategy, *Prorhinotermes* thus appears more similar to Rhinotermitidae with workers than to other termites with pseudergates, such as the Kalotermitidae.

As a consequence of their opposite food-gathering and reproductive behaviour, termites with and without workers do not occupy the same niche in natural environments. Kalotermitidae are reported to be very scarce in tropical rainforests, whereas Termitidae, and in particular soil-dwelling species, are dominant. However, Kalotermitidae seem more abundant in dryer habitats, or on islands out of reach of species with large colonies and lower dispersal abilities. In the framework of a large biodiversity project (IBISCA), we studied the termite assemblage at various sites in the San Lorenzo rainforest, Panama, to test for horizontal, but also vertical variations in species richness and composition. Results at ground level confirmed the predominance of the Termitidae. Soil feeders, and soldierless Apicotermitinae (*Anoplotermes*-group) in particular, were especially abundant and diversified. However, the canopy was found to be inhabited by 10 arboreal species, among which five were workerless (*Prorhinotermes* and Kalotermitidae). The forest canopy thus appears as another relatively dry, marginal habitat suitable for small-colony termites. By their generally overlooked presence in the upper strata of the forest, termites without workers might be more abundant and ecologically more important than previously recognized.

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Patterns of coevolution and local adaptation in slavemaking ants

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The coevolutionary dynamics of host-parasite relationships are mainly affected by the prevailing selection pressures and the evolutionary potentials of the interacting species, i.e. the standing genetic variation and the gene flow among populations. The opponent with the higher evolutionary rate is expected to exhibit local adaptation and thus to be ahead in the coevolutionary arms race. In social parasites and their hosts with their close phylogenetic relationship, recombination and mutations rates are likely to be similar and genetic variation and the amount of gene flow between populations should determine patterns of local adaptation. We studied intra-population genetic variation and population genetic structuring in two slavemaking ant systems: *Harpagoxenus sublaevis* and two *Leptothorax* host species from Europe and *Protomognathus americanus* and two *Temnothorax* hosts from North America. Additionally using field manipulations and behavioural experiments we analysed the occurrence of local adaptation in social parasites and their host species.

In the European system, cross-fostering experiments based upon staged slave raids on the larger host *L. acervorum* demonstrated very localized coevolution, with the parasite leading the arms race in some sites, while the host being ahead in other communities. Population genetic analyses revealed strong geographic differentiation in the social parasite *H. sublaevis* and even more so in *L. muscorum*, but a less pronounced reduction in gene flow between *L. acervorum* populations. The latter species, also characterized by a higher genetic variability, should thus be locally adapted to its parasite, while *H. sublaevis* should lead the arms race against *L. muscorum*, which showed only very low genetic variation within a population.

In the North American system with a generally much higher genetic variability, behavioral studies gave no indication of local adaptation. Instead, the advance of behavioral adaptations in host and parasite populations strongly depended on the respective selection pressures. However, a recent large scale field manipulation in two communities indicated strong local adaptation of the parasite *P. americanus* to its majority host *T. longispinosus*, which exhibits less gene flow between populations. In a cross-fostering field experiment, we manipulated the density and origin of social parasites at sites in New York and West Virginia. Host density strongly decreased in West Virginian plots with local slavemakers in comparison to either parasite-free plots or those with New York social parasites. At the ecologically favorable, high density New York site, host nest density was unaffected by our treatments, but the social organization, colony size and investment patterns of host colonies changed dramatically in response to our parasite manipulation. An increase in parasite pressure led to a reduction in the number of resident queens and workers, a male-biased allocation ratio and a lower productivity. In West Virginia, host nest demography did not change in response to parasite treatment, but raiding activity by New York slavemakers caused important life history strategy changes in host colonies, which invested more heavily in colony growth instead of sexual reproduction. Importantly, the success of slavemaking colonies strongly depended on an interaction effect between host population and parasite origin: slavemaking nest size (measured by the number of slavemaker workers and slaves) was much larger in their respective local host population, indicating adaptation of the parasite to its local host.

Evidences of Afrotropical origin of Myrmicinae

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W. M. Wheeler (1915) by first has paid attention to a paradoxical rarity of Myrmicinae in Baltic amber. Later it was revealed, that the similar rule is observed almost in all Cretaceous and Cenozoic deposits of Eurasia and North America. In a modern world ant fauna Myrmicinae is the largest subfamily including 152 genera and about 4400 species. In the vast majority of contemporary ecosystems, Myrmicinae are either the dominant ant group, or the second most abundant after Formicinae. Thus one of the most mysterious problems of myrmecology is where have arisen Myrmicinae and where their diversification formed. There are three sets of observations that indirectly imply an Afrotropical origin for Myrmicinae.

Practically all Cretaceous and Palaeogene ants have so far been found in Eurasia and North America, and they suggested delayed development of Myrmicinae. The oldest Myrfmicinae in Northern Hemisphere are known from Middle Eocene of USA (Arkansas amber, Green River Formation). Before the Miocene their incidence was very low. In the Middle Eocene deposits of Green River (USA) Myrmicinae comprise 2% of individuals and 2 of 18 species, in the Upper Eocene European ambers 2.6% of individuals and 42 of 147 species (including undescribed), in the Lower Oligocene deposits of Florissant (USA) 5% of individuals and 8 of 32 species, and in the Middle Oligocene of Bembridge Marls (UK) 0.7% of individuals and 2 of 18 species. Only in the Miocene did their participation reach 40% (Middle Miocene of Vishnevaya Balka in North Caucasus). A notable exception is the Sicilian amber with Myrmicinae about 50% of individuals and 6 of 15 species, which is now dated as the Early Eocene and attributed to the Afrotropical rather than the Palaearctic region.

There are important reasons to consider specialised desert-ant assemblages as having originated independently in five arid regions (in North America, the Palaearctic, South America, Australia, and southern Africa) from pre-existent humid faunas. Because of their characteristic pre-adaptation, viz. the presence of a proventricular valve, which permits storage of liquid food in the crop, the adaptive zone of diurnal zoonecrophagy is usually occupied in deserts by Formicinae and Dolichoderinae. Unlike them, Myrmicinae have the proventriculus closed by a sphincter, which is why they cannot store much food in the crop and so are usually carpophagous, storing seeds in the nest. This holds true for all deserts except the southern African ones, where *Ocymyrmex* species (Myrmicinae) occupy the niche of larger diurnal zoonecrophages. This could be interpreted as an indication that when the South African desert-ant assemblage was being formed, the ants better pre-adapted for this niche elsewhere (larger Formicinae and Dolichoderinae) were absent, thus enabling local Myrmicinae to occupy this adaptive zone. Only later did some species of *Cataglyphis* (Formicinae), larger diurnal zoonecrophages of Palaearctic deserts, reach there via dunes along the coast, but this adaptive zone had already been occupied by the highly specialised *Ocymyrmex*, so *Cataglyphis* was restricted to semiarid biotopes.

Recently we have described small but very interesting southern African Turonian ant fauna (Dlussky, Brothers, Rasnitsyn, 2004). It includes two species of *Orapia* (Armaniinae), two species of *Afropone* (Ponerinae) and earliest Myrmicinae *Afromyrma petrosa*. *Orapia* is a tipical Armaniinae. *Afropone* combines deeply plesiomorphic characters characteristic of Armaniinae (structure of the cranio-mandibular system, proclinate base of vein RS, angular 2+3RS) with apomorphies characteristic of advanced Ponerinae and basal Myrmicinae (triangular or absent cell rm). Print of *Afromyrma petrosa* is poor preserved, however important diagnostic characters of Myrmicinae (ant-like mandibles, two-segmented waist) are visible. We assumed, that an unknown relative of *Afrania* that combined plesiomorphic character states of Armaniinae with characters of advanced Ponerinae and basal Myrmicinae might well be an ancestor of Myrmicinae.

Decline and conservation of bumblebees

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Pollinators in general and bumblebees in particular have suffered declines in abundance and range contractions in the last 60 years, across much of western Europe and North America. Of the 25 bumblebee species known from the UK, three species are extinct and many more have undergone significant range contractions, with the possibility of further UK extinctions in the near future. It is widely accepted that these declines are linked to the intensification of farming practices, although much of the evidence is anecdotal.

The plight of our bumblebee fauna deserves particular attention because many other organisms are dependent on bumblebees for their survival. A large number of wild plants are pollinated predominantly or exclusively by bumblebees, sometimes by particular species of bumblebee. Thus, it seems probable that reductions in the abundance and species richness of bumblebees may lead to widespread changes in plant communities. These changes will have further knock-on effects for associated herbivores and other animals dependent on plant resources. In addition, bumblebee nests support a suite of commensal, parasitic and parasitoid species. There are also economic reasons for concern, for bumblebees pollinate some widely grown crops such as rape, field beans and various hard and soft fruits.

For many pollinator taxa, including bumblebees, fundamental aspects of their ecology remain poorly understood. Improved understanding of their ecology is vital if we are to design appropriate conservation strategies. I describe recent studies that reveal new details of the ecology of bumblebees, particularly with regard to the following: (a) Foraging range, nest density and landscape use; (b) Diet and habitat breadth: (c) Population structure, dispersal abilities and the importance of inbreeding in fragmented populations

Foraging range, nest density and landscape use

Foraging range is a key aspect of bumblebee ecology, for it determines the area of habitat (and therefore the amount of forage) which a nest can utilize. In consequence it also determines the appropriate scale of habitat management if we are to conserve bee populations, and the distances over which pollen might travel. This issue has become particularly topical with regard to the spread of genes from transgenic crops. Remarkably, despite the wealth of literature on bumblebee foraging behaviour there are rather few hard data available on bumblebee foraging ranges. They have proved to be unexpectedly hard to quantify. The obvious method is to mark bees at the nest and then to observe where they forage. In practice rather few marked bees are observed on forage, reflecting the difficulty in finding bees distributed thinly across a large area.

I describe an alternative approach. A large number of highly variable microsatellite loci have been developed for bumblebees, and most appear to work across a range of different species. These markers enabled us to reliably distinguish sisters from non-sisters. For the study species, workers from the same nest are known to be full sisters (although usurpation of queens or drift of workers between nests may lead to rare exceptions). By sampling workers of four common bumblebee species along a transect, then using microsatellite markers to identify sisters, we were able to quantify the distribution of foragers from nests and so estimate the minimum foraging range: 449m for *B. pascuorum*; 758m for *B. terrestris*; 450m for *B. lapidarius* and 674m for *B. pratorum*.

If the differences in foraging range we found between species are correct, then there are substantial differences in the area of forage available to each species; the *B. pascuorum* foraging range of 449m encompasses 62 ha, while that of *B. terrestris* encompasses 180 ha. All else being equal, this may enable *B. terrestris* nests to survive in degraded habitats with a lower density of forage, compared to species with shorter foraging ranges.

The molecular data also enables us to estimate nest density for the four study species, something that has not been achieved before. Estimates for densities of nests were 67.8/km^2 (range 48.3-76.9) for *B. pascuorum*, 31.9/km^2 (range 28.2-34.4) for *B. terrestris*, 120.3/km^2 (range 120.3-126.3) for *B. lapidarius* and 26.1/km^2 (range 24.6-31.1) for *B. pratorum*.

Data obtained from these studies has been used to parameterise and test models developed at the University of Newcastle which predict bumblebee nesting success in an arable landscape, and can be used to model the impact of land use change on bumblebee populations.

Diet and habitat breadth

A small number of bumblebee species (6 in the UK) seem to have been largely unaffected by changes to the environment in the last 60 years, and so far as can be established have suffered no declines in either abundance or range and remain more or less ubiquitous. I examine why some species have declined far more than others, and present evidence that this may be driven by dietary specialization. I present forage data on workers of 15 bumblebee species gathered from 172 one hour searches conducted at sites in southern UK, the Hebrides (western Scotland) and in New Zealand (to which UK bumblebees were introduced). I also review data on distribution, phenology and tongue length of these species. Overall, Fabaceae appear to be the major pollen source for most bumblebee species. In particular, long-tongued, late emerging species such as *B. ruderatus*, *B. humilis* and *B. subterraneus* specialize heavily in gathering pollen from Fabaceae, and a handful of unrelated plants, and this group of bumblebee species have all declined. Some of them are also at the edge of their geographic range in the UK, which may have rendered them more sensitive to environmental change. The decline of many bumblebee species is probably attributable largely to the loss of unimproved flower-rich grasslands, a habitat rich in Fabaceae. The bumblebee species that remain abundant are mostly short-tongued species that emerge early in the season and have less specialized diets; these species are very common in suburban gardens where they are able to exploit the broad range of floral resources. A third group of bumblebees are strongly associated with Ericaceae in moorland and heathland habitats, and have probably always had restricted distributions. A small number of species are not so easily categorised. *B. soroeensis* and *B. ruderarius* are not dietary specialists, nor are they close to the limit of their geographic range, but nevertheless they have declined.

Why should many bumblebee species prefer pollen from a small number of plant species mainly within the Fabaceae? I present evidence on pollen protein levels and the proportions of essential amino acids that show that the preferred plants provide higher quality rewards.

Population structure, dispersal abilities and the importance of inbreeding in fragmented populations

Owing to habitat loss populations of many organisms have declined and become fragmented. Vertebrate conservation strategies routinely consider genetic factors, but their importance in invertebrate populations is poorly understood. As monoandrous social Hymenopterans, bumblebees may be susceptible to inbreeding since their effective population size is determined by the number of nests, not the number of bees (most of which are sterile workers). I describe studies of the population genetics of three rare and declining bumblebee species (*B. muscorum*, *B. sylvarum* and *B. humilis*), on a model island system in the Scottish Hebrides, and on the mainland of the UK. We used microsatellites to study: population genetic structuring and geneflow; the relationships between genetic diversity, population size and isolation; frequencies of (sterile) diploid males - an indicator of inbreeding. We found significant genetic structuring in all three species, and isolation by distance. Populations >10km apart are all significantly differentiated, both on oceanic islands and on the mainland. Genetic diversity is reduced relative to closely related common species, and isolated populations exhibit further reductions. Most of the studied populations had an effective population size of <100. Many populations showed evidence of recent bottlenecking, and diploid males were detected in all three species. Our results demonstrate that fragmented populations of rare bumblebees are sufficiently small and isolated to lose genetic diversity through drift and bottlenecking. Limited production of diploid males in some inbred populations demonstrates a direct cost to inbreeding. Whether there are other fitness costs to inbreeding, and how important inbreeding is compared to stochastic events in driving local extinctions remains to be tested.

In summary, it is clear from the population structure and large foraging ranges of bumblebees that a landscape-scale approach is necessary to conserve diverse bumblebee communities. To conserve viable populations over the long term, large areas of suitable habitat are required. In the UK at least, nature reserves are probably too small and isolated to support metapopulations of the more specialised bumblebees in the longer term. Agri-environment schemes which enhance floral diversity (particularly of Fabaceae) in the farmed countryside are urgently needed.

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Wood ants use feeding state for the selective priming of navigational memories

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Ants can follow remarkably stereotyped and idiosyncratic routes to and from a familiar foraging area, implying the ordered recall of navigational memories. Foodward routes can sometimes be the same as homeward routes and sometimes the paths of the two routes differ significantly. In either case ants must acquire different views to guide the two stages of their round trip. We describe experiments which show that visual memories for guiding foodward or homeward paths can be primed solely by whether or not ants have fed, and so are in an internal state either to find food or to return home. The priming effect is powerful and can be seen when other possible priming cues are kept constant across the two conditions. In general, the priming of navigational memories is an important component of an insect's capacity to choose between different routes through the same environment.

On the capability to conditioned switching in higher social insects

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Keywords: ants, learning, maze habit, reinforcement, motivation, conditioned transswitching

The phenomenon of conditioned transswitching, discovered by E. A. Asratiyn, was studied in detal at different experimental models in vertebrates. Main point of transswitching of homogeneous or non-homogeneous motor conditioned reflexes consists in realization of adaptive behavior when the switchover acts. It is revealed many forms of transswitching and transswitched reflexes, conditioned by many factors: biological modal of reflexes, likeness or difference of tasks and way of their decision, stability of reflex, level of motivation and individual peculiarities of animals. It is emphasized that data about possibility of conditioned transswitching in higher social insects are not numerous and contradictory (Schneirla, 1961-1962; Reznikova, 1983, 2002; Kartsev at al. 1987, 2002). Take into account these circumstances we carried laboratory researches in the ants-active foragers *Myrmica rubra* in order to study its ability to conditioned transswitching of the formed maze habit when the reinforcement was forage (carbo-hydrate or protein) or *Myrmica rubra* brood, that is on conditioned when the ants learnt with social food motivation (forage) or protective one (transport of own brood). In several experimental series the ants formed maze habit on conditions food reinforcement (sugar syrup), and then the reinforcement was the *Myrmica rubra* brood. In other series the maze habit formed under carbo-hydrate food reinforcement (syrup) and in second part of experiment the brood of ants *Lasius niger* (protein forage) used as reinforcement. The reverse versions of experiments were carried too. During second part of experiment in the first experimental model on conditioned alteration of reinforcement the food motivation changed to protective one (or vice versa); in the second model the final link of the motor reaction changed under the same food motivation. In all experiments the activation of the motivation system was carried by the switchover using of corresponding reinforcement. Ability of ants-active foragers *Myrmica rubra* to conditioned transswitching of formed maze habit was showed. This ability realized in different ways: transfer of formed maze habit, its gradual alteration or fast change-over to another new strategy. The transswitching to another form of reaction could be accomplished with realization of instinctive mechanisms of behavior too. The probability to realize the mechanisms of conditioned or instinctive transswitching depends on concrete experimental conditions, the speciality of task, individual specific feature of ants. In large degree this probability depend on level of food social motivation in ants-foragers, that is on the degree of forage necessity of ant family.

Memory in honeybees: A network of parallel acting signalling cascades

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Keywords: cAMP, learning, memory, PKA

Throughout animal kingdom memory formation is a highly dynamic process that critically depends on a number of parameters, including the sequence and succession of stimuli during the training phase. Depending on these parameters a training procedure induce memories in a wide temporal range from short-term memories lasting only minutes up to long-term memories (LTM) that lasts for lifetime. Evidence from invertebrates and mammals show that various molecular mechanisms contribute to this multiphasic process of memory formation.

Learning and memory formation is generally studied under well-defined parameters including the control of satiation. Latter is especially important for appetitive learning paradigms as the associative olfactory conditioning of the proboscis extension response in honeybees. Since appetitive LTM is only induced after training hungry animals, our knowledge of the molecular machinery underlying memory formation is based on animals hungry during the time of training. We now addressed the question how the state of satiation during appetitive training affects memory formation and the underlying signaling cascades in honeybees.

Comparing groups of animals with different but defined feeding status at the time of conditioning reveals new and characteristic features in memory formation. As expected, three-trial conditionings of hungry animals induce a stable LTM consisting of a translation-dependent early long-term memory (eLTM; 1-2 d), and a transcription-dependent late LTM (lLTM; ≥?3 d). Feeding of a small amount of sucrose 4 h before conditioning leads to an impairment of learning and a loss of the different memory phases. Interestingly, the basal activity of the cAMP-dependent protein kinase (PKA), which is a key player in LTM formation, differs between animals with different satiation levels. Pharmacological rescue of the low basal PKA-activity in animals fed 4 h before conditioning leads to a rescue of transcription-dependent lLTM, while acquisition, mid-term memory and eLTM is still impaired. This provides first evidence for a central and distinct function of the cAMP/PKA cascade connecting satiation level with learning. Moreover, the central function of the cAMP/PKA cascade in LTM induction can be dissected into a cAMP/PKA-dependent processes that directly induces the induction of lLTM and a parallel acting cAMP/PKA-dependent mechanism required for other aspects of LTM formation. Taken together, variation of parameters essential for learning and memory formation provides a unique tool to uncover new functions and contributions of molecular cascades in neuronal plasticity.

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Memory formation after acquisition and retrieval in the honeybee (*Apis mellifera*)

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In honeybees, as well as in all other animals studied, memories take time to be established and can be disturbed during the time-interval of fixation. This process, during which memories become stable, is called consolidation. During the consolidation of a memory its formation can be inhibited by interfering with molecular processes that mediate the memory's formation at the time point of the interference. In this study we use inhibitors of translation to interfere with protein synthesis-dependent processes during memory consolidation. This enables us to differentiate between different memories whoseich formation depends on protein-synthesis. We are studying consolidation processes that are induced by retrieving a consolidated acquisition memory. In many studies it has been demonstrated that memory retrieval initiates two consolidation processes: consolidation of an extinction memory and reconsolidation of the acquisition memory. The strength of the consolidation processes depends on both the strength of the acquisition memory and the strength of retrieval trials. We demonstrate that in the honeybee (*Apis mellifera*) memory retrieval of a consolidated appetitive olfactory memory leads to both consolidation processes, depending on the number of retrieval trials. Surprisingly, this dependency is inverse to the one found in vertebrates and invertebrates when studying aversive conditioning paradigms. To elucidate this discrepancy we are now trying to unravel the influence of the acquisition on the formation of retrieval-induced memories in the honeybee.

Ion channels and modulations. The cellular physiology of neurons involved in honeybee olfactory learning

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Honeybees (*Apis mellifera*) can learn to associate an odour with a sucrose reward in a classical conditioning paradigm. The acquisition, memory formation and memory retrieval of the learned odour requires neural activity within the mushroom bodies and the antennal lobes. We assume that neurons within these brain areas undergo plastic changes that underlie the learning-dependent behavioural plasticity. But what are the cellular and synaptic mechanisms of insect olfactory learning? We investigate ligand-gated ionotropic receptors and their modulations on identified neurons of the honeybee olfactory pathway. For this, we combine patch clamp and neuroimaging techniques *in vitro*.

Within the primary olfactory neuropile of the insect brain, the antennal lobe, spatio-temporal patterns of odor-induced activity are produced through complex interactions of excitatory, inhibitory and modulatory synaptic transmission. We identified functional ionotropic acetylcholine receptors on cultured antennal lobe neurons. Applications of GABA or glutamate induced picrotoxine-sensitive chloride currents. This indicates one excitatory cholinergic and two inhibitory networks within the honeybee antennal lobe.

Projection neurons connect the antennal lobes with the mushroom bodies. They are probably cholinergic and the mushroom body intrinsic Kenyon cells express an ionotropic acetylcholine receptor. This cation-selective receptor has a neuronal nicotinic profile and high calcium permeability. Thus, activation of the conditioned stimulus (odour) during classical conditioning of the proboscis extension reflex induces a membrane depolarization and a calcium influx into mushroom Kenyon cells.

Octopamine ist the transmitter of the reward pathway in insects. In the honeybee it is released by octopaminergic VUM neurons onto antennal lobe and mushroom body neurons. Octopamine modulates the odour processing by modulating the ACh-induced currents of Kenyon cells probably through calcium-dependent signalling pathways. With patch Clamp recordings we showed that bath applications of octopamine reduce the ACh currents by about 30%. A similar reduction is induced by 8-bromo-cAMP or a Ca^{2+} ionophore. This implied that octopamine acts through a Ca^{2+}-dependent pathway.

Using calcium imaging we verified that octopamine induces calcium signals in cultured honeybee neurons. Pressure applications of octopamine induced transient elevations of the intracellular Ca^{2+}-concentration. If the cell is perfused with Ca^{2+}-free extracellular solution a rise of the concentration of Ca^{2+} is induced, indicating that Ca^{2+} is released from intracellular stores. The Ca^{2+}-signals can be blocked by the octopamine antagonists, mianserine or epinastine. We thus showed for the first time that octopamine induces Ca^{2+}-signals in native insect neurons.

Our data are incorporated into a working model of the synaptic wiring of the olfactory pathway and the cellular mechanisms of honeybee olfactory learning.

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Excitatory amino acids in memory formation and retention of the honeybee *(Apis mellifera L.)*: ontogenetic and genetic aspects

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Keywords: bee, glutamate receptors, memory, kynurenine disorders, imago development

Behavioral plasticity is one of the basic tools of evolution. The excitatory amino acid synapses are extremely plastic and therefore can play an important role in higher central nervous function such as learning and memory. Our study was focused on the role of glutamate receptors in the associative learning of the honeybee. The effect of the system and intracerebral injections of the L-glutamate and L-aspartate, their agonists, antagonists and modulators on memory formation and retention was analyzed in single learning trial experiments in wild bees during imago development and in *Tryptophanoxygenase* (--) knock-out bees. The sensitization and both the food and sensory excitability were controlled before experiments. Short-term memory was shown to be activated by L-glutamate, L-aspartate, AMPA, NMDA and domoic acid, but suppressed by GAMS, DNQX, AMPA receptor antagonist NS-257HCl, NMDA competitive antagonists AP4, AP5, AP-3, the NMDA ion channel blockers MK-801 and ketamine. Long-term memory was stimulated by L-aspartate, ibotenic and quisqualic acids, ACPD and L-phosphoserine, but suppressed by injection of –DNQX, MCPG, AP-3, noncompetitive $1mGluR_1$ antagonist CPCCOEt and $1mGluR_5$ antagonist SIB 1757.

This suggest that the heterogeneous population of glutamate receptors are present in the cerebral ganglion of the honeybee. The data indicate that NMDA receptors had the pharmacological profile similar to that of mammals. The central AMPA receptors exhibited pharmacological characteristics similar to those of mollusks. AMPA and NMDA receptors were involved in short term memory formation. Different subtypes of metabotropic glutamate receptors participated in long-term memory formation and retention. Coactivation of AMPA and NMDA receptors can be one of the possible mechanisms of the short-term memory stimulation. Metabotropic glutamate receptors can be activated by NMDA receptors.

The functional characteristics of different subtypes of glutamate receptors were shown to depend on age and bee genotype. The sensibility of NMDA receptors was maximal in 3 and 7 days of imago. The involvement of kainate receptors in short-term memory was documented only at 7 day. In contrast the sensibility of AMPA and metabotropic glutamate receptors was constant during development. The *Tryptophanoxygenase* (--) knock-out bees (with kynurenine deficit) showed a 1- to 2-fold increase of sensitivity of mGluR and of NMDA receptors. The short-term memory of the mutants but not of wild type bees was stimulated by kainate. Memory formation and retention can be modified during imago development and under gene determined kynurenine disorders.

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Watching the bee brain when it learns

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Honeybees have small brains, but their behavioural repertoire is impressive. They navigate over several kilometers using a geometric reference system of the environment, which they establish during observatory flights. They communicate about important places by a ritualized movement (the waggle dance) indicating distance and direction to the particular location from their nest site. They learn about the features of food sources (color, odor, shape, relative position). Reward learning in honeybees initiates a sequence of neural processes that lead to long-lasting memory, and pass through multiple transient memory phases. The lecture will present our top down strategy starting with behavioral observations under nature conditions, establishing a reduced but whole animal preparation that reflects the essential properties of associative learning and allows for the study of associative learning at the behavioral and neural level.

Optophysiological recordings are applied to study associative plasticity at the level of the single neuron and neural circuit. The report shall focus an recent data collected from the mushroom body. Special emphasis will be given to the question, how memory contents about rewarded odors are encoded in the network properties of the input to the mushroom body. The optophysiological approach allows us to trace memory not only with respect to the mechanisms involved in forming the memory but also to the patterns of synaptic plasticity that store the contents of the memory. A model will be presented that assigns different functions based on different neural coding strategies to these two neuropils.

Neuroscience in general needs model systems to unravel the intricate and complex working of the brain. Insects provide us with the ideal situation to address basic problems of brain science at a level of neural complexity at which it can be analyzed with the available methods using animals that still are able to behave. I shall highlight the unique opportunities of insects in the search for the neural basis of behavior.

Genomic dissection of behavioral maturation in the adult worker honey bee, *Apis mellifera*

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Keywords: honey bees, *Apis mellifera*, behavior, brain, development, genomics, microarray, gene expression

As individuals age, their behavioral responses to stimuli change in predictable ways. We used an integrated genomic approach to dissect natural behavioral maturation in the adult worker honey bee, *Apis mellifera*, using both genetic differences and neuroactive treatments that influence the age at onset of foraging behavior. Statistical analyses revealed extensive, combinatorial influences on mRNA abundance for most genes expressed in the brain (~5500 genes examined). Despite this apparent complexity, principal component analysis (PCA) revealed a surprisingly simple underlying gene expression architecture: 65% of variation between individuals was explained by 3 PCs, and >80% by 9 PCs. Distinct gene expression "axes" were associated with age, behavior, genotype, environment (colony), stress, and treatment. We used these axes and additional experiments to decompose brain gene expression into three components: (1) development of behavioral competency, which is complete by 8 days of age, (2) current behavioral state, e.g., nurse or forager, and (3) experience. We present a set of genes that are "best candidates" for mediating behavioral differences. Expression of these genes was associated with behavior irrespective of age or genotype, downstream of important modulators of behavior (e.g., juvenile hormone), and *not* downstream of behavior-consequent experience or environmental differences. Together with previous results, our findings demonstrate that there are robust molecular correlates of natural behavior that can be readily dissected to reveal important regulatory relationships in the brain.

The role of the "thelytoky" locus for reproductive dominance in honeybees (*Apis mellifera*)

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Keywords: thelytoky, *Apis mellifera capensis*, social parasitism, laying workers

The Thelytoky gene in the Capehoneybee (*Apis mellifera capensis*) suppresses recombination during meiosis in laying honeybee workers. Laying workers which are homozygous for the thelytoky-allele (*th/th*) partheogenetically produce almost clonal diploid offspring. They automictically lay fertilized eggs after the fusion of the central chromosomes in meiosis and have a drastically reduced crossing over rate. The thelytoky allele therefore behaves similar to a selfish gene and manipulates meiotic and sexual processes by maintaining homozygosity at this locus. Evolutionary theory predicts selection for selfish worker reproduction in species carrying such a gene. Thus it is not surprising to find that thelytokous workers of *A. m. capensis* have recently evolved into social parasites. These parasitic workers pheromonally mimic the queen, suppress reproduction in other workers, and make host colonies rear their offspring. Here we show that the *th* - gene, which prevents recombination with other genes and maintains the parasitic lineage as a genetic clone, also controls selfish behaviour in parasitic workers.

Genomic response to pheromones in the honey bee brain

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Pheromones produce stereotyped behavioral and physiological changes in a variety of species. A great deal of research has focussed on identifying receptors and neural networks that process the pheromone signals, but the molecular mechanisms by which pheromones alter the brain and thereby alter behavior have not been investigated in detail. Queen mandibular pheromone (QMP) is one of the most important and best-characterized pheromones regulating worker behavior in honey bees. QMP inhibits worker ovary development, and slows the transition from nursing to foraging in young bees. However, if a bee is the forager behavioral state, exposure to QMP appears to produce the opposite response and stimulate foraging behavior. We used microarrays to monitor gene expression changes that occur in the brains of young worker bees exposed to QMP over a timecourse of four days. Interestingly, the changes in expression patterns corresponded to the known behavioral effects of QMP: it preferentially upregulated genes associated with nursing, and downregulated genes associated with foraging. We further characterized the effects of behavioral state on QMP regulation of two of these genes, the wingless receptor Fz2 and the transcription factor Kr-h1. Though reactions to pheromones are considered to be stereotyped and hardwired, responses can be modulated depending on the state of the animal. By using gene expression as a sensitive biomarker of pheromone response in the brain, we can begin to characterize the neural pathways and molecular mechanisms by which this response modulation occurs.

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Molecular and pharmacological characterization of honeybee serotonin receptors

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The honeybee *Apis mellifera* is a model organism for studying insect division of labor, learning and memory. An important substance that has been implicated in the control and regulation of these phenomena is the indolalkylamine serotonin (5-hydroxytryptamine, 5-HT) Pharmacological and functional studies indicate, that serotonin activates various receptor subtypes which predominantly belong to the family of G protein-coupled receptors (GPCRs).

Using a homology based screening approach on a brain-specific cDNA library of the honeybee and a PCR-based strategy we have isolated cDNAs encoding three putative serotonin receptors. The deduced amino acid sequences of these putative honeybee serotonin receptors show the highest homology to a 5-HT$_7$ and a 5-HT$_2$ receptor from *Drosophila melanogaster* and a 5-HT$_1$ receptor from *Panulirus interruptus*, respectively. We have studied the distribution of the respective 5-HT receptor mRNAs in several tissues of the honeybee by RT-PCR. The analysis revealed a high amount in the central brain. By using *in situ*-hybridization we detected receptor encoding mRNA in cryostat sections of honeybee brain. We could prove receptor transcripts in neurons of the optic lobes, intrinsic mushroom body neurons, and deutocerebral neurons.

In a HEK 293 cell line, stably expressing the 5-HT$_7$ receptor protein, we investigated the intracellular signalling pathway. When activated by serotonin, the heterologous expressed 5-HT$_7$ receptor induces an increase in intracellular cAMP levels ([cAMP]$_i$). The stimulation with other biogenic amines (octopamine, tyramine, and dopamine) did not induce a significant change in [cAMP]$_i$ Furthermore, Am5-HT$_7$ causes a significant increase in the non-agonist stimulated cAMP levels relative to those of non-transfected cells. Therefore, the Am5-HT_7 receptor displays agonist-independent (constitutive) activity which has also been demonstrated for many other GPCRs.

A specific affinity-purified anti-Am5-HT_7 antibody detected a protein band of the expected size of ~66 kDa in homogenates of honeybee brains and HEK 293 cells expressing the Am5-HT_7 receptor.

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Molecular underpinnings of socially mediated plasticity in circadian rhythms in the honey bee *Apis mellifera*

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Keywords: honey bee, circadian rhythms, division of labor, plasticity, clock gene

Honey bees show remarkable socially modulated plasticity in circadian rhythms. Bee larvae require constant care and young “nurse” bees work around the clock with no circadian rhythms to provide it; older foragers have strong circadian rhythms that are used for sun compass navigation, dance communication, and for timing visits to flowers. To explore the molecular bases of this remarkable plasticity, we cloned orthologes for the principal clock genes and measured (with real time-PCR) their mRNA levels in whole brains of foragers entrained in a 12 hrs light: 12 hrs dark (LD), or a constant darkness (DD), illumination regime. Our phylogenetic analyses indicate that the honey bee has only the mammalian-type *cry* and lacks a true homolog to Drosophila *tim*. Brain mRNA expression profiles were also more similar to mammals than to Drosophila. Brain *cry* mRNA levels oscillated with high amplitudes (4.6-7.0 fold) and a peak at night, similar to the phase of *per*. Brain *clk* and *tim* mRNA levels did not show significant diurnal oscillations. By contrast to foragers, brain *per* and *cry* mRNA levels were weak or absent in nurses under both LD and DD illumination regimes. Taken together, our findings suggest that some important features of the honey bee clock are more similar to mammals than to Drosophila and that behavioral plasticity in circadian rhythms is mediated by molecular alternations in the central pacemaker. These findings suggest a link between colony social organization (division of labor) and plasticity in the molecular clockwork of bees.

The multifaceted role of cuticular hydrocarbons in social insects

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Keywords: cuticular hydrocarbons, nestmate recognition, fertility signals

Traditionally, cuticular lipids in insects have been thought to function as a protective barrier for preventing desiccation. However, being externalized chemicals they were opted in many insects as communicative signals. This is especially true for social insects, in which chemical communication has reached an evolutionary peak. Among the lipid components cuticular hydrocarbons have drawn special attention. Their complexity and specificity have lead to the assumption that they function as the label responsible for nestmate recognition. Specific experiments in several species have indeed shown that the hydrocarbons, but not the non-hydrocarbon lipid fraction indeed provide the necessary label for discriminating nestmates from alien individuals.

Recent studies have revealed another possible function for cuticular hydrocarbons, that pertaining to caste specific behavior and physiology. Specifically, many correlative studies have shown that these hydrocarbons may constitute a fertility signal and therefore mediate the complex queen-worker relationship that results in reproductive skew. In some case, a subset of cuticular hydrocarbon was implied while in other cases the more complex blend seems to be necessary for full activity.

There seems to be a contradiction between the above two function. Nestmate recognition, in particular in large colonies predicts that colonial odour would be homogenous among nest members, whereas fertility signals are based on differential expression of all or some of the relevant hydrocarbons. Reconciling between these to opposing phenomena should pave the way to better understanding pheromone parsimony in evolution.

Nestmate and non-nestmate discrimination by a CHC-sensitive sensillum in a Japanese carpenter ant

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Keywords: ants, hydrocarbons, chemosensillum, nestmate recognition, chemosensory protein, electrophysiology

Ants have developed a sophisticated chemical communication system that enables them to reject non-nestmate conspecifics and to accept nestmates. Many behavioral experiments have suggested that their aggressive behavior against non-nestmates is evoked by contact chemosensory detection of differences between colony-specific chemical signals of cuticular hydrocarbons. Despite this well-defined behavior, the sensory mechanism for nestmate and non-nestmate discrimination has been unclear. We describe a new sensory sensillum on the antennae of the carpenter ant *Camponotus japonicus* that functions in nestmate discrimination. This sensillum is multiporous and houses about 200 receptor neurons. Within the sensillum, we found a chemosensory protein, which can dissolve the CHCs in the hydrophilic surroundings of the receptor membranes. Using the recombinant protein, we dissolved the CHCs derived from different colonies in stimulus solutions and gave them to the sensillum. The results indicated that the sensillum responded only to the non-nestmate CHCs with vigorous impulse discharge but not to the nestmate CHCs. Thus, we would like to propose that in addition to the traditional dynamic “neural template hypothesis”, a peripheral mechanism may act as a “filter” for nestmate recognition.

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Queen signal and pheromonal parsimony in a ponerine ant

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Keywords: ants, reproductive conflicts, fertility signal, queen pheromone, worker policing

Primitive ant societies, with relatively simple social structure, give us the opportunity to explore the evolution of chemical communication, in particular of mechanisms underlying within-colony discrimination. In the same colony, slight differences among individual odors can be the basis to discriminate among different castes, classes of age and social status. Correlative studies have given some evidence that such inter-individual variation is associated with differences in reproductive status, but a direct proof for certain chemical compounds being detected and recognized by ants was lacking.

In the ponerine ant, *Pachycondyla inversa*, fertile queens and, in orphaned colonies, dominant, egg-laying workers are characterized by the predominance of a branched hydrocarbon (3,11-dimethylheptacosane) on the cuticle. Using electroanntennography and gas chromatography with electroantennographic detection, we showed that workers detect and react to this key compound (D'Ettorre et al. 2004a). 3,11-diMeC$_{27}$ is correlated with ovarian activity and, because it is detected, is likely to assume the role of a fertility signal reflecting the quality of the sender.

P. inversa workers kill (police) worker-laid eggs, and 3,11-diMeC$_{27}$ is also present in significantly higher amount on queen-laid eggs than on worker-laid eggs (D'Ettorre et al. 2004b). Since ant colonies keep eggs in piles, worker-laid eggs might become more acceptable once placed in the egg pile, by acquiring odour from touching queen-laid eggs. Using behavioural manipulations and chemical analyses, we showed that such "cue scrambling" does not occur. Policing, therefore, is stable against this potential cheating mechanism, probably because queen-laid eggs are marked with a queen signal which is not easily transferred by physical contact. This is likely to be an example of the widespread pheromonal parsimony, with a key chemical compound serving as a fertility signal and protecting queen-laid eggs from policing.

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Genetic and cuticular hydrocarbon variations among and within colonies of a non-aggressive subterranean termite

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Keywords: subterranean termite, *Reticulitermes santonensis*, microsatellite DNA, cuticular hydrocarbons, multivariate analyses, relatedness.

That some species of Isoptera and social Hymenoptera do not exhibit the intraspecific aggression is inconsistent with the kin recognition process commonly expected to occur in social insects. We investigated whether high genetic relatedness and cuticular hydrocarbon similarity could explain the absence of aggression among and within colonies of *Reticulitermes santonensis* termites (Dronnet *et al.* submitted). *R. santonensis* shows a special colony breeding system in which most families are headed by inbred secondary reproductives (Dronnet *et al.* 2005).

We analysed the cuticular hydrocarbons of 10 different workers from 14 colonies by gas chromatography and genotyped the same individuals using 10 DNA microsatellite loci (Vargo 2000; Dronnet *et al.* 2004).

Multivariate analyses showed a correspondence between genetic variation among colonies and cuticular hydrocarbon patterns. A novel approach combining genetic and chemical data (redundancy analysis) showed that a few hydrocarbons accounted for most of the genetic variation. The fact that genetic and chemical distances showed a strong positive correlation suggested that there might be a genetic basis for cuticular hydrocarbon variation but it is likely that some hydrocarbons are from environmental sources since genetic distance did not account for all chemical variation. Investigation at the intracolony level suggested that cuticular hydrocarbons did not depend on colony social structure.

We speculate that lack of intraspecific aggression in *R. santonensis* may have resulted in the loss of diversity in genetically derived recognition cues in this species supposed to be introduced from North American *R. flavipes* populations.

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The metamorphosis of the queen's chemical signature in the ant *Pachycondyla villosa*

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Keywords: ants, cuticular hydrocarbons, chemical profiles, *Pachycondyla*

Cuticular lipids play an important role in recognition process of social insects both at the colony and at the individual level. Indeed, there is evidence for a correlation between cuticular profile and reproductive status in some wasps and ants. For example, in the ponerine ant *Pachycondyla inversa* queens and workers show a very similar cuticular pattern, but one particular hydrocarbon (3,11-diMeC_{27}) is more abundant on the queen's cuticle and may act as a fertility signal (d'Ettorre 2004).

In the present study, we analysed a sibling species of *P.inversa*, *P. villosa*, and showed that the communication strategy between queens and workers is different. The cuticular pattern of young queens during the founding stage is very simple and resembles that of workers. In contrast, older queens from mature colonies show a more complex chemical signature, with a specific bouquet of compounds. Using gas chromatography with electroanntenographic detection, we showed that workers' antennae react to several substances present in the queen-specific bouquet, suggesting that this can be involved in the communication of queen fertility and the regulation of worker reproduction.

Sniffing Bees: Error rate differences in recognition of wasp and bee intruders by honey bee (*Apis mellifera*) entrance guards demonstrate overlapping cue distributions in the recognition of nestmate versus non-nestmate bees

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Honeybee entrance guards, *Apis mellifera*, use odour cues to discriminate nestmates from intruders. We tested the hypothesis that the odour cue distributions between nestmate bees and intruder bees overlap by comparing the acceptance of three classes of insects: nestmate worker bees, non-nestmate worker bees, and worker common wasps, *Vespula vulgaris* by entrance guards. We hypothesized that the overlap of cues between nestmate and non-nestmate bees would result in recognition errors. Conversely, we hypothesized that guards would not make errors in recognizing wasps because wasps and bees should not have overlapping recognition odours. This is what we found. There was a negative correlation between errors in recognising nestmate (error: reject nestmate) and non-nestmate (error: accept non-nestmate) bees. However, there was no correlation between errors in rejecting of nestmate bees and accepting of wasps. All wasps were rejected, even early in the summer when wasp intrusions were infrequent. The results strongly support the prevailing idea that overlapping cue distributions occur in the recognition of nestmate versus non-nestmate bees, resulting in recognition errors and leading to adaptive shifts in acceptance thresholds.

The biodiversity of honeybee races in Turkey

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Keywords: *A. m. anatoliaca, A. m. caucasica, A. m. carnica, A. m. syriaca, A. m. meda,* Turkey

Turkey is a geographically diverse country less than 1,000 miles long (east to west) and generally less than 500 miles wide (north to south), but in which elevation varies from sea level to over 16,000 feet (Metz 1996). Within that relatively small area occurs regions with Mediterranean, Continental, Desert, Alpine and Temperate-Rainforest climates (Spencer 1990). That variation in climate is reflected in tremendous biome diversity (Metz 1996), and consequently ecotypic diversity in honeybees (Ruttner 1988) as well as other widely distributed organisms. Often the transition between biomes will occur in less than 100 miles.

Geography has much to do with the climatic differences in Turkey (Metz 1996). The Black Sea, Ilgaz and Taurus Mountains respectively line the Back and Mediterranean Seas, and converge in the far eastern region of the country (Anti-Taurus Mountains). Between these mountain ranges is the Anatolian Plateau. This plateau receives neither the moderating influence of the Black nor the Mediterranean Sea due to these mountain ranges. In fact, the plateau is a semi-arid steppe suffering from the rain shadows produced by the Pontus and Taurus. Its thus has a continental climate characterized by hot, dry summers and long winters often with heavy snow falls (Metz 1996). This region is endemic to the Anatolian honey bee race (*A.m. anatoliaca*), which may differ from east to west (Ruttner 1988). These bees are characterized morphologically by their yellow bands and similar in size and color to Italian bees. Anatolian bees are known with energetic food collecting activity, saving energy and reserves. Drifting of bees are low compared to Caucasian. They are known as an aggressive race that is prone to swarming. In the cold winters that prevail in this region, they over-winter well with very little honey reserves. The Anatolian Plateau is not the only grassland in Turkey.

The Thrace region is an extension of the Balkans grassland that experience moderate temperatures throughout summer and mild winters (Spencer 1990). In this grassland region the Carniolan bee (*A.m. carnica*) is prevalent. These are dark, large bees that are known for their gentle nature. They swarm less than the Anatolian bees, and over-winter well in cold regions with a small winter cluster and use little propolis.

Where The Black Sea, Ilgaz and Taurus Ranges converge in eastern Turkey is the Eastern Highland (Metz 1996). Mountains here very rugged and are the highest in Turkey (up to 16,000 feet), which produces an alpine vegetation zone at higher elevations. The region is known for its severe winters with heavy snowfall, but summers at low elevation can be quite hot (Metz 1988). Ruttner (1988), this region is endemic to the Armenian race of honeybee (*A.m. armeriaca*). However, these bees may simply be an ecotype of the Anatolian bee. These are large bees with large colonies. They are easily distinguished from the Caucasus bee by having yellow bands. In other respects, little is known about them. The snow pack of the mountains of this region supply the headwaters of the Euphrates, Tigris and Aras Rivers. Those waters have recently (1980s) come under the control of a series of large dams in Turkey (GAP Project) that has reduced the water flow into the Tigris-Euphrates Valley as well as the Caspian Sea (Aras River). That water has been diverted to the arid southeast and to the eastern Anatolian Plateau. Environmental problems involving silting and soil salinization faced in the Indus and Mesopotamian valleys pose new problems (Postel 2000).

The Black Sea is a rocky coast isolated from the rest of Anatolia. The Black Sea mountains increase from an elevation of approximately 4,000 feet in the west to about 10,000 feet in the east. With that change in elevation is a corresponding change in climate. The eastern Black Sea region of Turkey is a temperate rainforest characterized by damp, forested, steep mountains skirting the coast that are cut by cascading rivers, while the far western region is hilly grassland (Metz 1996). The Caucasian bee (*A.m. caucasiaca*) inhabits this region. It is a large bee, with the largest colonies. These bees are gentile, rarely swarm, prone to drifting and known with excessive use of propolis. This may be due to the bee mass that is needed to survive winters in this region. Open debate exists as to how far inland and how far west along the Black Sea this honey bee occurs (Ruttner 1988; Smith *et al.* 1999; Smith 2002).

A Mediterranean climate persists between the Taurus Mountains and Mediterranean Sea, and also on the rolling plateau that parallels the Aegean Sea. Summers are hot and moderately dry while winters are mild and rainy. Vegetation changes from pine forest along the Aegean and western Mediterranean of Turkey to chaparral along Anatolia's eastern Mediterranean (Spencer 1990). The waters of the Aegean and Mediterranean are warmer and calmer than those of the Black Sea. At present, this area is considered to be within the range of the Anatolian bee. However, there scant evidence to support or discredit this claim.

The Arabian Platform makes up the final bio-geographic region of Anatolia (Metz 1996). It is south of the Anti-Taurus Mountain in the far eastern region of the country. It is characterized by arid rolling hills that continue into Syria, and desert conditions (Pope & Pope 1998). This region is inhabited by the Syrian bee (*A.m. syriaca*). It is the smallest, most aggressive bee in Turkey. Wasp and bee-wolf predation of workers is high in this region. These bees are known for their tendency to swarm.

Honeybees in Turkey differ not only in morphometrics but also in foraging behavior, as seen in flower fidelity (Cakmak 1997; Cakmak *et al.* 2000). There are still many gaps and transition zones where honeybees do not fit into a known honeybee race in Turkey. This great diversity and variation can be used to solve some problems such as resistant bees to disease and parasites in beekeeping.

There are many migratory beekeepers in Turkey and therefore many colonies are hybrids. This is particularly true in Thrace and some part of the Aegean and Mediterranean due to sunflower pollination and pine honey collection. It is hard to find stationary beekeepers in those regions. However, if this is possible the results may reveal the nature of the endemic native races in each area. This, in fact, may be possible since beekeepers catch swarms, but few rear queens to re-queen colonies. Just 5% of beekeepers buy queens from commercial queen breeders (The Turkish Ministry of Agriculture). This suggests that non-migratory beekeepers still have native races and ecotypes from these regions. This is of special importance because it provides the diversity to search for disease resistance and the most effective pollination vectors in agriculture settings.

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Gene pool of Black European bee *Apis mellifera mellifera* L. in Ural region

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***Keywords**: Apis mellifera*, population genetics, gene pool conservation

The critical condition of honeybee gene pool is one of the main reasons of the modern crisis in the Russian beekeeping. Black European bee *Apis mellifera mellifera L.* is unique adapted for cool long-lasting winter, *Nosema apis*, and intensive, but short honey yield. Unfortunately, for the last two ages its natural habitat became far less. In Russia *A. m. mellifera* is presented in the manner of separate isle - local populations.

In Institute of the biochemistry and genetics USC RAS complex of the methods, allowing analyse of honeybee gene pool in intensive intraspecific hybridization conditions was created. Now the complex includes mtDNA AFLP-PCR method for identification of the bee family race origin on maternal line, defensine gene AFLP-PCR method, RAPD-PCR, microsatellite polymorphism analysis, comparative sequence of separate cites mtDNA, modified morphometric method of V. V. Alpatov (1948).

In process of the work we investigated 1091 bee families from 74 apiaries in Ural region, as well as 130 bee families from artificial hollows in reserve "Shuligan-Tash". There was is shown that on majority of the apiaries gene pool A. m. mellifera and gene pool honeybees of the south races are in the ratio 1:1. So the main part of A. m. mellifera old natural habitat presents itself hybrid zone. The hybrid familis quota on apiaries varies within the range from 0,58 before 1,00.

However, we find four intact local populations A. m. mellifera. On their base is possible Black European bee gene pool reconstruction. At present we conduct the comparative analysis of discovered populations.

Besides, we have shown differences in immune answer of A. m. mellifera and bees of the south races. Low level of normal redox processes, more high stress-reactivity of antioxidative ferments, glyukozo-6-phosphatedehydrogenase, phenoloxidase cascade ferments, high and stable glycosamineglycanes level are characteristic for Black European bee. These immune answer particularities of A. m. mellifera can to serve as perspective criterions for reconstruction breeding.

Races of honey bees, human nations and religions

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Keywords: races of honey bees, religion

The races of honeybees in contrast to stocks of domestic animals really were not changed by the humans. In the majority of European countries the beekeepers work with aboriginal races of honeybees, which lived in the same regions several thousand years ago and the modern religions were formed at the background of existing honeybee races.

F. Ruttner (1988) separated new race of honeybees *Apis mellifera macedonica* from the large body of central Europian bees *A. m. carnica*. These bees live in the Nothern Greece, Bulgaria, Romania and (maybe) part of the former USSR. National bee scientists didn't recognize the Ruttner's hypothesis: the Bulgarians believe that they have aboriginal Bulgarian bees *A. m. rodopica* (Petrov, 1993), the Romanians think, that they have aboriginal *A. m. carpatica* (Foti et al, 1965), Ukrainians recognize aboriginal *A. m. acervorum* (new name is *A.m. sossimai* Engel, 1999). But from the scientific point of view the coincidence of the country borders and limits of the race distribution isn't possible.

F. Ruttner (1988, page 250) found very strange fact of the acute coincidence of the border of distribution of Bulgarian and Turkey honey bees with the frontier between these countries and he noticed: "An explanation for this observation is very hard to give". We noticed also, that the Macedonian bees are distributed in the countries with Orthodox Church only.

Our analysis of the facts of Europian history and distribution of the honeybee races gave the basement for conclusions about the mutual influence of social bees, main religions and life of human nations. These conclusions can be formulated as follows:

The distribution of the different aboriginal honeybee races in Europe coincides with the distribution of main religions. The Italian (*Apis mellifera ligustica*) and Carniolian (*A. m. carnica*) bees are distributed in catholic countries; macedonian bees (*A. m. macedonica*, Ruttner, 1988) live in the countries with orthodox religion, and dark forest bees (*A. m. mellifera*) are incompatible with Catholicism. The hybrid honeybee races are in use in Protestant countries usually.

It doesn't exist any honeybee race, which would be naturally distributed simultaneously in Christian and Moslem countries (exclusion is small Albania).

The human population has life problems in the near-border regions, where main religion and honeybee race don't correspond to one another and the system "main religion-honeybee race" is moving to the necessary balance.

Is it possible to formulate the following consequence, which will be important for beekeepers and bee scientists: the introduction of foreign bee races to the regions with inappropriate religion can't be successful. There are several examples, which support this statement.

On the our opinion the possibility of the reverse influence the bee races on the human life can't be excluded – maybe the use of appropriate races can harmonize the life of humans.

The above hypothesis is outside of scientific understanding of the world, but the religion is outside of it also. The strange link of coincidences of the events in the life of nations and social bees don't permit to leave this hypothesis outside of our attention.

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The evolution of termite functional diversity: a global phylogenetic perspective

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Recent studies of termite assemblage structure across the globe have shown very clear diversity anomalies, with diversity in tropical rain forests declining as follows: Africa > South America > Asia > Madagascar > Australia. These anomalies have been hypothesised to be due to island biogeographical processes, but have never been tested using detailed phylogenetic data. Such data now exist for the Termitidae as a whole and one termitid subfamily, the Macrotermitinae (fungus-growing termites). I use these data to test for island biogeographic patterns in global termite assemblages and show that assemblages are not nested sub-sets of the entire termite global species pool and that they are strongly influenced by (a) present and past biogeographical isolation from the African continent, (b) habitat quality, and (c) continental size and age. Assemblage structure appears to be strongly constrained by the number of successful colonisation events by wood-nesting termites as well as by the amount of time that the colonising clades have had subsequently to undergo adaptive radiation down humification gradients. This means that termite global assemblages are strongly influenced by historical processes and that they are only weakly ecologically convergent across continents.

In search of a coevolution between *Nasutitermes* and their actinomycete digestive flora

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Keywords: *Nasutitermes*, actinomycetes, specific strains isolation, microbiology, DGGE, 16S rDNA amplification

In the history of life, the order *Isoptera* experienced a large evolutionary radiation which is notably explained by beneficial associations with a varied digestive microbiota. These mutualistic associations are generally studied for their functional role in the insect's metabolism, but their evolutionary importance remain little considered. Our study focuses on the possible coevolution between a widely distributed genus of termite -the *Nasutitermes*- and a distinctive order of bacteria the *Actinomycetales*-. These microorganisms, generally present in soil, have strong capacities in the decomposition of recalcitrant polymers (lignin, cellulose), and so they could be suspected of being some advantageous symbionts for termites. Moreover, observations both in electron microscopy and on specific culture have shown that termites' guts contain numerous actinomycete populations, but their origins, exogenous or endogenous, are currently unclear. To decide between these hypothesis, two complementary techniques (culture in microbiology and DGGE) were used to isolate and determine specific strains from hindguts of termites which were subjected to different alimentary treatments. Analysis of 16s rDNA subunit, initially amplified by a nested-PCR, enabled us to investigate actinomycete diversity in various colonies and species of *Nasutitermes*, and perhaps to highlight a possible coevolutionary association. The results of our study will be discussed during the talk.

Workers of lower termites: no altruists, but hopeful reproductives

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Keywords: termites, social evolution, workers, relatedness, hopeful reproductives

Social insects are considered as prime examples of altruism in which individuals (workers) forego their own reproduction to help other individuals reproduce. Such a behaviour is favoured by natural selection because the workers rear close kin and in doing so enhance their inclusive fitness. Here I show, however, that this does not generally apply to termite workers. In the termite *Cryptotermes secundus* the workers, which form the large majority of a colony (sterile soldiers: < 5 %), are not altruists and do not stay to raise relatives. The workers develop into either winged (dispersing) or unwinged (replacement) reproductives and the probability that they do so is unaffected by the number of brood in the nest. Experimental field and laboratory studies further revealed that leaving the nest is largely influenced by ecological factors such as the nest's longevity and the probability to inherit the colony. Thus, these 'workers', which are likely to be typical for wood-dwelling termites, are unique among social insects; being a 'worker' does not entail costs and therefore is not determined by indirect fitness gains. Rather these 'workers' should be regarded as hopeful reproductives that stay in a safe protected environment, the natal nest.

New diagnostic characteristic for the species identification of termites

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Keywords: termites, taxonomy, genital apparatus, species identification

Termites play a very important role in the biocenoses, especially in the tropical regions. But at the same time in many countries they constitute a considerable economical problem. This is why there is a great number of works on the biological, ecological, behavioral and other aspects of the termites' life. But in spite of that, the classification of termites is far from perfection. The problem of the identification of closely related species of termites is very complicated. The structural features of the head, the mandibles, the antennae, the pronotum, the wing veins, the body color and the number of different size characteristics are now in use in termites' identification. In practice, however, many of these characteristics are highly variable and vary for different individuals not only within a species but also within some termites' genera. Therefore, these structural and size features are not sufficiently reliable for distinction of closely related species of termites. So, in that way, the problem of the search of new taxonomic characters is essential. These characteristics could be the features of the external genital apparatus of termites. Up to now the study of the external genital apparatus of termites has not been paid due attention. It is considered that genital apparatus is uniform in different families and can not be used in the taxonomy. The study of the genital apparatus of termites has been made mainly for finding out the philogenetic relationships of termites, cockroaches and other groups of orthopteroid insects.

In the present paper we have made an attempt to use some structural features of the external genital apparatus of termites for the taxonomy. The genital apparatus of 25 species of the biggest 4 families has been studied in detail. It has been established that only some characteristics of the genital apparatus of female species are suitable for species identification because they describe only unique sclerits. The genital apparatus of male is mostly membranous and inappropriate for taxonomy. We have finde out the structures of the external genital apparatus of the termites which are the most important for taxonomy. These structures are as follows: the medisternit, the basivalvae, the parasternits etc. Various structures have a different taxonomical value in the different families. The medisternit and the spermathecal opening are heavily sclerotized and are suitable for species identification in the family Kalotermitidae, whereas the basivalvae are reduced or absent (*K. durbanensis*). The basivalvae, in contrast, are well developed in the family Hodotermitidae and their form differs from species to species. In the family

Rhinotermitidae the structural features of the basivalvae and the opening of spermatheca can be used in taxonomy. In the family Termitidae the form of the basivalvae and the position of the spermathecal opening can be used for species identification as well. Furthermore, the cross banding pattern of the basivalvae is peculiar to this family. The anterior edges of the ninth sternum are well sclerotized and form the paratergits in two subfamilies – Macrotermitinae and Nasutitermitinae. We have found out that the structures we had proposed for taxonomy vary only within the species.

We have shown that the structural features of the external genital apparatus of the female termites can be used for species identification. Further investigation of the genital apparatus of termites with the increase of the number of species studied should allow us to speak about the new diagnostic feature with more confidence.

How flexibility of breeding systems in subterranean termites explains their invasive success

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Keywords: termites, *Reticulitermes*, breeding structure, social organization, relatedness, gene flow, neotenics-secondary reproductives, microsatellites

Termites (Isoptera) are a taxon independent from the social Hymenoptera. They provide a useful comparative context for understanding social evolution. Although their cryptic colony lifestyle does not make the study of social organisation easy, subterranean termites in the genus *Reticulitermes* are excellent models for studies of termite biology. Breeding systems and modes of colony founding can be complex; they are variable among populations and among species with important consequences for population genetic structure.

Here, we characterize and compare the breeding system and the social structure of two European species of *Reticulitermes* (*R. santonensis* and *R. grassei*) under urban and natural conditions.

The genetic investigation of colonies of the invasive species *Reticulitermes santonensis* located in natural and urban regions in France revealed that some colonies can be spatiallyexpansive, a trait less common in other *Reticulitermes* species. All colonies studied were headed by large numbers of inbred neotenic secondary reproductives (extended families), offspring of the primary reproductive pairs. Moreover, we found evidence for spatially separate reproductive centers, among which there was limited movement of neotenics and workers. The lack of genetic viscosity in the urban population was consistent with a large degree of human dispersal.

Unlike some other French species, *Reticulitermes grassei* colonies can be divided in to simple and complex families, based on the number and on the genetic relatedness among them. DNA fingerprinting of termites collected in different French localities under urban conditions showed that more than one colony is often involved in the same infestation.

Considering that *R. santonensis* may be an introduced population of the North American species *R. flavipes* (small colonies well delimited and colonies variable in aggression), a breeding system consisting primarily of extended family colonies containing many neotenic reproductives may facilitate human-mediated spread and establishment of *R. santonensis* in urban areas with harsh climates. Indeed the introduction of *R. santonensis* could be associated with important variation in the breeding system and social structure of colonies like in some ants species like *Linepithema humile*. We hypothesize that the diverse and flexible breeding systems found in subterranean termites pre-adapt them to invade new or marginal habitats. The change in social structure of introduced populations may make them more competitive than indigenous species resulting in the elimination of native species and a threat to biodiversity.

Macrotermitinae/fungi co-evolution: new data on other fungi than *Termitomyces*

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Keywords : termites, fungus-growing, symbiosis

Macrotermitinae have evolved complex behaviours to maintain and propagate the external symbiotic fungus, *Termitomyces sp*, which is only encountered within the termite nest. *Termitomyces* is grown on special substrate so called "fungus-comb" built up progressively from material of termite faecal origin. The fungus-comb appears to be a selective medium for its growth since any development of other fungi has been observed. However, observations using electronic microscopy of fungus-combs have revealed the presence of two types of mycelium which can be distinguished by their size. Furthermore investigations have shown that the largest mycelium belongs to *Termitomyces* To date, fungal community suppressed in fungus-combs is not established. In this work, we used in parallel both culture dependent-methods and PCR-DGGE analysis to describe the fungal diversity in fungus-combs from termite nests of different species.

PCR-DGGE of total DNA and culture-dependent techniques yielded a different description of fungal community in fungus-combs: only Basidiomycota (*Termitomyces*) was detected by PCR-DGGE whereas cultivation technique yielded isolates affiliated to the phylum of Ascomycota. This discrepancy may be due to the fact that molecular techniques favor numerically dominant fungi with high amount of vegetative mycelium while cultivation favor the isolation of fast growing microbes.

Fungal isolates from not contaminated fungus-combs were found to show different phylogenetic affiliation in comparison of those isolated from fungus-combs when separated from their termite nests (contaminated fungus-combs).

ITS sequences of Ascomycota isolates from not contaminated fungus-combs vary according to the termites species, suggesting the evidence of relationships between corresponding fungi and termite species.

Phylogenetic information in worker termite gut characters

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Termites are an ecologically important order, and there are an increasing number of phylogenetic studies of this group. The majority of these are based on molecular data, and little attention is generally paid to the phylogenetic information contained within morphological characters. However, the data to be found in termite gut characters is not only helpful for taxonomists, but can also be used to help define clades (Noirot, 1995; Donovan et al., 2000; Noirot, 2001; Bitsch and Noirot, 2002).

Termite species richness is biased towards the higher termites (Termitidae) with around two thirds of all species falling within this one family. Within termites, soil-feeding is the most successful feeding strategy, and is employed by the majority of the Termitidae. It is within this feeding group that gut characters have shown the greatest diversification, and I will cover the main gut features that help identify clades. The Termitidae are characterised by a reduction to only four (or two, in the case of the Apicotermitinae) Malpighian tubules, and this family also shows the introduction of a new character, the mixed segment, formed by an overlapping of the mid- and hind-gut. On the whole soil feeders have a relatively longer gut, with a tendency towards greater compartmentalization. It is also in this family that the enteric valve, found between the first and third segments of the hind-gut, shows the greatest development into intricate and complicated structures, particularly in the soil-feeding members of the Apicotermitinae and Termitinae.

These character states have arisen as a result of the interaction between functionality and phylogeny and, therefore, represent a mixture of phylogenetic and feeding group signals. In this presentation, I will cover the main synapomorphic gut characters defining various termite clades as currently recognised.

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Postglacial recolonization of southwestern Europe by subterranean termites: Genes tell complex story

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Keyword: subterranean termites, phylogeny, mitochondrial gene, cuticular hydrocarbons, allelic diversity

A preliminary phylogenetic study showing a complex differentiation of the subterranean termite *Reticulitermes grassei* (Kutnik et al, 2004), failed to resolve questions about the population structure of this widespread European species and its closely related species *R. banyulensis*. In the present study the origins and biogeography of *Reticulitermes* termite lineages were inferred from a comparison of geographic distribution patterns and phylogenetic relationships among populations distributed across the Iberian Peninsula and southwestern France. Phylogeny was based on the complete sequencing of the mitochondrial cytochrome oxidase II (COII) gene and the variability of cuticular hydrocarbons (HCs). Allelic variation was investigated at 8 microsatellite loci in 9 Iberian and French populations of the two *R. grassei* clades. Allelic and genetic diversity in terms of polymorphism, number of alleles and heterozygosity appeared to decline in function of distance from southern Spain. The French populations of both clades showed a greatly reduced number of microsatellite alleles, indicating their derivation as a peripheral isolate following the species' dispersal. The combination of genetic and chemical analyses was consistent with the hypothesis that *R. grassei* diverged into two main lineages at the beginning of the Quaternary, and then survived the main Pleistocene glaciations in two distinct Iberian refugia. From there, both lineages spread north and east during the last interstadial that began about 14,000 years ago (BP).

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Integration of multiple sources of information by desert ants navigating familiar routes

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Keywords: desert ant, *Cataglyphis*, navigation

Along an unfamiliar route to a food-site, desert ants, like honeybees, may be guided by global path integration (PI) – using a celestial compass and some form of odometry, foragers are able to monitor their position with respect to their nest, and set a direct course to the position of a previously visited food-site. If forced to produce an unexpected dogleg, foragers relying on PI for guidance will under-turn towards the food-site. With repetition a forager's route can become stereotyped as it incorporates various types of landmark guidance. By manipulating the cues encountered along a habitual dogleg route to a reliable food-site marked by a landmark, we examine the memories that can contribute to the stereotypy. The shape of the route depends on the prominence of the landmark, probably reflecting the different guidance strategies forming the route. If the landmark is prominent, then the foragers will produce direct trajectories using the landmark as a beacon. If the landmark is less conspicuous then foragers will initially under-turn, perhaps using PI for guidance, and then later turn towards the landmark. With no landmark marking the food-site, a forager's habitual trajectory will again exhibit an under-turned segment ending, however, in a random search slightly short of the food-site. We find that if a forager's visual cues match the familiar route exactly, then the use of global PI is suppressed and guidance is produced by a combination of landmark strategies. Removal of the feeder-landmark and manipulation of a forager's PI state have only subtle effects on the initial direction of the path segment: the trajectory retains the habitual under-turning or directness. This stability suggests that there is an independent component of guidance that mirrors the direction of the habitual trajectory. We surmise that, foodwards as well as homewards, a familiar en-route landmark may serve as a sign-post for triggering the recall of a local vector that encodes information about the following route segment. Because the habitual route may formed from guidance by both PI and beaconing, the local vector memory is likely to encode commands from the output end of the navigational control system, after the integration of the different guidance strategies rather than some form of higher level PI memory.

The interaction between spatial memories in the wood ant

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Keywords: wood ants, *formica rufa*, navigation, visual learning, snapshots, route learning

Wood ants use visual landmarks to guide themselves along familiar foraging routes. Here we present experiments examining the learning of these visually guided routes and the form that these visual memories take. In our first series of experiments we investigated what information ants had learnt for guiding their homeward routes when they had previously been restricted to food bound journeys. In a second series of experiments we investigated the interaction between visual snapshot memories by switching the location of a food site after ants had developed direct routes. Ants' initial headings gradually rotate towards the new food location. We see similar route change when ants are placed directly on the food rather than travelling there themselves suggesting that that the changes are because of changes in the weighting of goal snapshots rather than a single evolving route memory.

Learning at consequential stages of orientation in bumblebees and paper wasps

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Keywords: bumblebees, paper wasps, learning, foraging, nest orientation, visual discrimination

The study was aimed at comparison insect learning abilities in different situations. An individual was trained to penetrate through the maze into feeder with sugar water, into it's own nest or into the transparent cage with the feeder. The maze contained two entrances: free (+) and closed in the depth (-). The entrances were marked by different visual stimuli. Three series of experiments were performed. In the first one, bumblebees (of three species) were trained to discriminate colours or shapes of the figures at the feeder, and when a bumblebee had solved this task, the same stimuli were offered in parallel at the nest entrance. A half of individuals had two similar tasks, while the other one had inverse tasks ("+" at the feeder became "-" at the nest). No differences were found between the groups. Thus there is no direct transmission of foraging experience to nest orientation. It confirms our previous results in paper wasps and honeybees (Kartsev, 1996) and other available results in bumblebees (Colborn et al., 1999). However, we can suppose (in agreement with Fauria et al., 2002) that there is interference between tasks if they are learnt simultaneously.

In the second series of the experiments, bumblebees were first trained at the nest and then at the feeder. No direct transmission of individual experience between nest orientation and foraging was found as well. Nest task did not prevent simultaneous learning at the feeder (however some influence can not be excluded). In general, learning at the feeder was more successful than that at the nest.

The third series of the experiments was performed with wasps *Paravespula germanica* F. The wasp was trained to discriminate colours (purple "+" and yellow "-") at the entrance to the transparent cage (about 0,4m x 0,4m x 0,6m) to reach for the feeder. And then the same colours were offered at the feeder box. Three individuals had two similar tasks simultaneously, and three others had inverse ones. The differences between the groups were not significant. The learning at the feeder was more successful than that at the cage entrance. Thus not only foraging and nest orientation but even consequential stages of foraging orientation are to some extent independent in insects.

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The learning of rules and concepts by the honeybee

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Keywords: honeybees, learning, matching samples, symbolic matching, concept learning

The honeybee is a social insect that can survive only as a member of a community, known variously as a colony, nest, or hive. For maintaining their nest and caring for their brood, foraging bees have to repeatedly travel between their nest site and food sources to collect pollen and nectar, and continuously exploit new food sources. In order to forage successfully, bees have to learn and remember not only the colour, shape as well as odour of flowers that are bountiful in these nutrients, but also how to get to them and return to their colony by using celestial and terrestrial cues, i.e. landmark constellations within the framework of a time-compensated sun compass. Honeybees have therefore evolved a number of navigational skills for successful foraging, that require extensive, perceptual capacities and central evaluation and storage mechanisms. Bees display perceptual and “cognitive” capacities that are surprisingly rich, complex and flexible. We would like to present here the recent progress in our laboratory regarding the honeybee’s ability to learn abstract concepts and rules while navigating through their environment. They are as follows:

1. Honeybees can learn to use sensory stimuli as navigational ‘Signposts’ to indicate route: i). bees can learn to negotiate a maze by following a mark that indicates a correct path leading to the reward box [1]; ii). Sensory stimuli tell bees which direction to turn [1, 2]; iii). Bees are able to group and recall signposts associatively, in which a particular signpost indicates the identity of the following signposts along the route [1, 2, 3 & 4].

2. Honeybees are able to learn abstract concepts, such as sameness, in delayed matching to sample tasks, in which they are required to respond to a matching stimulus, and difference in the delayed non-matching to sample tasks in which they are required to respond to a different stimulus. They can also transfer the learnt rules to new stimuli of the same or a different sensory modality. Thus, bees can not only learn specific objects and their physical parameters, but also master abstract inter-relationships, such as sameness and difference [5].

3. Honeybees can learn the order of patterns in a sequence, and choose to ‘pay attention to’, for example, only the first of two patterns in a sequence, while ‘ignoring’ the second (or vice versa) and use it to choose a correct path in the maze in delayed matching to sample tasks. They can also apply that knowledge of order to solve new questions about order [6].

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How size limits sensory capabilities in bumblebees and why it matters for colony organization

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For pollinating insects, like honeybees and bumblebees, vision and olfaction are important sensory modalities utilized for detecting and identifying nectar and pollen rich blossoms by flower-specific signals. In bumblebees, distinct size variation occurs within the worker caste of a colony. We investigated the effect of scaling on morphology, physiology and behavioral capability of the visual and olfactory system of the bumblebee, *Bombus terrestris*.

For the visual system we could demonstrate that large workers have extended facet diameters in conjunction with reduced inter-ommatidial angles. Thus, both overall sensitivity and image resolution are superior in such individuals. In a behavioral test we found that a 33% increase in body size is accompanied by 100% greater precision in single target detection. In small bees the minimum number of ommatidia involved in target detection is seven, while in large workers a single ommatidium is sufficient for target detection. This improvement in spatial resolving power is much stronger than that predicted by surveying ommatidial arrays, indicating that measuring eye optics alone is insufficient for predictions of single object resolution, unless combined with behavioral tests.

For the olfactory system we found that antennal sensilla number, sensilla density, volume of antennal lobe neuropil and volume of single identified glomeruli correlate significantly with worker size. These anatomical results predict higher odor sensitivity in larger bumblebee workers due to larger olfactory epithelial surfaces. We tested this prediction by means of behavioral experiments, where bees had to respond to an odor at various concentrations in a dual-choice test. We could demonstrate that large individuals were able to detect on average a 10 times lower odor concentration compared to their small nestmates.

To summarize, our results show that large bumblebees exhibit a superior sensory system compared to their small conspecifics, which help them to detect flowers more efficiently. These results may also contribute to the understanding of the mechanisms underlying size-related division of labor in bumblebees.

Neurochemical dissection of the honey bee dance language

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Keywords: *Apis mellifera*, biogenic amine, octopamine, serotonin, waggle dance

Forager honeybees (*Apis mellifera* L.) return to the colony and perform symbolic dances that indicate the location and quality of food sources to nest mates[1]. This requires assessing resource profitability, translating the foraging trip into a vector oriented with respect to the sun azimuth, and encoding all this in stereotyped dance movements[1]. The honey bee dance language is the most advanced communication system known among the invertebrates, but the neurobiological mechanisms underlying dance behaviour have been largely unexplored. Our experiments explored the modulation of dance communication by the biogenic amines.

The biogenic amines are a key family of neuromodulators and neurohormones with diverse effects on insect physiology, behaviour and social behaviour[2,3]. We developed two non-invasive methods (an oral and a topical treatment) that allowed us to explore the effects of octopamine and serotonin on dance behaviour. We studied five different components of the dance: 1) the likelihood of a forager dancing, 2) the number of dance circuits performed and 3) the vigour of the dance (these three convey the forager's 'assessment' of the quality of the resource[4,5]); 4) the duration of the waggle phase (which represents the distance to the food source); and 5) the angle of the waggle phase measured against vertical (which represents the direction to the food source relative to the sun[1]).

Octopamine showed dose-dependent effects and modulated the components of dance involved in the communication of the quality of the food source, suggesting a role for octopamine in the perception or processing of reward in the honey bee brain. In contrast, there was no effect of serotonin on any of the five components. These are the first findings on the neurochemical modulation of honey bee dance language and open a new line of study on this communication system.

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Insect mushroom bodies and the evolution of sociality: insights from scarab beetles?

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Keywords: termite, cockroach, honeybee, generalist, specialist, herbivore, behavior

It has long been acknowledged that the social Hymenoptera have particularly large, complex mushroom bodies, prompting speculation that these higher brain regions play a critical role in complex social behaviors. However, it has also been noted that large mushroom bodies are found in non-social insects such as the cockroaches. What behavioral capacities might large mushroom bodies promote in general, and how could they have contributed to the evolution of eusociality? A unique comparative model for investigating these questions is presented by the scarab beetles, in which small and large mushroom bodies are correlated with distinct behavioral ecologies within a single taxonomic family. Scarabs with a derived generalist plant-feeding lifestyle display a significant increase in mushroom body calyx volume and intrinsic neuron number. This increase in mushroom body size is additionally accompanied by doubling of the calyx that is strikingly similar to that observed in the basal Hymenoptera. This suggests that the initial acquisition of large mushroom bodies in disparate insect taxa may have been driven by selection for behavioral flexibility in detecting and utilizing varied food sources. This initial acquisition may in turn have preadapted lineages for the evolution of eusociality, as in the termites (the sister group of the cockroaches) and the social Hymenoptera.

Gene expression in honeybee mushroom bodies and its gene orthologues in non-social insects/invertebrates

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Keywords: honeybee, mushroom body, ecdysteroid-regulated genes, tachykinin

The honeybee is a social insect and its colony consists of a queen, workers and drones that have different roles. In addition, various complex communications and divisions of labor are performed by colony members to maintain colony activities. Mushroom body (MB) is one of insect brain structures, which is important for learning, memory and sensory integration. Honeybee MB function is believed to be closely associated with honeybee social behavior for the following reasons: 1) The MBs of the aculeate Hymenoptera, including the honeybee, are more prominent compared with those of other insects. 2) Honeybee MBs have a high degree of structural plasticity and the volume of the neuropil varies according to the division of labor. To clarify molecular basis underlying honeybee MBs function, we identified over 20 genes expressed selectively in the MBs of the honeybee brain using matrix-assisted laser desorption/ionization with time-of-flight mass spectometry, differential display and cDNA microarray method. In this symposium, I will present the expression pattern of these MB-selective genes and discuss possible function of these genes in honeybee in comparison with those of their orthologues in non-social insects/invertabrate. Furthermore I would like to discuss our strategy to examine involvement of these genes in the honeybee visual behaviors.

Life history and behaviour shape honeybee genome evolution

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Keywords: honeybee, genome, esterase, GST, P450, evolution, environmental response, xenobiotics

The honeybee is the most specialised insect to have been sequenced thus far, its biological individuality reflected in major differences in genome size and organisation. We now know there are approximately 10,000 protein coding genes represented in the honeybee genome. This highlights an unexpected 25-30% deficit of genes compared to the vinegar fly (*Drosophila melanogaster*; ~13,000 genes) and mosquito (*Anopheles gambiae*; ~14,000 genes). Intriguingly, there are few differences in the numbers of developmental and/or housekeeping genes between these species. The apparent difference corresponds to a paucity of environmental/stress response molecules in the honeybee. Our comparative genome analyses show there is a clear reduction in the number of metabolic enzymes including glutathione-S-transferases, cytochrome P450s and carboxyl/cholinesterases in the honeybee. These enzyme families regulate many hormonal, nutritional and chemosensory processes in higher organisms including response to xenobiotics. Our hypothesis is the honeybee has reduced its dependence on genetic diversity in response to evolving more specialised nutritional and reproductive strategies and complex social and 'cognitive' behaviour. We have identified a small increase in the number and regulation of key neurological genes that may have accommodated this shift. Arguably, a significantly reduced molecular diversity may place the honeybee at greater risk to environmental change including toxic chemicals.

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Thermoregulation of honeybee (*Apis mellifera* L. Spin.) colonies during summer and winter in the Subtropics

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Keywords: honeybees, *Apis mellifera* L., thermoregulation, extreme temperatures, subtropics, protection, honey production

Bee colonies in the subtropics are active year-round: queens lay eggs, foragers collect nectar, pollen and water; hive bees maintain in the brood-nest steady temperature [T] (34.5-36.7C) (**1**). However, nest heating and cooling require energy, resulting in high honey consumption. (**2**). We studied: (**i**) The behavior of individual workers and colonies at extreme summer and winter T,(**ii**) The impact of protecting bee colonies from extreme T on worker population and honey production.

(i). 1. Survival of workers at high T. The survival rate of individual foragers in spring at 45, 50, 55 and 60°C during 15, 30, 45 and 60 min was established at the end of each exposure, and 24 hours later. Lethal effects were evident after a 30 min exposure to 50° C. (**3**).

(i). 2. Water economy. Individual workers' *body weight losses* increased from 36 to 50°C and from 15 to 60 min; the slope of the curves decreased with exposure duration. At similar T and exposure durations, water consumption was lower than the body weight losses. Water intake at 28-45°C was low (3.5-4.5 mg/hr/worker), it rapidly increased above 45°C (13.3 mg/hr/bee at 50°C). (**4**).

(i). 3. Thermoregulation of a honeybee colony and workers' behavior at high T. At 48°C ambient T-thermoregulation was limited to brood-nest; its T did not exceed 37.6°C, due to evaporative cooling. Foragers' activity decreased at noon was resumed later at 47°C, due to intensive transport of water and 30% sucrose soln. for nest cooling. The number of fanning bees at the hive entrance, air current velocity and the activity of water carriers were affected by brood-nest T. However, the activity of foragers carrying 30% sucrose soln., depended upon ambient T. (**5**).

(i). 4. Conclusion: Individual workers were resistant to T up to 50°C and continued foraging at 48°C. Applying evaporative cooling bee colony can maintain steady brood–nest T, which is lower by 11°C than the ambient T, and sustain extremes of summer hot spells.

(ii). 1. Protecting bee colonies from summer overheating is based on reflecting solar radiation from beehives. *Empty hives*: The paint color used for coating beehives determines its inner T: white painted hives were cooler by 12°C, than the aluminum painted ones (in September, T-maximum was 37.8 and 50.8°C, respectively). (6).

Colonies were kept in white and aluminum painted hives exposed to sun: Brood-nest T was similar in both groups. Outside this area, the T was the higher in aluminum coated hives, where the activity of fanning and water carrying workers was the highest. In white painted hives, brood areas (BA) and honey production (HP) were higher than in aluminum painted group (BA was 3.400 and 2.500 cm^2/colony; HP was 12.5 and 7.6/kg/colony, respectively). (**7**).

(ii). 2. Protecting bee colonies from winter cold is based on absorbing solar radiation by beehives. In colonies placed inside Infrared-Polyethylene **(PE)**-covered enclosures and control colonies in white painted hives exposed to solar radiation, the T was always higher in PE-covered colonies. Outside the brood area it was higher by 9.3 and 2.7°C during a bright day and a clear night, than in the uncovered control, respectively. Brood-area size in PE-covered group was higher (+ 2.290 cm^2 versus -504 cm^2/colony) than in the control group. Also, adult bee population was stronger (3.8 occupied frames/colony versus 1.8/frames/colony in controls) and produced twice as much honey (20.8 kg/honey/colony versus 10.2 kg/colony) than the controls. (**8**). Similar effects have been observed in colonies kept in black painted hives (**9**).

(ii). 3. Conclusion: Protection of bee colonies from extreme temperatures enhanced worker population size and production of spring and late summer honey yield, even in a mild Mediterranean-type subtropical climate.

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Brood nest incubation strategies in honeybees

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Honeybees maintain an elevated brood nest temperature between 33 and 36°C. Lower or higher temperatures result in malformations, increased mortality and lower behavioural performance. Cooling is achieved by collecting, spreading and evaporating water, wing fanning, dispersal of the bees on the comb and heat shielding. Warming is achieved by the bees gathering on the brood and producing heat with their wing muscles.

In several observation hives, the behaviour and temperatures of worker bees were investigated by means of thermography combined with video and endoscopic recordings. As described by Esch (1960) and Schmaranzer et al. (1988), brood heating specialists remain motionless on the comb surface for several minutes (up to 1 hour, personal observation) while maintaining elevated thorax temperatures. Lateral, close-up endoscopic inspections of such bees revealed that they take in a crouched body posture and actually press their thorax onto the brood cap surface to enhance heat transfer by means of conduction (Bujok et al. 2002). During immobility, the tips of the antennae touch the brood cap surface, suggesting sensory feedback. This characteristic body posture clearly differs from that of resting bees which have a body temperature at ambient level and are not touching the comb with their thorax. After gently pushing these bees aside ($T=40.5\pm1.1$°C, $N=36$), the thermographic image revealed a “hot spot” of elevated temperature ($+1.6\pm0.7$°C, max. $+3.2$°C compared to the surroundings) on the brood cap surface where the bee had previously been sitting, confirming that heat had been transferred from the bee to the brood cell.

A second heating strategy was discovered when individually marked bees (Kleinhenz & Tautz 2003) on the brood comb surface were traced over longer periods of time: During long-time visits to empty cells that are scattered among the sealed brood cells, worker bees maintain elevated thorax temperatures without performing any visible work. Due to the hexagonal cell shape, heat may be transferred to up to 6 adjacent brood cells. A similar behaviour is known from brood-incubating hornets (Ishay & Ruttner 1971) which rear their brood in paper nests with similar cell arrangement.

Most cell visits ($N=22$ of 27) were preceded by a prominent warm-up (up to $+9.6$°C) or the bees had been maintaining an elevated thorax temperature during brood incubation on the comb surface as described above. In common observation hives, the onset of heat production during the cell visit was indicated when the cell interior started to “glow” in the thermographic image (indicating high temperatures) or when the thorax temperature at the end of the cell visit was higher than in the beginning of it.

A special observation hive allowed us to view the bees laterally when they were inside a cell and to study their temperature. Motionless bees were either resting with their thorax at ambient temperature (32.7 ± 0.1 to 33.4 ± 0.3, $N=5$) or they were producing heat with their thorax muscles and maintaining thorax temperatures from 36.0 ± 0.7°C to 40.3 ± 0.7°C ($N=8$) during long cell visits of up to 63 min duration.

In earlier investigations on division of labour in honeybee colonies, bees performing long-time cell visits (>2 min up to 1.5 hours) in the absence of any visible work were considered to be resting. Although resting inside cells also occurs, our observations show that such bees may be engaged in colony thermoregulation as well. If no thermographic information is available, the two behaviours may be distinguished by the respiratory pumping movements of the bees’ abdomens. These movements are fast and continuous in heating bees, indicating high rates of gas exchange, whereas they are discontinuous with long breaks and short bursts of movements in resting bees (Kaiser et al. 1996, Kleinhenz et al. 2003).

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Thermoregulation and the effects of rearing temperature on developmental stability and learning and memory in the honey bee, *Apis mellifera*

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Honey bee workers maintain the brood nest of their colony within a narrow temperature range of 34.5 ± 1.5°C. The narrow temperature range maintained by colonies implies that there are significant fitness costs if brood is reared outside the normal range. Here we show that individuals of different patrilines have variable thresholds at which they engage in thermoregulatory behaviour and that genetically diverse colonies are better able to maintain a stable brood nest temperature than genetically uniform colonies. The short-term learning and memory abilities of adult workers are affected by the temperature they experienced during pupal development. In contrast, long-term learning and memory is not significantly affected by rearing temperature. Furthermore, we could detect no effects of incubation temperature on fluctuating asymmetry, as a measure of developmental stability, in workers, queens or drones. We conclude that genetic diversity is important in enabling honey bee colonies to maintain a stable brood temperature and that the most important consequences of abnormal rearing temperatures are subtle neural deficiencies affecting short-term memory.

Thermoregulation of honey bees in winter by means of vertical movement in the hives with vertical gradient of temperature

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Keywords: honey bees, winter cluster, thermopreferendum, temperature regime

The winter cluster of honey bees and its thermoregulation is very interesting, inscrutable and not fully investigated object[7]. It is necessary to investigate this object and behaviour of bees in cluster with the aim of elaboration of the optimal method on honeybee wintering.

Russian psalm-reader E. Shevelev (1893) was the first who observed the thermopreferendum of honey bees in winter: "Bees moved upwards-downwards on the comb according to the outer temperature"[6]. His glass hive was connected with the outside through "drilled hole in the house wall".

Our gradient device with regulated vertical temperature gradient was based at the very low heat conductivity of the air in the downward direction due to the air convection. So it was easy to create temperature gradient in any volume (or hive) with electrical heater disposed in the upper part.

In our experiments bees of the small colony distributed almost uniformly in the interval of 15-36°C with periodical activization and active moving in the zone $>25°$ [1, 2, 4]. Queens preferred the temperature zone $>26°$ with rare short travels without stoppages to the zone $< 26°$. Small babynucs had overwintered successfully during 4 winter months[2] and this fact gave possibility to say about the normal conditions for bees despite of the following principal differences from conditions in the natural winter cluster.

Low density of bees disposition is the reason of normal CO_2 concentration (0.03%) and low relative humidity (up to 50%) while in the winter cluster CO_2 is near 1-2% and RH $>80\%$. We compensated dehydration of bees by offering drinking place, but bee body water contents was essentially lower in comparison to usual methods of overwintering (inside bee cellar or outside)[3]. In the cluster the bees of outer layer are at unfavourable conditions at 12-15°. They need to support body temperature above the chill-coma point and therefore the winter cluster can't be the best for honey bee overwintering.

Theoretically honey bees don't need to excrete additional heat to support the conditions for their surviving in winter in the hives with temperature gradient. Their energy losses (food consumption) have to be minimal as the thermopreferendum is the dynamic reaction of any organism with the aim to minimize the energy losses. Every bee can find the best temperature conditions by moving up or down according their variable needs. But in practice the honey and bees losses during winter are almost the same in the hives with gradient and at nice colonies overwintering in the natural winter cluster according to the experience of Ukrainian beekeepers, who started to use proposed temperature regime for the mass storage of two frame nucleus colonies in winter[5].

The obtained results gave base for revision of our knowledge about some processes in the bee cluster.

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Swarming of honeybee colonies in Turkey

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Keywords: *Apis mellifera*, swarm, races, Turkey

Swarming is the means whereby honeybee colonies reproduce. About half of the worker bees leave the colony with the old queen and start a second colony, while the remaining workers remain with the young queen. There are several honeybee races in Turkey. Each race is adapted to a different, and each has unique swarming tendencies. Swarming of bee colonies is known to be affected by a number of factors in the hive, which include the environment and genetics of honey bee race. However, the collective decision process of workers to swarm is not well understood. At the extremes are the Caucasian bee which rarely swarms and the Syrian bee which produces multiple swarms each year.

Apis mellifera caucasica (Caucasian bees) is adapted to the temperate rain forest of the eastern Black Sea region. This is a mountainous, cool, humid area with long, snowy winters. These bees swarm at most once each year. Swarming seems to depend on incoming nectar flow and space in the hive. Colonies that swarm lose half of the worker force, which affects nectar collection rate and winter cluster size. Weak colonies without sufficient honey will not survive the winter in cold climate. Caucasian bees usually have less than 10-20 queen cells. There is little predator pressure in the endemic range of the Caucasian bee to increase swarm production.

A. m. carnica is endemic to the Thrace region of Turkey. It typically swarm more often than *A. m. caucasica*. The Carnolian bee averages three swarms per colony each year, and correspondingly produces more queen cells. However, *A.m. carnica* still produces relatively few swarms per colony each year when compared to other races found within Turkey. The general consensus is that this occurs because it is adapted to the cool regions of the Balkans and need to store enough honey to survive the winter and maintain a large mass of bees for the winter cluster.

The Anatolian bee produces a paradox in terms of our understanding of swarming frequency. These bees swarm more than *A.m. caucasica* and *A.m. carnica*. Each colony can average five swarms per year, depending on the region and internal conditions of the hive. However, like the Caucasian and Carnolian races, *A.m. anatoliaca* is adapted to long, cold winters. What is different climatically in their endemic range is the summer season, which is dry and hot. (Central Anatolia). Thus summer temperatures may be as important as winter for selecting swarming rate. *A.m. anatoliaca* is known by beekeepers to be very efficient in collecting nectar and to use honey stores less rapidly than the other honeybee races of Turkey.

A.m. syriaca swarm more often than any other honeybee race in Turkey. It constructs hundreds of queen cells. This high swarming rate may be due to unpredictability of the environment, which is the hot, dry desert region of the southeast. On the other hand, honeybee losses due to predators is known to be severe in the endemic region of the Syrian bee. Predators such as *Vespa orientalis* and *Philanthus triangulum* prey heavily on honeybees and are known to can kill the work force from entire colonies. Therefore, *A.m. syriaca* may swarm often to increase the chance of survival from predators. Finally, *A.m. syriaca* does not need to store as much honey as *A.m. caucasica* in north to survive winters because this season typically is the wet season when flowering occurs.

A. m. meda is not known well and there is insufficient data about its swarming tendencies in Turkey.

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Emotional nature of adaptive nest abandonment by honeybee swarms

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***Keywords**: Apis mellifera*, emotions, cognition, perception, stereotypies, swarming, absconding, migration, ataractic pheromones of the honey bee queen

The neuroethological analysis of stress manner of nest abandonment by honeybee swarms revealed that emotional arousal of the bee brain and subsequent changes in it's cognitive perception is the *modus vivendi* not only adaptive swarming, absconding and migration but also other bee behaviours and behavioural development as well.

The surplus of emotional excitation of the CNS of the bee accompanying it's emotional arousal is often abreacted by changes in speed of cognitive expression of stereotypical behaviours, appearance of stereotypies or even motionlessness. Interestingly most dances of bees identified by an author as stereotypies activate other bees and serve them by the way of so called information transfer.

As result of emotional nature of honey bee cognition, it's behaviours depend both on excitatory effect of different nest and outside nest stimulations and potent calming effect of ataractic pheromones of the queen and her young brood. Significantly, the final expression of migratory instinct in adaptive swarming, absconding and migration is preceded by a line of behaviours that appears along with increase of excitation of CNS of the sufficiently stress sensitive bee .The most common behaviour for all three mentioned above main types of nest abandonment by swarms is stress related engorgement with honey or nectar. Expression of other stress behaviours such as queen cell building, queen rearing etc. depends, apart from genetic background of the bee, on type and intensity of a given stress swarm reaction.

Moreover such stereotypies as dances and engorgement with honey, are conditioned by changes in metabolism of dopamine accompanying emotionally enhanced production of endogenic opioids.

Behavioural plasticity in ant queens of the *Pachycondyla villosa* complex

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Keywords: ants, behavioural plasticity, queen and worker tasks, *Pachycondyla*

Social insects, ants in particular, show a great variation in colony founding strategies. Colonies can be founded either by a single queen (haplometrosis) or by two or more queens (pleometrosis). Founding queens show a full behavioural repertoire and may be able to perform typical worker tasks, such as brood care and foraging. However, as soon as the first worker force emerges, the queens abandon most behavioural tasks except laying eggs.

There is evidence that mature queens of *Leptothorax rugatulus*, a derived ant species, lack the behavioural plasticity necessary to revert to task performed during their early stages of life (Rueppell et al. 2002). In the present study, we tested whether a more ancestral ant genus possesses this behavioural flexibility. In the Neotropical species complex *Pachycondyla villosa*, new colonies are usually started cooperatively by two or more young queens who establish a dominance order with a division of labour. Co-founding can lead to primary polygyny, where queens stay together after workers have emerged. We artificially removed all the workers from six mature colonies of *P. villosa* and *P. inversa* and observed the possible change in the behaviour of queens. Our results show that queens of these ponerinae ant species are rather flexible and are able to expand their repertoire to worker tasks, if needed.

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Simulating the regulation of task selection in honeybees

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Social insects show the impressing ability to regulate their division of labour in a decentralised way. The regulatory system is based on individual perceptions of stimuli. If these stimuli exceed a task-specific threshold, the corresponding behaviour is triggered. In literature, several models of habituation and reinforcement processes are described which can explain the emergence of division of labour and the emergence of worker specialisation in social insects. These models are quite abstract and the corresponding articles refer mostly to ants as their source of inspiration. We created a multi-agent simulation of a honeybee colony that incorporates such stimuli-threshold reinforcement mechanisms in combination with brood nursing and trophallaxis. In contrast to recent literature, we modelled the stimuli in a very realistic manner, so that their properties reflect the circumstances of real honeybee colonies. The used stimuli are: light gradients, brood pheromone, crop fillings, direct assessment of the content of comb cells near (below) the agent (bee), waggle dances, tremble dances and queuing delays. The results of our simulation demonstrate that our simulated honeybee colony is able to perform similar to real honeybee colonies: The colony regulates the brood nursing in a hoemeostatic way and performs the recruitment of nurses, nectar receivers and foragers in a demand-driven way. Thus our simulation shows that the mechanisms suggested in literature suffice to generate an auto-balanced honeybee colony.

Temporal division of labor in the gray-black spiny ant, *Polyrhachis dives*

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Keywords: division of labor, sub-caste, guarding behavior

Although division of labor is an essential phenomenon in ants, the underlying mechanisms are poorly understood. The Gray-black spiny ant (*Polyrhachis dives*), a common ant in agricultural habitats of Taiwan, exhibits an exchangeable guarding behavior to defend nest or protect food source with a foraging behavior. A colony ethogram was constructed to reveal the behavioral repertoire of the 3 sub-castes of workers. Since the frequency of behavior performance changes in the sub-castes, we compared the mandible size, body length, volume of poison gland and Dufour gland among the sub-castes to unveil the relationships between the morphology and the sub-castes. The results showed no significant difference of all morphological characters among 3 sub-castes, except the volume of poison gland. The nurse workers had significantly less poison in the gland than that of foragers and guards. However, there was no difference between the latter. Dependent on colony size, food quality and food resource density, the guards were exchangeable. The potential mechanisms underlying the task-switching were discussed.

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Regulation of chamber size in nests of leaf-cutting ants

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Keywords: leaf-cutting ants, nest-building, fungus chamber, regulation

Ants build nests to protect themselves against enemies and to create a suitable microclimate for workers, brood and the queen. Leaf-cutting ants build conspicuous nests with separate_chambers for fungus gardens and refuse material. It is an open question whether the size of the chambers housing the symbiotic fungus depends on its size or on the number of workers inhabiting the nest. In order to investigate whether the fungus volume or the number of_workers in the nest is responsible for the final size of a fungus chamber, we created artificial nest arenas of clay in which workers could enlarge a small pre-existing chamber in order to place a fungus garden initially located outside of the arena. Two experimental series were performed: in the first one, we presented a constant number of workers with different volumes of fungus in independent tests. In the second one, we presented different numbers of ants with a fixed volume of fungus. In both series, both the final chamber size excavated by the ants after the fungus garden had been placed inside the chamber, and the total volume of the excavated tunnels, were recorded. It was observed that the overall size of the nest, i.e., the total volume of the chamber plus the volume of the tunnels, depended on the number of inhabiting workers. However, results suggest that the volume of the fungus serves as a template for the final size of a chamber, independent on the number of workers presented in the colony.

Modelling multiple transfer and nectar flow in honeybees

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Honeybee colonies have to collect nectar in the environment to cover the colony's energy demands. This task is performed by forager bees. Foragers returning from a successful foraging trip do not store the collected nectar by them selves, in contrast, they handle it over to nectar-receivers. A forager bee does not always transfer the whole amount of collected nectar to just one nectar receiving bee. Such partial unloadings may recur several times within an unloading process after a forager returns to the colony. The rate of these multiple transfers increases with an increase of nectar flow on the nectar source, independent of the sugar concentration of the nectar offered by the source. We found, that this increase of multiple unloads does not only affect the foragers collecting on one source but the whole cohort of foraging and nectar receiving honeybees. Our simulation of honeybee foraging shows a new, yet unknown possible mechanisms of information transfer via multiple nectar transfers and the local availability of global information about the over-all environmental situation regarding the nectar flow in a honeybee colony.

Preliminary experiments on the foraging activity of *Messor* ants from Greece

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Keywords: *Messor*, foraging, seeds, activity

The seed-harvesting ants of the genus *Messor* represent a significant ground-dwelling group in the Mediterranean ecosystems. Their effect on the constitution of the vegetation of Mediterranean meadows has not been extensively documented. We conducted experiments to assess the daily activity of ants in relation to the abiotic factors of the study area. In addition cafeteria experiments on the food preferences of *Messor* ants were held at this same area. Finally, we tried to evaluate the relationship between the size of the ants and the size of seeds available. Results indicate a clear pattern on the ant daily activity with direct liaison to environmental factors such as air temperature and relative humidity. *Messor* ants prefer the smaller and slimmer seeds among those offered. There is no direct correlation between worker size and seed size, however, larger seeds tend to be selected mainly by larger ants.

Evolution of activity patterns in annual eusocial insects

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Halictid bees show ample variability not only in social organisation but also in the course of annual eusocial nest cylces. The nest cylce of many sweat bees (Hymenoptera, Halictidae) can be described as a sequence of active (queen or workers collect food, build and provision brood cells) and inactive phases (nest is closed). Recent observations in *Lasioglossum malachurm* show a flexible number of worker generations interrupted by phases of inactivity. This holds not only for populations distributed on a larger geographical scale (Knerer 1992, Richards & al. 2000) but also between colonies within a single nest aggregation (Strohm & Bordon-Hauser 2003). Activity breaks occur during the whole annual growth period, that starts with solitary nest founding and ends with the emergence of the last sexuals. As this period is limited by the length of the season, every break reduces the potential productivity of a colony. Up to now not much attention has been directed to this apparent waste of time. We developed a simple mathematical model to identify mechanisms, that allow overall fitness increase despite the fitness loss due to productivity reduction by breaks. Our model extends the classical optimal control approach developed by Macevicz and Oster (1976). It accounts for differential mortality during active and inactive phases and for delay between laying of eggs and emergence of adult individuals.We found a systematic structure for the temporal occurence of fitness increasing breaks during the season, which is in excellent accordance with field observations.

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Worker policing: a mechanism to discriminate between worker-laid and queen-laid eggs

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In *Pachycondyla inversa*, like in many other ant species, workers cannot mate but are not sterile. They could pursue their individual interests by laying male eggs. The rewards of selfishness can be reduced by coercion in which worker-laid eggs are "policed" by other workers. Indeed, worker policing by egg eating does occur in *P. inversa* (d'Ettorre et al, 2004)

Queen-laid and worker-laid eggs differ in the relative proportions of surface chemicals, but so far, evidence for a queen-marking pheromone were only correlative.

One cue on the surface of eggs that could be used in discrimination is the hydrocarbon 3,11-diMeC$_{27}$, of which the concentration is higher on queen-laid eggs. We are currently testing whether worker-laid eggs treated with extracts of queen-laid eggs and with 3,11-diMeC$_{27}$ alone are more accepted than control worker-laid eggs.

Honeybee as new model for functional genomics

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Keywords: honey bee, superorganism, functional genomics, innate imunity, apiculture

Honeybee is on the way to be recognized as an important model organism for the study of neurobiology, resistance against pathogenes, innate immunity, allergic reaction, development, mental health, longevity, phenotypic plasticity in the female sex that results in different castes, as well as for the investigation of a role of royal jelly and its proteins in these processes. The honeybee has several features (haplo-diploidy, caste system, slow ontogeny, rich behavioural potential, high economic and ecological value through polination) that make it an ideal test system for both applied and fundamental functional genomics. Good examples include ongoing research on the genetical control of learning and memory, genes involved in sex determination, the genetics and regulation of the caste system, the identification of genes which are involved in foraging. These include the characterization of disease resistance genes, the development of stock identification tools, tools for marker assisted selection for productivity, the in vitro production of royal jelly proteins and other products used by the pharmaceutical industry. Consequently, understanding how bees use innate immune responses to battle their many disease agents could well offer general insights into human medicine. The products of this immune response are themselves touted as a novel source of pharmaceuticals, as are various hive products.

The perspective and interest for functional genomic research on the honey bee (*Apis mellifera* L.) are expected to expand with the release of the honey bee genome sequence (see http://hgsc.bcm.tmc.edu) and the development of new molecular methods.

Antimicrobial peptides in insects: structure and gene regulation

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Keywords: antimicrobial peptides, insects, *Drosophila*, gene regulation, termite, honey bees

Gene-encoded antimicrobial peptides (AMP) are widespread in nature. In multicellular organisms from both the vegetal and animal kingdoms, AMPs form a first-line of host defence against pathogens. These endogenous AMPs are involved in the innate immunity of many species and are playing an essential role in terms of resistance to infection and survival. Depending on their tissue distribution, AMPs could insure a systemic or a local protection of the organism against environmental pathogens. In invertebrates, including insects, various classes of AMPs have been identified. A large part of the AMPs display both hydrophobic and cationic properties, and most of them have a molecular mass below 10 kDa. They adopt an amphipathic structure (a-helix, b-sheet, or mixed structure) that is believed to be essential for their antimicrobial action. Nevertheless, in spite of the extreme diversity in their primary and secondary structures, all these natural AMPs have the particularity to affect, *in vitro*, a large number of micro-organisms with identical or complementary activity spectra.

The purpose of this overview is to focus on AMPs from insects, and more precisely on the regulation of their gene expression through the *Drosophila* genetic model. Biochemical analysis of the hemolymph of the fruit-fly *Drosophila melanogaster* and other Diptera has led to the discovery of eight classes of AMPs. These peptides can be grouped into three families based on their main biological targets. *Drosophila* AMPs are synthesised by the fat body in response to infection, and secreted into the hemolymph. Most of them can also be induced in surface epithelia in a tissue-specific manner. Finally, some of them are constitutively expressed in defined tissues, such as the salivary glands or the reproductive tract. The structures and activities of some of the insect AMPs, with a focus on AMPs characterized in social insects, namely in bees and termites, will also be reviewed.

Characterization of honeybee Toll related receptor gene *Am18w* and its potential involvement in host immune responses

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Keywords: Toll receptor, gene silencing, antimicrobial peptides, immune response, honeybee

Insect innate immunity involves a number of the intracellular signaling pathways, which control expression of the immune related molecules. The Toll family of receptors are involved in the intracellular signal transduction and subsequent activation of the anti-microbial peptides. Here we report isolation and characterization of a novel gene (*Am18w*) from honeybee *Apis mellifera*, which encodes Toll related receptor 18 Wheeler and shares striking 51.4 % to *Bombix mori 18 wheeler*, 46.6 % identity to a *Drosophila Toll-7* receptor and 42.5 % to *Drosophila 18 wheeler*. The protein sequence analysis revealed a conserved (TIR) intracellular signaling domain characteristic of signal transducing receptors found in Toll and mammalian interleukin 1 (IL-1) receptors. The expression profile of honeybee receptor gene *Am18w* was examined in all developmental stages, before and after immune challenge. We have also examined effects of the gene silencing (RNAi) on the expression level of the effector molecules. Here we demonstrate that introduction of dsRNA probe into honeybee larvae successfully disrupt endogenous mRNA of the target gene. The effect of *Am18w* gene silencing on the expression level of the honeybee anti-microbial peptides is discussed.

The linkage map of the honeybee: present status, use and prospects

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Keywords: honeybee, microsatellites, linkage map, recombination rate, bulk segregant analysis

The linkage map of the honeybee has been constructed in three steps, using microsatellite markers prepared in the laboratory from partial genomic libraries (Solignac *et al.*, 2004), from a library of cDNA of the brain (Whitfield *et al.*, 2002) and from the complete sequence of the genome. The map was calculated using the software CARTHAGENE (Schiex and Gaspin, 1997). The number of markers in the last version is 1,694 and the map is now saturated (16 linkage groups). The average density of markers is 3,01 cM^{-1}. The genetic length of the genome is even higher than in the previous estimate and reaches 5,102 cM. This size, joined to the fact that heterozygosity is rather low in the species, needs a high number of markers to detect a linkage in a whole-genome scan. Conversely, once a candidate region is defined, and the density of markers increased in the region, it is easy to get very close to genes of interest, thanks to relatively small physical size of the genome (230 megabases, i.e. 45 kb per cM). Centromeric regions were genetically determined on the linkage groups using half-tetrad analysis of laying workers of the bees from the Cape of Good Hope (Baudry *et al.*, 2004).

The various assemblies of the sequences for the whole genome have used the successive versions of the map to organise the scaffolds (themselves built from overlapping contigs). The last map allowed to organise 451 scaffolds in the assembly of January 2005, representing a total of 160 Mb, and to orient those of the scaffolds that contain at least two markers with a non-null distance, i.e. most of them.

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Monogynous and polygynous red imported fire ants, *Solenopsis invicta* Buren (Hymenoptera: Formicidae), in Taiwan

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Keywords: multiplex PCR, Gp-9, monogyny, polygyny

The social forms of the Red imported fire ants, which were initially discovered in Taoyuan County in 2003, were determined. Both polygynous and monogynous colonies were found. The inclusion of both social forms suggested two possible scenarios of fire ant invasion. Fire ants queens or colonies of both social forms could have invaded Taiwan together at approximately the same time. Alternatively, fire ants of one social form could have invaded Taiwan before the other within a short time period. The scenario of lone invasion by either polygynous or monogynous colonies was ruled out due to male sterility of polygynous colonies and the presence of both social forms. The significance of the presence of both social forms in the red imported fire ants in Taiwan is also discussed.

A study of *Myrmica sabuleti* (Hymenoptera, Formicidae), the ant host of *Maculinea arion* (Lepidoptera, Lycaenidae), in relation to a beltway construction project

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Keywords : ant community, biodiversity, *Maculinea arion*, *Myrmica*,

The Choisille river valley, near Tours (France), currently shelters a meta-population of Large Blue butterflies (*Maculinea arion*), a protected species at the national and European levels that depends obligatorily on a plant host (*Origanum vulgare*) and an ant host (*Myrmica sabuleti*) to complete its life cycle.

In July-August 2004, we carried out a study for the General Council of Indre-et-Loire, as part of preliminary impact studies for the northwest section of the Tours beltway construction project.

The inventory of ants and *O. vulgare* was performed on 100m² square of each of five sites and the abundance of *M. sabuleti* and other ants was evaluated using baits.

Two of the three most populous sites of the valley are directly threatened by the project. The mitigation measures proposed by the General Council consist in saving a little section of one of the threatened sites, arranging two other potential sites already visited by *M. arion*, and displacing the butterfly populations from the threatened sites to a fifth dry grassland site. The biological feasibility of these measures was evaluated using a comparative study on the state of *O. vulgare* and *M. sabuleti* on sites where *M. arion* was largely present and on sites planned for the future populations of butterflies.

The mitigation measures proposed by the General Council are discussed.

Population genetics of rare bumblebees

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Keywords: *Bombus*, population genetics, conservation, inbreeding, microsatellites

Bumblebees are ecologically, agriculturally and economically important as pollinators of crops and wildflowers. Unfortunately, many species throughout Western Europe, North America and Japan are suffering from declines in range and abundance, largely as a result of habitat fragmentation due to agricultural intensification. Such species now occur in discrete and isolated populations. Owing to their sociality and consequent reduced effective population size, bumblebees in these populations are thought to be particularly susceptible to inbreeding depression. To assess this threat, the population genetic structure of three rare bumblebee species in the UK (*Bombus humilis, B. muscorum* and *B. sylvarum*) has been investigated using microsatellite markers. Parameters for the conservation of these rare species, e.g. viable population size, are also being defined. Population genetic aspects of the decline of these pollinators will be discussed.

The role of habitats in structuring and conserving bumble bee assemblages

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Keywords: bees, bumble bees, *Bombus*, conservation, biogeography, foraging

Both wild and managed bees provide the essential ecosystem service of pollination which is of great ecological and economical importance. Unfortunately, every continent except Antarctica has reported declines of pollinators, principally due to habitat loss and degradation as well as pesticide exposure. Ample evidence now exists that European bee populations are in peril (Kearns *et al.*, 1998) but, as with most of Europe, relatively little is known about Irish bumble bee community ecology, and consequently, their conservation biology. The only current record of Irish species has been complied by the BWARS group (Bees, Wasps and Ants Recording Scheme) associated with the Biological Records Centre, U.K., but the records for Ireland are depauperate and provide no indication of the conservation status of different species. Our methodology critically assesses the influence of habitat type on structuring Irish bumble bee communities, as well as prioritizing individual species for conservation (Fitzpatrick *et al.*, In press). We present data from a variety of E.U. priority habitats, and 'historically' sampled sites, characterizing and quantifying the bumble bee assemblage in Ireland. Potentially, such a comparative approach could be extended across Europe to other similarly designated habitats. For the selected habitats, the management regime present has a significant influence on the diversity and abundance of both the forage and nest sites available within each habitat. Accordingly, recommendations for suitable management of species found to be of conservation concern can now be created.

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The role of social bees in provision of the ecosystem service of pollination in NE Greece

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Keywords: honey bee, *Apis mellifera*, Apoidiea, self-pollination, cross-pollination, Rosaceae

Conservation biologists are increasingly paying attention to the importance of biodiversity for the maintenance of human health, wealth and well-being, as exemplified by the concept of ecosystem services (e.g. Costanza *et al.* 1997). A major terrestrial ecosystem service is that of pollination, which is generally considered to be undertaken by insects, particularly bees (Buchmann and Nabham 1996). Concern is growing over the shortfall in this service due to intensive agricultural practices; for example, Kremen *et al.* (2002) have recently shown that crops of water melon (*Citrullus lanatus*) in California that are surrounded by intensively farmed land suffer reduced pollination. The northeast of Greece has amongst the highest densities of managed honey bee (*Apis mellifera*) colonies in the world and at the same time contains a great diversity of other bee species, both social and solitary. It is also an important producer of numerous fruit, nut and seed crops, and agricultural activities vary considerably in intensity within it. We therefore undertook an empirical study in NE Greece to determine (i) the pollination service that spring crops received in relation to agricultural land use and (ii) the role of the honey bee and other eusocial bees versus other flower visitors in the pollination of these crops.

Orchards of almond (*Prunus dulcis*), apricot (*Prunus armeniaca*) and sweet cherry (*Prunus avium*) were selected in the vicinity of the Chalkidiki Peninsula, NE Greece, and their size and surrounding land use quantified. All these crops are thought to require, or benefit from, cross-pollination (Free 1993). Insects visiting flowers were collected by hand sweep netting and insects flying within the orchards were collected using water-filled pan traps so as to related potential pollinator diversity and density with agricultural land use. Fruit set was then compared between flowers that had been experimentally bagged and hand self- or cross-pollinated with others that had been bagged without pollination and others that were unbagged and to which insects were allowed unrestricted visits. These experimental pollination treatments allowed us to quantify the pollination service provided by flower visitors, the role of social bees therein, and their relationship to land management.

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The influence of floral rewards on bumblebee foraging behavior: higher quality pollen means more visits

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Keywords: *Bombus*, foraging behavior, niche differentiation, pollination, protein, resource partitioning

Pollinators have long been known to respond to differences in floral nectar concentration, and to show preferences for more reliably rewarding flowers. In comparison almost nothing is known about how pollen quality influences pollinator behavior. We examine variation in pollen quality within plants visited by European bumblebee species and show that those plant species from which bumblebees frequently collect pollen have higher pollen quality (percentage protein content and proportion of essential amino acids), compared to plants that are only infrequently visited. We also show that rare bumblebees with the narrowest diets collect pollen exclusively from plants whose flowers offer the highest reward, while more common species have a relatively broad pollen diet. Previous studies have argued that coexistence in sympatric bumblebee species is attributable to partitioning of nectar resources according to tongue length; our results point to niche differentiation in the pollen resources exploited by bumblebees. Although it is clear that differences in diet breadth are responsible for species coexistence, comparatively little is known about the way in which food quality influences dietary specialism in sympatric foragers. Our results suggest that varying degrees of dietary specialization according to resource quality may facilitate coexistence within ecologically similar, sympatric animal species.

Seeing in the dark: vision and landmark orientation in a tropical nocturnal bee

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Keywords: halictid bees, vision, compound eye, optic lobe, landmark orientation

Some bees and wasps – like the tropical nocturnal sweat bee *Megalopta genalis* – have evolved nocturnal behaviour, presumably to exploit night-flowering plants or avoid predators. They display impressive visual behaviour despite having apposition compound eyes, a design adapted for bright light. In theory, this eye design should render these insects blind by mid-dusk. But despite this, we have discovered that they are able to learn landmarks around their nest entrance prior to nocturnal foraging trips, and to use them to locate the nest upon return. The morphology and optics of the eye, and the physiological properties of the photoreceptors, have evolved to give *Megalopta's* eyes almost 30 times greater sensitivity to light than the eyes of diurnal honeybees, but this alone is not sufficient to explain their nocturnal visual behaviour. Their improved sensitivity must therefore be due to a strategy of photon summation in time and in space, the latter of which requires the presence of specialised cells that laterally connect ommatidia into groups. First order interneurons, with significantly wider lateral branching than found in diurnal bees, have now been identified in the first optic ganglion of *Megalopta's* optic lobe. The extent of the spatial summation they might provide can account for *Megalopta's* ability to visually orient to landmarks at night.

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Visual cognition in honeybee navigation

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Keywords: honeybees, feature extraction, associative grouping and recall, categorisation

Honeybees are remarkably skilled navigators. Once they discover an attractive flower patch a few kilometres, or sometimes up to 10 km away from their hive, they can travel between their hive and food site repeatedly with extraordinary precision. To successfully navigate to the goal on foraging trips, the honeybee uses multiple strategies. We report here the progress made in our laboratory in the investigation of the way honeybees look at objects in their environment, learn and memorize them e*n route*, and then associate them with the route and the distant goal.

1. Honeybees can learn and remember the appearance of visual objects at different distances, and capture global as well as local features of objects [1];

2. Bees are able to extract the general properties of visual objects, such as orientation, bilateral symmetry, radial symmetry or circular symmetry, and apply them to distinguish between these and other objects. This faculty enables bees to detect prominent visual objects, namely landmarks along the route, which require much less storage space to be memorize [2, 3, 4].

3. Foraging bees usually follow a fixed route that they divide into segments, by using prominent objects as sub-goals. Honeybees are capable of the associative grouping and recall of these visual objects. A prominent visual object (landmark) with an attached local vector that spans the distance to the next landmark plays the role of a signpost to indicate the next sub-goal on the route [5, 6].

4. Honeybees, like monkeys and pigeons, can be trained to distinguish between different types of naturally occurring scenes in a rather general way, and to group them into four distinct categories: landscapes, plant stems and two different kinds of flowers. They exhibit the same response to novel visual objects, that differ greatly in their individual, low-level features, but belong to one of the four categories. [7].

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Visual memories in wood ants: binding of landmark edges to perceived centre of gravity

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Keywords: ants, navigation, landmarks, learning, memory, vision, snapshot models

Many insects rely on familiar landmarks to navigate through the world. One important navigational strategy is to store two-dimensional retinotopic 'snapshots' of the visual environment taken at various points along a route. Subsequently, the insect can repeat a learnt route by moving to match its current view of the world with the appropriately recalled snapshot. In this way, snapshots can both lead the animal along a particular route and specify a final destination.

We have recently been exploring what visual information wood ants use to recall the most appropriate snapshot memory. Ants were trained to feed at the base of a black rectangular wall. Following training, the wall was replaced by an intensity gradient fading from black to white across its horizontal axis. This leaves the ant with only a single vertical luminance edge to navigate by, insufficient information to select the appropriate stored snapshot if only edges are represented in the visual memory. However, ants are relatively unperturbed by the gradient stimulus and still take a straight line path towards it. We challenged ants with various wall and gradient stimuli in order to determine what cues are used to recall the appropriate snapshot.

Ants' responses to a variety of landmark types are consistent with recall of snapshots based on the angle between the edge of the landmark and its horizontal visual centre of gravity (CoG). Our results suggest that local edges and CoGs can be bound together during visually-guided navigation.

Do honeybees optimally use optics of their eyes?

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Keywords: bees, vision, foraging

The optical resolution of the honeybee eye is approximately 100 times worse than ours. Thus it is likely that honeybees use optimally optics of their eyes. However, behavioural experiments with honeybee workers have shown that circular stimuli, in order to be detected or discriminated, must project on at least 7 ommatidia (Giurfa et al. 1996; Giurfa et al., 1997). Because theoretically it is possible to detect a stimulus that projects onto one ommatidium, it has been concluded that in honeybees behavioural resolution is significantly worse than the limit set by optics of their eyes. Later it has been shown that honeybee workers detect and discriminate stimuli having dim centre and bright surround from a longer distance than those having bright centre and dim surround (Hempel et al., 2001; Hempel et al., 2002). This result agrees with a hypothesis that, in order to detect a stimulus, honeybees need to optically resolve its borders. To test this hypothesis, we analysed the detection limits for oval stimuli. It appeared that honeybees react only to stimuli whose borders they can resolve. The resolution of border detectors is set by optics of the honeybee eye.

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How foraging bees are guided by floral displays

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Keywords: bees, vision, colours, patterns, flower signals, flowers

Pollinators can respond differently to floral food sources and it is useful to understand pollinator visits as a result of information transfer and decision making. The behavioural responses depend upon perception, memory and evaluation of flower signals, in particular visual displays. But which signals are available to a pollinator's eye and how are they used by pollinators to create appropriate foraging responses? Are they optimised allowing a pollinator to reliably detect, discriminate and recognise flower displays?

The honeybee's visual system is an excellent model to analyse floral signals from the point of view of bee-subjective perception. Flower colours can be measured either with help of a spectrometer (Menzel & Shmida 1993) or a calibrated imaging device (Vorobyev et al. 1997). Using the latter, a view of a whole floral display is obtained and views through a bee's eye can be simulated for different distances. Perceptual models, which describe how chromatic and achromatic aspects of colour are processed in the bee brain (Giurfa and Vorobyev 1998, Vorobyev et al. 2001); are used to assess the visual cues present in flower displays for bees.

When flowers are at a larger distance, their detectability is constrained by the spatial distribution of achromatic, e.g. brightness contrasts. In experiments bees detect dim disks surrounded by bright rings from further distance than bright disks surrounded by dim rings (Hempel et al. 2001). When viewed through the low resolution eye of the honeybee the majority of bee-pollinated flowers look like dim disks surrounded by bright rings, which indicates that flower patterns are optimised for detection by bees. Where flower patterns are not optimal for detection, their detectability is improved by increasing flower size. Being at close distances to flowers, chromatic cues are solely used by bees for flower discrimination. We present experimental evidence that chromatic salience and generalisation of salient display features influence the bee's discrimination performance.

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Sensitivity of the ant *Myrmica sabuleti* to light intensity

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Keywords: ant, *Myrmica sabuleti*, vision, light, adaptation

The sensitivity of *Myrmica sabuleti* workers to light intensity has been studied thanks to operant conditioning as a method, by assessing the lowest light intensity (i.e. the ants' threshold) necessary for inducing the conditioned response. Six experiments were performed, each one on six experimental societies, according to the following protocol. The ants were conditioned during 10 days under a first light intensity (= I_1) and their threshold was then assessed. This threshold appeared to be an exponential function of the square root of the light intensity value (I_1) used during the 10 conditioning days. The ants were then placed during one day in another light intensity (= I_2) and their threshold was again assessed. This threshold differed from the previous one: it was higher (or lower) according to the increase ($I_2 > I_1$) (or to the decrease; $I_2 < I_1$) of the light intensity. But the newly acquired threshold was not so high (or so low) as that presented after a 10 days period under the I_2 intensity. So, after one day under a new light intensity, the ants' adaptation was not complete, at least was not as complete as that presented after a 10 day period in that light intensity. We suppose that, though having small eyes and a rather poor vision, M. sabuleti workers possess one or several cytological and/or physiological systems allowing them to adapt their vision to the light intensity.

History and significance of small hive beetle introduction into the US

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Keywords: small hive beetle, SHB, *Aethina tumida*, history and significance, control measures

The small hive beetle (SHB) was identified in Florida in 1998 after beekeepers reported a number of honey houses were affected by strange-looking honey with nearby colonies collapsing for unknown reasons. It is thought the beetle may have come from South Carolina where it was introduced by ships calling at Charleston or other ports, but this has not been confirmed. It took a considerable amount of time to identify the pest as very little published information existed and many beetles in the same family (Nitidulidae) look similar. After identification, it was observed that the beetle had been in the state for enough time that consideration of eradicating the insect was abandoned. This also led to very high initial populations that often appeared catastrophic.

Since discovery in Florida the beetle has slowly spread across the United States and it has over wintered as far north as Minnesota in honey bee colony cluster. Most recently it has been reported as far afield as Portugal, presumably introduced via queen importation from the state of Georgia.

Small hive beetle, (*Aethina tumida*) is considered most problematic near honey houses where larvae in honey change the sweet chemically, causing fermentation and abandonment by the bees. Weak, stressed and small colonies are also at risk from beetles that appear to search them out. The beetles are strong fliers and can survive outside bee colonies for extended periods of time. The larvae complete their development outside the colony, usually in the soil. This leaves them vulnerable to chemical treatment outside the hive. Recently, a trap has been developed to lure beetles using pheromones.

Appearance of the small hive beetle has caused a revolution in honey house management. Scrupulous sanitation in extracting facilities has reduced populations considerably. No longer can ready-to-extract combs be left for protracted periods. Some beekeepers use refrigeration to protect vulnerable combs. Chemical treatments exist but they are time consuming and cannot target beetles directly. This paper will examine the newest information on this introduced species.

Testing the haploid susceptibility hypothesis: parasites and social organisation

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Keywords: *Bombus*, *Crithidia*, social organisation, parasites, haploid susceptibility

The haploid state of males in eusocial Hymenoptera has been proposed as a driving force in the evolution of social behaviour on the assumption that haploidy results in higher susceptibility to pathogens. Here we test the assumptions of the "haploid male susceptibility hypothesis". We challenged males and workers of the bumble bee *Bombus terrestris* with its parasite *Crithidia bombi* but found no differences in either susceptibility or intensity of infection between haploid males and diploid females. We reviewed observational studies on parasitism in haplodiploid insects and found that in 15 out of 26 cases haploid males had lower prevalence. We suggest three explanations for our results based on genetics and ecophysiology. Our results suggest that the haploid susceptibility hypothesis does not explain the origin or maintenance of social systems in the eusocial Hymenoptera.

Nosema bombi – variation or sibling species?

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Keywords: Bumble bees, Microsporidia, *Nosema bombi*, morphological variation

The microsporidium *Nosema bombi* is a locally common parasite of bumble bees and molecular data suggest that the same parasite infects a large range of different bumble bee hosts. Although molecular methods do not demonstrate species diversity of Microsporidia in the *Bombus* complex, two years¥collections in Sweden and Denmark demonstrate large variability at the light microscopy and transmission electron microscopy level. The differences are greater at the light microscopic level than in the ultrastructure. Variable parameters are e.g frequencies of the two spore morphs, spore size, presence of coupled spores, presence of grouped spores, and willingness to eject the polar filament. At the ultrastructural level the most apparent differences are seen in the length and arrangement of the polar filament. The morphological and ultrastructural data demonstrate that *N. bombi* is a highly variable microsporidium or even may represent closely related sibling species. Further work is motivated to elucidate how the described morphological variation in *N. bombi* is represented at the molecular level.

Intra-genomic variation in the rRNA gene of the microsporidian parasite of the bumble bee, *Nosema bombi*

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Keywords: ribosomal RNA, *Nosema bombi*, microsporidia, bumble bee, concerted evolution

In a recent study, the ribosomal RNA gene was used to characterize the molecular diversity of *Nosema bombi*, a common unicellular parasite of bumble bees (Tay et al., in press). Microsporidian isolates from eight European bumble bee species were sampled. Despite uncovering a low level of polymorphism, the variation between isolates was substantially less than that seen between established microsporidian species and therefore one species, *N. bombi* was considered responsible for all eight infections. Although only one microsporidian species was identified, host susceptibility and symptoms of infection are known to vary widely among *Bombus* species and it was hypothesized that the low level of polymorphism found could reflect 'strain' differences among *N. bombi*. Therefore it is possible that the identification of multiple rRNA types from one individual host bumble bee could represent the co-occurrence of multiple infections. Unfortunately this hypothesis is confounded by the widely accepted fact that rRNA exists in multiple copies in the genomes of the majority of organisms. In the human infective microsporidian species, *Enchephalitozoon cuniculi*, rRNA genes are found in a sub-telomeric position at each end of each of the 11 chromosomes in its haploid genome (Brugere *et al.*, 2000). In *N. apis*, rRNA genes occur in a tandem arrangement (Gatehouse and Malone, 1998). Although in many species all of the rRNA copies are homogenized by a process known as concerted evolution, more and more studies are uncovering a variety of differences between the copies. It is not known how many copies of rRNA occur in the *N. bombi* genome or if they are identical, therefore we set out to determine the sequence of an individual's rRNA genes. Four single spores from one source were isolated by laser microdissection. An rRNA region of 122bp, which includes the ITS region, was amplified from the spores and the amplicons were then cloned. Two sequence types occurred in all spores. These short and long types possess different numbers of GTTT repeats in the ITS; the short sequence has two repeats and the long has three. The two types occurred in roughly equal proportions. The remainder of the sequences contained one or two largely unique

SNPs or indels. We conclude that rRNA sequences in *N. bombi* are not fully homogenized. Intra-genomic variation in the rRNA gene may confound the identification of *N. bombi* strains at this locus.

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Prevalence and distribution of the microsporidium *Nosema bombi* in bumble bees (*Bombus* spp.)

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Keywords: microparasite, *Bombus* spp., *Microspora*, rRNA

Bumble bee (*Bombus* spp.) infections with the obligate intracellular microsporidian parasite *Nosema bombi* have been recognized since the early 20th century. *N. bombi* apparently infects numerous *Bombus* species, where it is primarily found in host Malpighian tubules, extending secondarily into the midgut, the tracheal matrix, connective tissue, the fat bodies (MacFarlane et al., 1995) and the nervous system (Fries et al., 2001). Until now little data are available on the incidence of parasitism with *N. bombi* in wild bumble bees. Within the EU project Pollinator Parasites (QLK5-CT-2002-00741) we collected from the field more than 2500 bumble bees of 12 different species in 2003 and 2004 from Sweden (Ingemar Fries), Denmark (Ronny Larsson), The Netherlands (Sjef van der Steen), Switzerland (Rahel Salathe) and Northern Ireland (Sandra Mustafa and myself) to report the prevalence of *N. bombi* in the field, dissected them and examined the ventriculus, Malpighian tubules and fat bodies by light microscopy (x 400 magnification) for microsporidia. In central Sweden and in Switzerland the rate of infection was very low (1-3%) infections in comparison to ~13% in the other areas. However, I have shown that molecular detection of *N. bombi* by PCR amplification of its partial rRNA is more sensitive than light microscopic observation (Klee et al. 2005) which suggests that the actual infection rate in the field might have been higher. The molecular detection method was developed for European *N. bombi* based on the molecular genetic study of Tay et al. (2005), who found that *N. bombi* is the only known microsporidium to infect bumble bees. Sequencing of partial rRNA of microsporidia within *Bombus occidentalis* from Canada by Elaine O'Mahony (Queen's University Belfast) has revealed the same sequence as in *N. bombi* from European *B. terrestris*.

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Infection routes of *Nosema bombi* in *Bombus terrestris*

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Bumble bees are used for pollination in greenhouses. Their economic importance has resulted in an expanded indoor rearing. Bumble bees carry several parasites and diseases, among others *Nosema bombi*, that can affect the rearing. To increase the knowledge of *Nosema bombi*, studies on infection routes are conducted: (1) inducing a *Nosema* infection in larvae, (2) inducing a *Nosema* infection via sucrose solution 50% to adults in a colony and (3) horizontal transmission in a bumble bee colony.

To induce a *Nosema* infection in larvae, *Nosema* spores in sucrose solution 12.5% were administered to individual larvae in open cells. These larvae were 15 to 20 days old. Ten to 15 days after application, the infected bees emerged. Administration of 175.000 spores per larvae resulted in a microscopically detectable infection of the Malpighian tubes and ventriculus in bees, checked immediatley after emergence. Adminstration of *Nosema* spores via the sucrose solution to adults did not result in an infection within 6 weeks after spores administration. In order to study the horizontal transmission, in seven colonies larvae of 15 to 20 days were individually infected with 200.000 spores. Periodically all bees were marked to record the period of emergence. At the end of the life span of the colony, bumble bees were microscopically checked for *Nosema* spores. The study revealed that the infection was transmitted horizontally and that bumble bees could be infected in the adult stage.

The route via the larvae is important as the administration of spores to adult bees does not result in an infection. In colonies in which the treated larvae are removed by the bumble bees within four days after administration, neither a *Nosema* infection developed.

Confusing fitness effects of *Nosema bombi* (Nosematidae, Microsporidia) in the bumblebee *Bombus terrestris*

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Nosema bombi is an obligate intracellular parasite that infects different bumblebee species at a substantial, though variable, rate. To date its impact on host fitness is not well understood. In a laboratory experiment we found that, if infection occurs at an early stage of colony development, virtually all individuals are infected. In some cases males and young queens showed reduced viability and deformities. The mortality rate of workers in the infected colonies is very high. In a natural environment the reduced worker survival should lead to small colony size and therefore an early colony death or no reproduction. To test this we performed a field experiment. We infected one group of bumblebee colonies with *Nosema bombi* spores at the worker production stage and we kept another group as controls. We put 28 colonies in the field. During colony development we collected workers and faeces to measure infection intensities. In parallel, we measured several life history traits to find probable costs to the host. We found that the infected colonies were significantly smaller and none of them produced sexuals, whereas 4 out of 14 controls produced sexuals. With such severe effects, *Nosema bombi* seems to decrease its opportunities for transmission to the next host generation.

Foraging behaviours of three social wasps species in southern Ukraine

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Keywords: social wasps, yellowjackets, paper-wasps, *Vespula*, *Polistes*, behaviour, foraging strategy

Foragers of some species of paper-wasps and yellowjackets are known to be attracted to social wasps aggregations feeding in urban areas on rubbish containers, in markerts and in orchards, where they damage the ripe fruits (plums, pears, apples and grapes) (Edwards, 1980; Parrish and Fowler, 1983; Raveret Richter and Tisch, 1999). Individual foragers of the other species act independently. Social wasps in southern Ukraine differ in the source of carbohydrates at different stages of their life cycles. The experiments and observations of social wasps carbohydrate resource choice were conducted during July 2004 at the forest and steppe zone of the Black Sea Reserve where *Polistes dominulus*, *P. gallicus* and *Vespula germanica* nest sympatrically. Four density levels of paper-wasps on feeders (empty feeder, one wasp of *P.dominulus*(1D) or one of *P. gallicus* (1G); two wasps (2D or 2G); 6 wasps (6D or 6G) were used for determing species response to aggregations. An approaching forager demonstrated the following behaviours: A) a wasp made a round flight above the feeder and flew away. B) a wasp sat down and then immediately flew away. C) a wasp sat down and fed. For foraging strategies analysing we constructed three wasps models to simulate feeding insects.1. Using tied alive wasps of *P. dominulus* and *P. gallicus* at different density levels it was shown that all the species under study decreased their activity as the number of tied wasps increased. *P.gallicus* foragers preferentially fed on feeders with few or no wasps present. This species distinguished what species was on the feeder. An increase in the density from 1G to 6G led to the lesser occurrence of the C - type behaviour of *P. gallicus* foragers. But an increase in the density from 1D to 6D resulted in a higher frequency of its A- type behaviour, but decreased activities B and C. *P. gallicus* didn't feed at 6D density level. *P.dominulus* foragers reacted only to the density increase. There were no differences in its behaviours between 1G and 1D, 2G and 2D, and 6G and 6D. *V. germanica* changed its behaviour only with an increase in *P. dominulus* density on feeders. Using freshly killed *P. dominulus* and *P. gallicus* at the similar four dencity levels it was found that foragers of *P. dominulus* and *V. germanica* made some longer flights around the feeder with dead insects and if they sat down they fed. Using *P. dominulus* and *P. gallicus* washed in hexan at the similar four density levels as wasp models, it was discovered that *P. dominulus* and *V. germanica* foragers decreased its C- type behaviour on feeders with 2G and 6G. Thus, *P. gallicus* foragers prefer disperse foraging strategy. *P. dominulus* and *V. germanica* foragers demonstrate aggregation strategy. It is possible that visual and olfactory cues are responsible for the observed distribution of the different species foragers at food source.

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Conflict resolution in insect societies

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Keywords: worker reproduction, conflict resolution, dominance hierarchy, *Temnothorax*

Insect societies are often referred to as superorganisms, in which all individuals cooperate to increase the reproductive output of the society as a whole. However, group members are genetically not identical and conflicts exist over reproductive decisions. While kin selection theory explains the evolution of cooperation and altruistic behaviour among selfish individuals further hypothesis based on the degree of kinship among group members explain regulations of reproduction and conflict resolutions within societies. Although kinship is undisputedly one of the most important factors underlying reproductive patterns, recent studies on the organization of insect societies document that predictions based on kinship alone are often not met. Additional factors, such as lack of information or lack of power held by individuals to allow adaptive manipulations, and also costs at the colony-level might explain discrepancies between theory and empirical data. Aim of this study is to investigate the meaning and importance of these factors in the context of worker reproduction in *Temnothorax* (formerly known as *Leptothorax*) ants. In contrast to expectations from kinship, workers in the monogynous and monandrous species *Temnothorax unifasciatus* refrain from producing their own sons in queenright colonies but form reproductive hierarchies in queenless groups where the top ranking workers start to lay haploid eggs (Heinze et.al. 1997). Whether workers in queenright colonies are prevented from reproducing by the queen, by their fellow workers or even by themselves is still not clear. In an experiment in which *T. unifasciatus* colonies were split and reunited, workers from the queenright part did not show any overt aggression against the high ranking workers from the queenless group but engaged in ritualised dominance interactions.

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Termite diversity in young eucalypt plantation in the tropical forests of Kerala State (India)

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Keywords: termite diversity, eucalypts, *Odontotermes*, *Microcerotermes*

Information on the termite fauna in a young eucalypt plantation was generated; through a one-time line transect sampling and monthly sampling for an year. The transect sampling recorded 11 species falling under two families and four subfamilies. The subfamily *Macrotermitinae* dominated with eight species while the other three subfamilies were represented by only a single species each. A temporal pattern of abundance was observed for the different active foraging species of termites. During April - November, a single species, *viz. Odontotermes obesus*, was the most abundant. During December – January, *Microcerotermes fletcheri* was dominant while *O. feae* dominated during February and March. Rainfall was found to have a negative influence on diversity of the active/foraging species of termites. Of the total termite samples collected, 40 per cent belonged to the single species *Odontotermes obesus*. Among the species recorded during the whole of the study, one is a new species and two are new records to Kerala State.

The use of balances linked to dataloggers to monitor honeybee colonies

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Keywords: honeybee colonies, balances, dataloggers, running average, detrended data

Honeybee colonies are often weighed, as a means of monitoring both honey production and colony health. For example, McLellan (1977) weighed hives daily and used the data to calculate a polynomial equation for predicting honey reserves. Electronic balances with a precision of 10 g were linked to 12-bit dataloggers (giving an overall precision of about 30 g) and used to monitor honeybee colonies over 14 months. The weight data were used to examine: 1) seasonal changes in hive weight; 2) magnitude and duration of changes in beehive weight due to rainfall; and 3) the size and timing of swarms. Data were used to calculate the 25 hour running average, which was then subtracted from the observed weights to generate the hourly detrended data. The 25-hour running average, calculated for each hour by averaging the weight data for the previous 12 hours, that hour, and the following 12 hours was useful for monitoring longer-term changes in hive weight, such as that due to increases and decreases in colony strength, honey collection, and swarming. The hourly detrended data were useful for monitoring daily fluctuations due to forager activity and water gain and loss. Magnitude (difference between highest and lowest values of the day) of the detrended data were usually, but not always, correlated with hive weight gain. The detrended data were fit to sine curves to examine the frequency of the daily weight changes. Datalogger-linked balances may be useful in the analysis of the effects of pathogens and parasites and their control.

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Ant communities in Ireland with special reference to those on limestone grassland

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Keywords: ant species mosaic, *Myrmica, Lasius, Formica, Tetramorium*, Ireland

The Irish ant fauna comprises about 18 species. In south-eastern Ireland, *Tetramorium caespitum* occurs with *Myrmica* spp., *Lasius niger* and *L. flavus* and *Formica lemani* in coastal dune ecosystems. Observations on their distribution, seed gathering (myrmechory) and aphids will be presented. In woodlands, *Formica lugubris* occurs in both native oak (*Quercus petraea*) and plantation woods in southern Ireland. However the number of colonies is in serious decline in recent decades and the appropriate management of afforestated woodlands needs to be addressed urgently. *Formica aquilonia* occurs at a single site in Northern Ireland, and may comprise a single polydomous colony: although limited in its overall distribution, this species seems to be self-sustaining at this site. Species such as *Lasius fuliginosus*, *L. mixtus* and *L. umbratus*, and *Stenamma westwoodi*, are very rare or occasional in Ireland. Perhaps the most diverse mosaic of species occurs in limestone grassland, such as in the karst region in the Burren in western Ireland. The soils are shallow including bare rock, management includes grazing by domestic cattle, and the use of artificial fertilizers is very limited or none. Here the species are *Myrmica ruginodis*, *M. scabrinodis*, *M. sabuleti*, *M. schencki*, *M. rubra*, *Leptothorax acervorum*, *Formica lemani*, *F. fusca*, *Lasius flavus*, *L. niger*, and *L. mixtus*. We have studied their distribution in quadrats baited with crumbs, and related the distribution to vegetation and other characteristics.

Worker confrontations of invasive ants at food sources under laboratory conditions

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Keywords: introduced ants, invasive species, food competition, aggressive behavior, artificial confrontations

Introduction and extinction of species is a natural phenomenon that has been greatly accelerated with the large development of human trade. Due to their small size and good adaptation abilities ants are commonly transferred by man. Among invaded areas, remote oceanic islands are common places for such introductions.

Floreana Island in Galápagos Archipelago (Ecuador) shelters a minimum of 24 ant species among which at least 14 have been introduced. Most of these exotic ants are well-known widespread tramp species. The recent evolution of species distributions there reveals that the process of invasion is still very dynamic (von Aesch and Cherix 2005).

The simultaneous presence of several introduced and potentially invasive species at the same place is a great opportunity to study their interactions and competition strategies. If successful introduced species are known to possess high competition skills, we know little about underlying mechanisms that allow them to outcompete other species. We admit that competition for food is one of the main factors of competition and we study here the use of direct physical aggression in the context of food acquisition.

We confronted small groups of 150 workers. Groups of two different species are allowed to recruit to food on the half of an experimental area divided by a removable wall. Once a recruitment behavior is clearly established the separation is removed and the behavior of ants recorded.

We paired three species: *Solenopsis geminata*, *Monomorium destructor* and *Tetramorium simillimum*. The *S. geminata – T. simillimum* pair was the most pacific, with few fights. On the other hand, the two pairs implicating *M. destructor* resulted in a huge proportion of fighting workers and a strong decrease of foraging activity on both sides. Previous field data on colonization of food baits for several hours indicates that *M. destructor* and *S. geminata* behave both as dominant species with high competition abilities (von Aesch and Cherix 2005). In this study, when in competition with a submissive species as *T. simillimum*, they react in very distinct manners. *M. destructor* strongly diminishes its foraging activity and invests a large number of workers in direct physical aggression when *S. geminata* nearly ignores *T. simillimum* and maintain foraging. This may be an explanation of the slow invasion capacity of *M. destructor* outside of the village area where it was introduced about twenty years ago.

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The influence of social context on ants' collective foraging patterns and individual decision-making

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Keywords: ants, social context, decision-making, recruitment trail, home-range marking

In nature, animals should be able to adjust their foraging behaviour to focus on areas that contain the most valuable food patches with low associated risks of predation or competition. Foragers can access such information through their own experience but also through the use public information (see e.g.Danchin *et al.* 2004). Ant societies are well known examples of social integration of information. In this respect, ants can acquire a global knowledge about the quality of environment which exceeds their individual capacities by estimating the local density and activity of nestmates in an area. Home-range marking (Devigne & Detrain 2002) that is passively laid by walking ants can be a cue about the level of occupancy of a location that allows scouts to assess the potential interest of explored areas. Here we show in the aphid-tending ant species, *Lasius niger*, that the recruitment intensity as well as the rate at which information about food is conveyed by scouts to nestmates depend on the level of home-range marking (Devigne et al. 2004). Over a marked set-up the discovery time of a sugary food source decreases while the probability for scouts to recruit nestmates and to keep on laying a trail increases. Among ants making U-turns on their return to the nest, home-range marking helps them to resume laying a trail after the U-turn and delays its occurrence. The resulting higher trail amount and speed of information transfer increase the number of foragers mobilized to frequented areas that are potentially safer and promote recruitment and exploitation of food sources to better known sites. Finally we will review examples of social cues acting upon ants'decision-making as regards task allocation (Gordon & Medhiabadi, 1999) or nestmate recruitment to new nesting sites (Pratt, 2005).

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Negative pheromone in an ant foraging trail network

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Keywords: ants, organisation, foraging, trail, pheromone, repellent

Insect societies are complex systems which face the challenge of co-ordinating the activities of their many individuals. Ant trail pheromones increase system performance by attracting foragers to rewarding sections of the colony's trail network. Previous work on social insect foraging has focussed on the role of these positive, attractive pheromones. Computer simulation studies indicate that the effectiveness of foraging trail networks could be greatly improved by repellent or negative pheromones. If foragers marked unrewarding trails with a negative signal, other foragers could avoid these parts of the trail system. However, despite the strong theoretical advantage, there are no known examples of negative pheromones in ant foraging trail systems. Here we provide the first evidence for such a pheromone. We show that Pharaoh's ants (*Monomorium pharaonis)* mark the unrewarding branch at a trail bifurcation with a signal which greatly increases the probability of other foragers selecting the opposite branch or making a U-turn. Foragers also increase their lateral motion on their approach to this signal, showing that the signal is volatile and indicating that it may help them locate a rewarding branch at a trail bifurcation. We are also investigating the longevity of this signal and possible mechanisms of deposition, to better understand its role within the organisation of the foraging system.

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Transport chains in foraging grass-cutting ants: efficient load carriage or improved information transfer?

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Keywords: ants, foraging, efficiency, information, load size, transport

Foraging workers of the grass-cutting ant *Atta vollenweideri* often transport a given load consecutively, thus forming transport chains. We tested the predictions of two hypotheses concerning the causes for the occurrence of transport chains: First, the "economic-transport-hypothesis" predicts that workers may transfer fragments because loads are either too large for the carrying ant, or the ants are too small for the loads they carry, thus rendering transport inefficient. As a consequence, the probability of occurrence of transport chains is expected to depend on fragment size independent on fragment quality, being higher for those fragments that are difficult to carry. The "information-transfer-hypothesis", conversely, suggests that the behavioural response of transferring fragments may have been selected for because of its positive effect on the information flow, rather than for an improvement in the economics of load-carriage: By dropping the load a worker may return earlier back to the foraging site and be able to reinforce the chemical trail, thus enhancing recruitment. In addition, the transferred fragments may themselves act as information signals about what plant is currently harvested, thus enabling workers to choose among sources of different quality or to search specifically for them. This hypothesis predicts that the formation of transport chains

should strongly depend on fragment quality, and be independent of fragment size. To distinguish between these alternatives, workers from a field colony were presented with standard paper fragments that differed either in size or in quality. Neither an increase in fragment mass nor in fragment length changed the frequency of occurrence of transport chains. In addition, transport via transport chains took longer than if it was accomplished by a single carrier all the way through. Regarding fragment quality, the frequency of occurrence of transport chains increased with increasing fragment quality independent of its size. In addition, high-quality fragments were transferred after shorter distances, i.e., attractive loads were dropped more frequently and after a shorter distance than less attractive ones, with the first carriers returning to the foraging site to continue foraging. Results suggest that rather than enhancing the economic of load carriage at the individual level, transport chains increases the information flow at the colony level.

The influence of experience on host-plant selection by the leaf-cutting ant *Atta colombica*

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Keywords: leaf-cutting ants, foraging, experience, host plants

Colonies of the leaf-cutting ant *Atta colombica* were studied in Panama to examine the influence of experience on host plant selection. Eleven rarely accepted plant species were tested over three days on colonies with different experiential background. Colonies to which the offered plant species were unknown accepted them readily on the first encounter, but rejected all of them on the following days. This phenomenon is known from the laboratory as 'delayed rejection' (Knapp *et al.* 1990). 'Experienced' colonies however, which had encountered those plants before, rejected the species on their first encounter.

The duration of experience was determined in the field by presenting colonies with leaf disks treated with cycloheximid (CHX), a fungicide undetectable by the ants (Ridley *et al.* 1996). Five colonies were offered treated leaf disks once. Treated leaf disks were initially accepted by all colonies. Within 48 hours, however, all colonies rejected the substrate. Over the following weeks, untreated leaf disks were used to monitor acceptability. The duration of rejection differed between the colonies and ranged between eleven to 18 weeks until the foragers began harvesting the substrate again.

Overall, experience significantly changes the acceptability of certain plant species and is gained through 'testing' and a feed-back control of the fungus. The foraging experience of each colony is different and changes permanently as ants sample plants each day and colonies 'forget' previous experience.

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Trophic egg production and prey retrieval by the foundress in the ant *Manica yessensis:* Their contributions to the first worker production

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Keywords: ant, colony founding, *Manica*, trophic egg

Manica is a small ant genus of the Myrmicinae containing 1 species in Japan and Europe each and 4 species in North America. The genus is assumed to be closely related to *Myrmica*. Since the semi-claustral colony founding, which behavior had been considered as typical in the Ponerinae and Myrmeciinae, was confirmed for the European *Manica rubida* (Le Masne and Bonavita, 1969), foundress foraging behavior has been observed also in the Attini, Dacetini, and the seed-harvesting ants of *Pogonomyrmex* and *Messor*, all of which are myrmicines, so that presently this mode of colony foundation is not simply considered as a "primitive" trait, but rather the question as to what ecological factors force or permit foraging by foundresses has become more important. When cultured in the laboratory, the foundress of *Manica yessensis* also regularly forages and retrieves given insects into the brood chamber and feed them to the larvae. In addition, the author recently confirmed that the foundress lays two kinds of eggs; one is reproductive eggs and the other is trophic eggs (Masuko, 2000). The reproductive egg is bean-shaped and twice heavier (in wet weight) than the trophic egg which is oval-shaped. Thus, the nutrition for the first worker production in this species is based concurrently on trophic eggs and retrieved prey. To know how these two kinds of nutrition are used properly in brood rearing, *M. yessensis* foundresses were collected immediately after nuptial flight on the east slope of Mt. Fuji and they were separated into three groups with different nutritional regimens, under which conditions they were observed and compared for the outcome of brood production. The results suggest that trophic eggs are sufficient for the larval cohort to reach the 4th instar (the final instar in this species) but the further maturation needs additional food supplied from outside the nest.

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Recruitment in a scent path laying stingless bee to food sources of different profitabilities

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Keywords: stingless bees, *Trigona*, recruitment, food profitability, communication, foraging

In collective foraging social insect colonies commonly adjust the number of recruits to a food source's profitability. Honeybees and *Melipona* stingless bees recruit more nestmates to food sources of higher profitability than to ones of lower profitability (Seeley 1995, Biesmeijer and Ermers 1999). In contrast, scent trail laying ants are only capable of an increased recruitment to a highly profitable food source if it is discovered simultaneously with a less profitable food source. Scent trail laying ant colonies were not capable to re-allocate the workforce to the richer food source while recruitment to a less profitable food source still went on (Beckers et al. 1990). In the present study we examined (i) whether a colony of a scent path laying stingless bee, *Trigona recursa*, is capable of recruiting more nestmates to a highly profitable food source than to a simultaneously offered less profitable food source and (ii) whether re-allocation of the workforce to a highly profitable new food source is possible while recruitment to a less profitable one is still going on. The parameters of sugar ingestion by *Trigona recursa* (sugar intake rate [mg/s], sugar per crop load [mg]) were significantly higher for a 40 % w/w sugar solution (which therefore was more profitable) than for a 20 % w/w sugar solution. Collective foraging was observed without any interference with the recruitment process. When at the start of the experiment one bee was trained to a 20 % w/w food source and another bee at the same time to a 40 % w/w food source and both allowed to feed and recruit ad libitum, the significant majority (median of 85 %) of recruits arrived at the 40 % food source. The selection of the more profitable source did not result from a comparison of both food qualities by individual bees. Less than 1 % of the bees (n = 459) appeared at both feeding sites. When we presented the 40 % w/w food source 90 min after recruitment had started at the 20 % w/w source, the number of recruits at the 40 % feeding site never exceeded their number at the 20 % site. Again this outcome did not result from decisions by the individual bees (0.5 % of 417 bees tasted both food qualities). Instead this phenomenon is more likely to be explained by a positive feedback resulting from the large number of bees already exploiting the poor source and reinforcing the scent trail. New recruits continue to select the more intensively marked trail but neglect the new one to the richer food. This finding resembles the behavior of scent trail laying ants rather than that of honeybees or *Melipona* stingless bees (Beckers et al. 1990, Seeley 1995, Biesmeijer and Ermers 1999).

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Vibrating food receivers: an optimal transmission of recruitment signals in bees

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Keywords: stingless bees, *Melipona*, recruitment, communication, thorax vibrations, signal transmission, trophallaxis, food receivers

Recruitment mechanisms of social insects often involve a complex interplay of various signals. A characteristic feature common to the recruitment communication in highly eusocial bees (honey bees, stingless bees and bumble bees) are pulsed thorax vibrations, generated by the foragers upon their return to the nest. The temporal pattern of these signals correlates with the profitability, and in some bee species also with the distance of a food source. So far, the ways in which this potential information is passed on from the foragers to the hive bees is poorly understood.

Foragers of stingless bees (Apidae, Meliponini) do not embed their vibratory signals into complicated dance movements, as it is known from honey bees, but predominantly generate their thorax vibrations during trophallactic contacts with hive mates. In previous studies on the recruitment communication of *Melipona seminigra* we measured vibrations not only on the foragers themselves but also on the hive bees fed by them. In the present study it was investigated whether these vibrations are generated by the food receivers themselves or rather represent a so far unnoticed way of vibration transfer in bees. During trophallactic contacts the vibrations of both the forager and the food receiver were simultaneously picked up using two Laser-Doppler-Vibrometer units. The temporal pattern of the vibrations of both bees (pulse duration, pulse sequence), and the main frequency component of the single vibration pulses were compared. Judging from the wave-form of their thorax oscillations, the food receiving bees do not generate the signals themselves. As long as the trophallactic contact was sustained, the body of the food receivers vibrated every time the forager generated a vibrational pulse. Hence, during trophallaxis the temporal pattern of the vibrations picked up on the two bees was identical (pulse duration: $R=0.986$; pulse sequence: $R=0.998$), as well as the main frequency component of the simultaneously measured pulses ($R=0.991$). From these results we conclude that during the food transfer the receiving bees are vibrated by the foragers, which thereby project any potential information within their signals directly onto their hive mates. This finding adds to the important role attributed to trophallaxis as a central event of information transfer during recruitment communication in social bees.

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Associative learning and cross-modal recall as "recruitment" mechanisms in honeybees

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Keywords: honeybee, foraging, olfaction, vision, associative learning, recall, memory

During foraging flights, honeybees learn visual and chemical cues associated with a food source. We investigated whether learned olfactory cues can trigger visual and navigational memories in honeybees that assist them in navigating back to a known food source. In a series of experiments, marked bees were trained to forage at one or more sugar water feeders, placed at different outdoor locations and carrying different scents or colours. We then tested the ability of these bees to recall the locations (or colours) of these food sites and to fly to them, when the training scents were blown into the hive, and the scents and food at the feeders were removed. The results show that (1) bees, trained to a single, scented feeder at a given location, can be induced to fly to the same location by blowing the scent into the hive; (2) bees, trained to two feeders, each placed at a different location and carrying a different scent, can be induced to fly to either location by blowing the appropriate scent into the hive; (3) bees, trained to two feeders, each decorated with a different colour and carrying a different scent, can be induced to find a feeder of either colour by blowing the appropriate scent into the hive; and (4) bees, trained to three feeders, each placed at a different location and carrying a different scent, can be induced to fly to the three locations by blowing the appropriate scent into the hive – but only if distinctive colour cues are added to the locations. Thus, familiar scents can trigger navigational and visual memories in experienced bees. This capacity for complex associative memories is not limited to one or two, but bees might well be able to form multiple associative memories at the same time depending on the environmental information available. Importantly, recent results showed that a scent needs to be present at the food source itself in order for the bees to form strong associative memories. If the scent is presented at a spatial and temporal distance from the food source, bees seem unable to link the scent with the location of the food. Our findings suggest that the odour and taste of the nectar samples that are distributed by successful foragers on returning to the hive, may trigger recall of navigational memories associated with the food site in experienced recruits and, thus, facilitate their navigation back to the site. We believe that associative learning and cross-modal recall of this kind serve as additional "recruitment" mechanisms in honeybees, to assist rapid and efficient exploitation of food sources.

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The influence of floral rewards on bumblebee foraging behavior: higher quality pollen means more visits

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Keywords: *Bombus*, foraging behavior, niche differentiation, pollination, protein, resource partitioning

Pollinators have long been known to respond to differences in floral nectar concentration, and to show preferences for more reliably rewarding flowers. In comparison almost nothing is known about how pollen quality influences pollinator behavior. We examine variation in pollen quality within plants visited by European bumblebee species and show that those plant species from which bumblebees frequently collect pollen have higher pollen quality (percentage protein content and proportion of essential amino acids), compared to plants that are only infrequently visited. We also show that rare bumblebees with the narrowest diets collect pollen exclusively from plants whose flowers offer the highest reward, while more common species have a relatively broad pollen diet. Previous studies have argued that coexistence in sympatric bumblebee species is attributable to partitioning of nectar resources according to tongue length; our results point to niche differentiation in the pollen resources exploited by bumblebees. Although it is clear that differences in diet breadth are responsible for species coexistence, comparatively little is known about the way in which food quality influences dietary specialism in sympatric foragers. Our results suggest that varying degrees of dietary specialization according to resource quality may facilitate coexistence within ecologically similar, sympatric animal species.

Tracing bumblebee footprints on natural flowers

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Keywords: *Bombus*, repellent scent marks, epicuticular hydrocarbons, corolla epicuticle

Many insects are known to leave lipid footprints while walking on smooth surfaces, presumably because the deposited substances improve tarsal adhesion. In bumblebees, tarsal hydrocarbons also function as scent marks that allow detection and avoidance of recently depleted flowers (Goulson et al. 2000). In the present study I used GC-MS to detect bumblebee (*Bombus pascuorum*) hydrocarbons on corollas of deadnettle (*Lamium maculatum*). Deadnettle corollas and bee legs (hexane extracts) showed partly overlapping profiles of surface hydrocarbons, with odd-numbered alkanes (C23 to C33) predominating in both. *B. pascuorum* leg extracts additionally contained several odd-numbered alkenes (C25:1 to C31:1) in larger quantities. These chemical markers were also detectable on deadnettle corollas that were exposed to visits by foraging *B. pascurum* workers. The amount of pentacosenes (C25:1) on corollas was found to be linearly related to the number of bumblebee visits, with workers depositing approximately 16 ng per visit (extrapolated to a total of 65 ng of bumblebee epicuticular hydrocarbons). Pentacosenes were retained on visited flowers without loss for 2 hours, probably much longer. The findings suggest that flower epicuticles retain a chemical record of bee visitation, potentially informative to pollination ecologists. The evident long retention (low volatility) of bumblebee hydrocarbons necessitates new explanations concerning the rapid loss of repellency of visited flowers observed in behavioural studies of bumblebee foraging.

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Age-dependent structure and content of labial gland in males of *Bombus terrestris*

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Keywords: Bumblebee, *Bombus terrestris*, labial gland, apoptosis, smooth endoplasmic reticulum, male marking

Male bumblebees are equipped with paired labial gland whose cephalic parts secrete male marking pheromone. Cephalic part consists of numerous acini and the ducts connecting particular acini. Each acinus is formed by several secretory cells and a large lumen, in which the secretion is stored. Main organelle of secretory cells in young males (up to the fifth day of age) is smooth endoplasmic reticulum, which is probably responsible for pheromone secreting. As the amount of secretion increases, the volume of secretory cells decreases, they become flatter and organelles start to disintegrate. The first apoptic cells were observed in five days old and the last living cells in ten days old males. After ten days of male bumblebee life, no cells remain alive and even the volume of cell remnants gradually decreases. The progression in amount of secretion is consistent, it increases till the fifth day and after tenth day, it decreases probably due to the secretion release. The content of 2,3-dihydrofarnesol, the main pheromonal component, decreases to zero in 20 days old males.

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Microgynous queens in ants: social parasites or dispersal morphs?

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Keywords: ants, microgynes, macrogynes, social parasites, dispersion

In a small number of ant species, queen size is reported as dimorphic, with small “microgynes” and large “macrogynes”, that only differ in size. This polymorphism correspond with alternative reproductive strategies that could potentialy evolve into social parasitism. A short review will be presented and a new case wil be described in the ant *Manica rubida*. This species lives mostly in mountainous regions. Its colonies are either monogynous or contain a few large, macrogynous queens. Colony foundation is semi-claustral and takes place after a nuptial flight. In the Alps (Morillon, Haute-Savoie, 700 m a.s.l.), we discovered in 1998 a colony containing many small alate microgynes, which did not engage in a nuptial flight and stayed in the nest the following winter. We found these microgynes in this nest throughout the following years. The size of all the gynes indicated a completely separate polymorphism. The microgynes had a normal spermatheca and could be fecundated, but rarely (1 of 38 cases). They generally behaved like workers in brood care, though they had wings which they lost with time. One of the gynes presumably tried to found a new colony near the mother colony, with aggressive encounters between the workers of the two parts. In June 2003, we observed a new colony with microgynes 4 km away from the first one. In June 2004, the “mutation” appeared to have spread to the entire valley of 10 km, with colonies having both macrogynes and microgynes, some colonies containing still only macrogynes. The significance of these microgynes is not yet clear, but there are at least two hypotheses for their existence. (1) The microgynes are social parasites of *M. rubida*. A preliminary phylogenetic analysis indicates that *M. rubida* microgyne differs from its host with a few base pairs in the mitochondrial genes COI and COII, suggesting that there is some reproductive isolation between the two morphs. This difference is similar to what has been found between the social parasite *Myrmica microrubra* and its host *Myrmica rubra*. (2) The microgynes are part of a dispersal strategy. The small microgynes spread locally from the mother nest, whereas the large macrogynes establish new colonies after a nuptial flight. This kind of dispersal strategy has been shown in *Myrmica ruginodis*. The presumed dispersal strategy is not totally efficient, however, as the colonies produce many microgynes which stay in the home nest as workers.

Intraspecific social parasitism by reproductive bumblebee workers

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Keywords: social parasitism, kin selection, reproductive conflict, male parentage, drifting

The evolution of extreme cooperation, as found in eusocial insects is potentially undermined by selfish reproduction among group members. Here we show that workers of a bumble bee (*Bombus terrestris*) enter unrelated, conspecific colonies in which they then produce adult male offspring, and that such socially parasitic workers reproduce earlier and are significantly more reproductive and aggressive than resident workers that reproduce within their own colonies. Our findings suggest that male production by intraspecific social parasitism is a distinct reproductive tactic in *B. terrestris* workers. Therefore explaining levels of worker reproduction, and hence the potential of worker selfishness to undermine the evolution of cooperation, will require more than simply a consideration of the kin-selected interests of resident workers. It will also require knowledge of the full set of reproductive options available to workers, including intraspecific social parasitism.

Reproductive conflict in social insects: male production by workers in a slave-making ant

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Keywords: worker reproduction, slave-making ants, *Polyergus*

In insect societies, workers cooperate but may also pursue their individual interests, such as laying viable male eggs. The case of obligatory slave-making ants is of particular interest because workers do not engage in maintenance activities and foraging. Worker egg laying is therefore expected to be less detrimental for colony efficiency than in related, non-parasitic species. Furthermore, as slave-making workers usually do not perform brood care and thus might have little power in manipulating sex allocation, they might be more strongly selected to increase their direct fitness by producing their own sons than workers in non-parasitic species. In this study we investigated worker reproduction in four natural colonies of the slave-making ant *Polyergus rufescens*, using highly variable microsatellite markers. We also studied possible dominance interactions between workers in artificially orphaned colonies in the laboratory. Our results show that *P. rufescens* workers do not express any overt aggression among each other after orphaning. However, most workers from queenless colonies had developed ovaries, whereas most workers from queenright natural colonies had undeveloped ovaries. As colonies in this species comprise several thousand workers, reproductive dominance of individuals might be expressed chemically rather than physically.

Our most important result is that workers produce up to 100 % of the males. This study thus presents the first direct evidence of an almost complete take-over of male reproduction by workers in ants.

Phylogeny of the ant genus *Chalepoxenus*

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Keywords: social parasitism, dulosis, slave-making ants, Formicoxenini

In ants, there are numerous social parasites, species that parasitically depend on the help of already established host colonies during a part of or even during their whole life cycle (Hölldobler and Wilson, 1990). One type of permanent social parasitism is slave-making or dulosis. Slave-maker colonies are predominantly initiated in summer by young, mated slave-making queens, which invade a host nest, kill or expel the resident queen and, in some genera, also all adult workers. Host workers that emerge from the conquered brood, subsequently care for the slave-making queen and her offspring. In the following years, the slave-making workers attack neighboring host nests and capture their pupae to provide the colony with new slaves for all tasks in the nest. Moreover, degenerate slave-makers exist, which have completely lost the worker caste.

Chalepoxenus is a genus of parasitic ants that belongs to the tribe Formicoxenini and comprises probably five or more rarely found and poorly known species, distributed in the Mediterranean area and the Near East (Buschinger et al., 1988). The aim of our study is to investigate, by DNA sequence comparisons, the phylogenetic relationships of the genus *Chalepoxenus* and its various host species from several collecting sites. We analyzed the mitochondrial cytochrome oxidase gene from live or ethanol conserved samples of the dulotic species *C. muellerianus*, *C. tauricus*, *C. kutteri*, of their host species, and of the degenerate slave-maker *C. brunneus*. According to our data, *Chalepoxenus* is a phylogenetically old taxon with an early split into two lineages, one containing *C. muellerianus* and *C. tauricus*, the other one containing *C. kutteri* and *C. brunneus*. All species of the genus *Chalepoxenus* are only distantly related to their host species.

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The evolution of social parasitism: Implications for sympatric speciation based on phylogenetic studies of allodapine bees

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Keywords: allodapine bees, social parasitism, sympatric speciation

Investigations of social parasitism in ants have suggested that sister-group relationships between hosts and their parasites may arise from sympatric speciation events. The observation that these ant parasites are closely related to their hosts, a relationship known as Emery's rule, has also been extended to other social species, including wasps and corbiculate bees. The applicability of these ant-based theories and models to any of these other social insects is largely unknown, however, recent research has begun to focus on many of these less studied species.

The allodapine bees have received hardly any attention in this area, despite the many independent origins of social parasitism (at least 11) in this group. These numerous origins result in social parasites of varying divergence ages, ranging from relatively recent, to very ancient origins, with each of these origins providing a unique insight into the processes that may have been involved in the evolution of a parasitic strategy.

This study uses phylogenetic techniques to examine the origin of social parasitism in allodapine bees, focusing on both facultative parasites and inquilines found in Australia, Madagascar and Africa. The social parasites found in Australia are inquilines, which diverged about ten million years ago (mya) and have very complex adaptations to social parasitism. The allodapines in Madagascar evolved only two mya, and are facultative parasites, with very few parasitic adaptations. Both inquilines and facultative social parasites have been found in Africa. Using phylogenetic analyses to infer host-parasite relationships can be problematic because it is difficult to discriminate between events occurring at the origin of social parasitism and those occurring after. Therefore the host-parasite relationships found in Madagascar are more likely to reflect the early evolutionary stages and the mechanisms involved in social parasite evolution.

The analyses of the host-parasite relationships from Madagascar do not conform with Emery's rule, suggesting that allopatric speciation is the likely mechanism responsible for the evolution of social parasitism in these species. It is therefore reasonable to suggest that the species of social parasites in Australia and Africa, and even other social insect species with ancient divergences and similar phylogenetic patterns, may not have actually evolved via sympatric speciation. As the phylogenies that appear to suggest sympatric speciation may have actually been produced through the passage of time, with the occurrence of numerous speciation and extinction events.

The exciting potential of remote feral bee colonies for *Varroa* coexistence

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Keywords: honey bees, varroa, controls, survival

When *Varroa* mites first became a problem, concerned parties immediately turned (A) to the use of chemicals as a control measure. That happened, despite earlier abundant evidence that chemical treatments: 1) are at best a short term measure, 2) result in an intense pressure that can lead to resistant mites, 3) keep susceptible bee strains in the gene pool, 4) can have both lethal and sublethal effects on bee colonies (e.g.,queen failure), 5) may damage favorable microfauna, 6) result in ever higher costs, and 7) may lead to residue problems in wax and honey. Seemingly, all those reservations have been borne out. Mechanical procedures (B) against varroa have gained some following, including: 1) periodic destruction of infested drone brood (labor intensive), 2) small cell size foundation, 3) screen bottom boards, and 4) mineral oil (of questionable value). Breeding programs (C) have become more prominent, involving detection, selection, and propagation of favorable traits. In the USA we now have hygienic and SMR/Russian bees under continuing development. During the past few decades, after varroa arrival, feral colonies in remote areas (D) experienced a catastrophic decline, followed by resurgence in population density. A deliberate programmed effort could have been instituted upon first varroa arrival in the United States (that is, establish experimental apiaries and wait for "survival of the fittest"), but that didn't happen. Some individuals have now begun to exploit the potential that feral colonies provide. (By feral, I include managed colonies in remote areas that have had no treatment against varroa mites.) John Kefuss and colleagues, for example, have had success with *Apis mellifera intermissa* queens from Tunisia and their naturally mated descendants. Erik Osterlund in Sweden promoted a mix (the "Elgon" stock) between Buckfast bees and the east African mountain bee, *A. m. monticola*. Some selected bee strains (at times along with the use of small cell size foundation) have proved promising. Of special interest is the fact that some strains of Elgon bees exude an odor that apparently repels varroa mites, a trait that would likely not have become apparent in a chemical treatment regime. In the Santa Barbara area we instituted two programs; 1) deliberate introduction of varroa to a large offshore, uninhabited, island, as well as 2) monitoring varroa impact on bee colonies next to or within isolated wilderness areas or nature preserves. Results were mixed. Feral colonies composed of mixed genetic traits have survived for several years, but colonies of genetically uniform bees perished in an island ecosystem. Feral colonies located remote from beekeeper activity could now have strains quite resistant to varroa mites and should be investigated.

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See also: (http://www.beesource.com/pov/lusby/meetlusby.htm)

Honey bees and *Varroa* mites – natural selection vs directed breeding

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Keywords: *Apis mellifera*, *Varroa destructor*, natural selection, host-parasite adaption

Africanized honey bees (*Apis mellifera adansoni* imported into Brazil) coexist with *Varroa destructor* mites in South America as do isolated populations of European bees. Similar host-parasite adaptations have also been reported from North Africa. In Europe, however, it is generally accepted that the mite population must be controlled to avoid colony collapse. Bee breeders claim to have produced or imported mite resistant stock (i.e. Kefuss et al, 2003; Rinderer et al., 2001, Wallner, 1994) but such claims remain unsubstantiated or only indicative when such bees are tested elsewhere. Although progress is reported from directed selection for specific traits to limit mite population growth, this has not resulted in bees that survive without mite control measures (Harbo & Harris, 2001; Büchler, 2000). The return of feral bee populations has been reported, indicating survival of non-treated mite infested honey bees also in Europe (Le Conte, 2004). It seems as if European races of honey bees co-exist with *Varroa* mites only where man has not interfered by implementing mite control. We have studied the survival rate for over six years in a population of mite infested honey bee colonies (N=150) in an isolated area to determine if all colonies would perish, and their parasites along with them. Over this time period the winter mortality rate of colonies have increased and then decreased. The swarming tendency rate has initially decreased but again increased and the mite infestation rate in brood less bee colonies decreased the fifth year of infestation. Six years (in June) post mite infestation, five of the original colonies remain and along with them five daughter colonies (swarms). The results suggest that some sort of host-parasite adaption has occurred, ensuring the survival of both host and parasite.

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Population dynamics of bees, brood and *Varroa* mites in honey bee colonies selected for tolerance to *Varroa* infestation

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Keywords: Population dynamic, *Varroa destructor*, Honey Bee, selection, host tolerance

A stable host parasite relationship between honey bee and *Varroa* mite requires mechanisms of the host to limit the increase of the population of the parasite. From autumn 2003 till spring 2005 we compared the population dynamic of *Varroa* mites, bees and brood in Carniolan colonies from Hohenheim to colonies selected for *Varroa* tolerance. These colonies were headed by queens deriving from "survivors" of a selection experiment on the island of Gotland, where 150 isolated colonies have been left untreated since 1999. After a dramatic loss of colonies in 2002 a small rest population remained stable till today.

8 Carnica and 7 Gotland colonies were established at an isolated military training area not accessible for other beekeeper. For population measurements we used the "Liebefeld Method": the number of honey bees and brood cells were evaluated in 3 week intervals and samples of bees and brood were analyzed for *Varroa* infestation.

In April 2004, an average start infestations of about 700 (Gotland colonies) and 400 (Carnica colonies) *Varroa* mites, were calculated. At that time, the colonies had about 6,000 bees and between 10,500 (Gotland) and 14,000 (Carnica) brood cells. At the end of the season 2004 the Gotland colonies had about 16,550 bees, on average, while the average population in the Carnica colonies decreased to about 10,500 bees. The highest absolute infestation levels were measured in August with about 9.000 *Varroa* mites in the Carnica and 6.500 in the Gotland colonies. By the end of the year, all Carnica colonies died showing the typical symptoms of a heavy *Varroa* infestation. Only one of the Gotland colonies died during the summer due to queen-loss. The remaining colonies were still alive at the end of the year. However, in late winter also the remaining Gotland colonies died.

In spite of the higher start infestation and a higher brood amount throughout the season the Gotland colonies had significant lower infestation rates at the end of the season compared to the Carnica control colonies. These preliminary results indicate that the Gotland colonies have established mechanisms to reduce the increase of the *Varroa* population.

The use of soft chemicals to control *Varroa* mites in the US and Canada

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Keywords: Formic acid, oxalic acid, *Varroa* mite control, soft chemicals

The era of the use of synthetic pesticides to control *Varroa* is coming to an end in the United States. The two major products (Apistan® and CheckMite+®) that have held the mite in check for a decade and half are quickly loosing their effectiveness due to resistance. Beekeepers are now searching for alternative controls, many of which have been pioneered in Europe. These are the so-called "soft chemicals," including formic, oxalic and other organic acids, as well as essential and other types of oils.

Because these products are considered more "natural," and often are present in honey at low levels, they do not represent the threat of contamination that existed with the hard pesticides formulated from the two legal materials, pyrethrins (Apistan®) and organophosphates (Coumaphos®) and extra-legal materials formulated using amitraz or other compounds. On the other hand, soft chemicals are less effective in small doses, more difficult to register, and also require much more knowledge and labor by the applicator. They are often abundantly available, being used in a wide range of products, and so chemical manufacturers have little economic incentive to go through the expensive process to obtain the required information demanded by regulatory agencies.

The current status and use of these soft chemicals in the US will be explored. The author will provide a historical analysis of their use in *Varroa* control, and discuss the efforts underway to both collect data on their effectiveness, and where they are in the registration process.

Integrated control of *Varroa* in the Netherlands

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Keywords: honeybees, varroa, integrated control, drone comb, Thymovar, formic acid, oxalic acid

When Varroa control can be carried out depends on one hand on the infection rate and on the other hand on the beekeepers practice like swarm prevention and honey flows. Integrated control which depends on the infection rate and which implies the need of more than one tool to be used during the year, meets these prerequisites.

It also forces to monitoring the varroa infestation on a regular basis. PPO Bijen has made a Year scheme for control, which tells the beekeeper how to act, depending on the number of dead mites that are found on the bottom boards of the hives. Until now Dutch beekeepers use drone comb removal is spring and early summer, Thymovar and formic acid in summer and oxalic acid in early winter.

To be able to intervene when needed, the range of available tools has to be widened. PPO Bijen tries to increase the periods of applicability of methods, and to add new methods. Biological control is in study now.

Integrated control of Varroa has to be combined with the prevention and control of other bee diseases, and has to fit well in the beekeepers managing methods. The present state of the art will be presented.

Ants from Cretaceous amber of Japan

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Keywords: ants, palaeontology, amber, Cretaceuos, Japan

Amber in Japan is found in several localities. Among them, that from Iwaki City of northern Honshu has been known as Cretaceous amber (Schlee, 1990). The Iwaki amber from Tamayama formation, Futaba group (lower Santonian, 87Ma) sometimes contains insects, arachnids and plants. CS & TT of the authers found 2 pieces of amber that includes ant-like insect in a collection from Iwaki City. MK checked the material and concluded that one is a worker belonging to Dolichoderinae. So far the dolichoderine ants have been reported from Canadian amber but the taxonomic placement was not definitive (Grimaldi & Agosti, 2000). Our findings have confirmed the occurrence of dolichoderines in the upper Cretaceous. The other specimen is an apterous hymenoperan individual and has an isolate petile which is node-like, and thus considered to be an ant. The material has short scapes, flexible funicles, large eyes situated posteriorly, and no lobes on the propodeum. These characters suggest that the ant would be placed under Sphecomyrminae, but the depressed vertex gives an unique shape of the head. The subfamily was recently reviewed to include 5 genera (Grimaldi et al., 1997; Grimaldi & Agosti, 2000; Bolton, 2003). Because of the unclear situation of the amber, some important characters, e.g. the mouthpart, the metapleural gland orifice and the gaster, are difficult to observe. The Iwaki amber is almost same age of that from Taymyr of Siberia where Dlussky (1975, 1987) described three sphecomyrmines: *Cretomyrma*, *Baikuris*, and *Paleomyrma* (later renamed *Dlusskyidris*). We will discuss the implication of the Iwaki amber.

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The genetics of royalty: caste-genotype association in a leaf-cutting ant

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Keywords: caste determination, nepotism, royalty allele, *Acromyrmex*

Leaf-cutting ant queens produce genetically diverse offspring because the queens mate with multiple males. Worker offspring with different fathers have been found to have different likelihoods of developing into the two main worker castes. While this genetic influence on worker-caste determination has been suggested to be adaptive, a similar influence on queen-worker determination could potentially be costly to colonies and lead to conflicts between patrilines. Here we examine whether there is a similar genetic influence on whether a female larva develops into a queen. We examined workers and gynes for five colonies of the leaf-cutting ant *Acromyrmex echinatior*. In three of these colonies we found that individuals from different patrilines differed in their propensity to develop into gynes. The possible mechanisms involved and implications of this will be discussed.

Do cuticular hydrocarbons provide kin protection in *Tribolium* genus like in social insects?

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Keywords: *Tribolium*, cannibalism, cuticular hydrocarbons, cannibalism vulnerability or kin recognition

Cuticular hydrocarbons are included in the class of releasers known as “surface pheromones”. Such pheromones are important for social insects to allow the recognition of conspecifics but, nothing is known about the rule of cuticular hydrocarbons of flour beetles. Study of cuticular hydrocarbons of newly emerged *Tribolium* pupae and eggs were done to identify and quantify the lipid class on cuticular surface of pupae and eggs using GC-MS (Gaz chromatography-Mass spectrometer) methods. Therefore, PCA (Principal component analysis) and clustering investigations of cuticular hydrocarbons profile allowed species classification. *Tribolium brevicornis* cuticular hydrocarbons profile could explain the adaptative anti-cannibalism strategy and pupae recognition observed like in social insects’ populations.

Cardiocondyla elegans: strict daughter composed nests invaded by unrelated sexuals

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Keywords: ants, nest genetic structure, ergatoid males, reproductive structure

Cardiocondyla elegans is a small myrmicine ant that lives in sandy and moist soil. In this species, all males are ergatoid (wingless) and mutually tolerant. Female sexuals are normal with functional wings. One nest can contain about 10 males and more than a hundred female sexuals. In such conditions, reproduction must take place inside the nests between brothers and sisters. Therefore, one can assume that this species displays a high amount of inbreeding and that relatedness increases to values above 0.75 (Boomsma et al., 2005). We developed primers for 5 variable microsatellite loci to study the genetic structure of nests (Lenoir et al., 2005). Ten workers from 22 colonies from 4 different locations were genotyped. We also determined the genotypes of 10 winged queens, the sperm contained in their spermathecae and all the males found in two of these colonies.

In the field, nests are at close distances (95% of the nests have a neighbour within 1m) and relationships between workers from different colonies are peaceful. Such conditions usually indicate a polycalic population structure. Nevertheless, we found that each nest of *C. elegans* is composed of the offspring of a single multiply mated mother queen. Our results on sexuals indicate that both the winged females and the males found in a nest can be foreign individuals. As a consequence, the females can be inseminated by their brothers as well as by foreign males, even if they don't leave their natal colony. Multiple mating of gynes lowers nestmate relatedness to some extent. The calculated value of F_{is} is negative, which indicates that the "invasion" of the nests by foreign sexuals seems to compensate inbreeding. Moreover, some alleles are specific to a particular population, leading to a positive F_{st}.

This first genetic study on *C. elegans* shows a very specific reproduction strategy. All the nests are composed of daughter workers of a single queen and constitute meeting places for unrelated sexuals.

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The impact of aqueous extracts from *Calatropis procera* (Ait) on *Microtermes sp.*

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Aqueous extracts (2.5%, 5% and 10%) from dried leaves, stems, roots and latex of *Calatropis procera* were tested as a deterrent agent against *Microtermes sp.* The results indicated that the concentrations tested significantly ($p<0.01$) protected the wooden baits from *Microtermes sp.* The reduction in the weight of wooden baits was found to be inversely proportional to the concentration at all treatments. The protection ranking of the aqueous extracts was as follows: roots, latex, leaves and stem. This anti-feed deterrence qualifies Calatropis procera and its products as a biocontrol agent.

Queen mating frequency and male parentage in *Polistes dominulus* (Christ)

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Keywords: *Polistes*, microsatellite, queen mating frequency, worker reproduction

Studies on the consequences of variation in queen mating frequency for social evolution and intracolony reproductive conflicts in eusocial Hymenoptera are of considerable theoretical interest (e.g. Bourke and Franks 1995), and require detailed genetic analysis at the colony and population levels. Queens of primitively eusocial wasps of the genus *Polistes* are generally thought to mate just once (e.g. Queller *et al.* 2000). Yet, contrary to expectations based simply on intracolony relatedness structure, *Polistes* workers do not produce any of their own male offspring in the presence of the queen (Arévalo *et al.* 1998; Strassmann *et al.* 2003). To test the generality of these results, we studied the maternity and paternity of workers and male offspring in colonies of *Polistes dominulus* (Christ), a primitively eusocial species in which colonies can be founded haplometrotically or pleometrotically. We collected nests on plants (*Phragmites australis* Trin., *Tanacetum vulgare* L., *Elytrigia elongata* Nevski. and *Artemisia marshalliana* Spreng) in the Black Sea Reserve, Kherson region, Ukraine in 2003 and 2004. Microsatellite genetic analysis of queens, workers and males from haplometrotic and pleometrotic nests was undertaken at four highly variable loci (Henshaw 2000). Genotyping of 538 workers from 15 haplometrotic colonies showed that 80% of queens were singly mated (12/15) although double mating was recorded in 20% (3/15) of cases. The population effective mating frequency was therefore low (m_e = 1.2). Most of the 259 analysed males were queens' sons, in agreement with findings from other studies of congeners (Arévalo *et al.* 1998; Strassmann *et al.* 2003), but workers were also responsible for limited (6.4%) male production. Cofoundresses shared reproduction in the 4 pleometrotic colonies studied (216 workers analysed), and produced all males (65 males analysed), concurring with previous work on congeners (e.g. Field *et al.* 1998).

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Test of new microbiological preparation for *Ascosphera apis* control in beehives

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The epizootic situation by honeybee diseases in Russia is enough intense now especially by *Ascosphera apis*. Though in an arsenal of veterinary practice there is wide choice of the effective domestic and foreign chemical preparations intended for ascospheros suppression their long (more than 3-4 years) use can result in formation of resistance to chemicals at the agent of this honeybee disease. On the other hand, the beer jack long time becomes soiled toxic substances that essentially reduces quality, and consequently also cost of received products of beekeeping. At laboratory of microbiological control in All-Russia Institute of Plant Protection (VIZR) on a basic strain of *Streptomyces sp.* VIZR-15 new biological preparation "Ascospherin" is developed. Results of toxicological researches testify to ecological safety of a strain-producer (LD_{50} for mammalian animals - 215 mg/kg).

Preparation for experiments was produced at laboratory conditions in the liquid form. Producer - *Streptomyces sp.* VIZR-15 is cultivated at t=28°C within 5 day in Erlenmeyer flaks on the artificial diet including: a soy-bean flour - 1,0 %; glucose - 1,0 %; NaCl-0,5 %; sweep - 0,3 %, water. A solution was separated from fungi by filtering. Laboratory researches have shown high antagonistic activity of a preparation concerning suppression of growth of the ascospheros agent - *Ascosphera apis* (Boykova et. al., 2004).

The first experiments under production conditions, were carried out in 1999-2000 years on apiary of "Telman" collective farm in St. Petersburg region have shown, that at processing poorly infected families, the preparation reduces the honeybee infection right at the beginning of melliferous period. Against a strong degree of honeybee infection, in the tested concentration, it appeared poorly effective, but next year reduce the disease development (Boykova et. al., 2004).

In 2003-2004 years research work was carried out on the apiary of Biological control department (St.-Petersburg State Agrarian University, Pushkin). The treatment of honeybee families was carried out by putting of medical solution in feeding troughs. The treated group included 10 honeybee families from which 5 have treated by liquid preparation diluted in 5 times with a sugar syrup. 5 families were treated by preparation liquid diluted in 10 times. The control group consists of 5 honeybee families to which we gave a sugar syrup without preparation. Among tested families there were both ill and healthy families. Healthy families were treated with the purpose of preventive maintenance of ascospheros occurrence.

Experiences have shown, that tested *Streptomyces sp.* strain (№ 336) has shown high antagonistic activity in relation to *Ascosphera apis* (at 43 day after treatment efficiency has made 75 %). In 2005 development of illness in the treated families was not observed at all. Hence, the preparation created on the basis of isolated *Streptomyces sp* strain can be used as preventive means for honeybee ascospheros control, as alternative to a chemical method. Nevertheless, in connection with a slow capture bees of a sugar syrup with actionomyces it is necessary to improve tested or to find other ways of entering of preparation in a honeybee jack.

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Portraits and puzzles in the history of insect sociobiology

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Keywords: *Apis mellifera*, Dzierzon, eusociality, Grassé, history, kin selection, Maeterlinck, Marais, Réaumur, Smeathman, sociobiology, superorganism

The history of insect sociobiology is an immensely rich field that has only just begun to be written. I outline eight open questions about persons and episodes:

1. The relationship between *Apis mellifera* and the early growth of social-insect studies. What exactly is the relationship between this one species and the growth of insect sociobiology as a whole before 1800?

2. Réaumur's unpublished book on ants. R.A.F. de Réaumur's book on ants was in mature manuscript form by the late 1740s, yet he neither published it nor seems even to have mentioned it to any of his correspondents. One would like to know why.

3. Public indifference to König and Smeathman's papers on termites. Johann Gerhard König's (1779) and Henry Smeathman's (1781) descriptions of the enormous nests and colonies of *Macrotermes* were unlike anything previously known in the West. It is a puzzle that their papers did not create a public sensation.

4. The Dzierzon movement in honey-bee biology. Johannes Dzierzon not only undertook an extensive research programme in the biology of honey bees in the mid-19th century but led a movement to propagate his scientific approach.

5. The Marais/Maeterlinck plagiarism dispute. After the appearance of Maurice Maeterlinck's (1926) book on termites, he was accused by Eugène N. Marais of having plagiarized key parts from Marais's (1925-26) magazine articles on *Macrotermes*. My preliminary verdict is that Maeterlinck was not guilty of one form of plagiarism, but guilty of another.

6. Grassé's influence on insect sociobiology in the period after World War II. Pierre-Paul Grassé's was a dominating figure in our discipline in post-war France. How did his particular form of leadership influence insect sociobiology in this period?

7. The emergence of the concept of eusociality. Charles Michener's definition of eusociality has near-hegemony in our discipline, yet it is far from clear how it originated.

8. The the kinship and late-superorganism paradigms of the colony. The concepts of the colony as kin-group and as a superorganism are, strictly speaking, at sharp variance with each other, yet they coexist peacefully today, including at IUSSI meetings. My working hypothesis is that they do this by a sort of niche differentiation.

Myrmecophilous and termitophilous Staphylinidae from Wasmann to the present

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Keywords: ants, termites, myrmecophiles, termitophiles, history

Erich Wasmann in over 200 publications described most of the new genera and species of myrmecophilous and termitophilous Staphylinidae and many other ant and termite dwelling species from the 1880's until his death in 1931. He also provided a theoretical framework to explain the various adaptations. Wasmann defined defensive forms, mimicry forms and indifferent forms of body shapes. The general idea was that the indifferent forms provided the raw material for the development of mimicry and defensive forms. Wasmann was also a pioneer in the use of photography in insect taxonomy.

With the above as background, this paper will outline some of the contributions by workers after 1931, particularly Reichensperger, Borgmeier, Seevers, Kistner, Jacobson, Pasteels, Rettenmeyer, and Hölldobler.

Varroa mite and honeybee mortality after treatments by two chemicals preparation (laboratory tests)

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The problem of harmful insects and mites resistance to chemical pesticides now becomes more and more significant for an agricultural production. If in the field of plant protection against pests and diseases this problem is removed mainly by a regular rotation of agricultural crops which are cultivated on the same territory, concerning beekeeping there is only one way - regular rotation of pesticides. Therefore, selection and introduction in beekeeping the new preparations suitable for honeybee family pests and diseases control is actual and practically important task. Rather sharply this problem stands concerning *Varroa* mite - the most dangerous parasite of honeybees distributed practically in all apiaries of Russia.

According to this purpose two chemical preparations (dimethan and omite) which are used for control of phytophagous mites in plant protection were tested for control of *Varroa* mite in the period of 2001-2004 yeas. At the same time the toxicological action of the same preparations on honeybees was quantitatively investigated.

In laboratory conditions the 16 experimental variants were done. Six - with mites treating by two new acaricides in 3 different concentrations each. 7 – widely use in Russia for *Varroa* mite control preparation (bipin 0.1%) in officially recommended concentration was taken as an etalon for comparison of tested ones efficiency. 8 - control variant where mites were dipped in the water. Honeybees were treated by the same way (9-16 variants). In all variants treating has done by insects or mites dipping in water solution of the preparation. Mite's mortality four times per first day and honeybee's mortality eight times per 8 days after treatments was fixed.

The highest mortality of mites at 24 hours after treatments (87.1±2.85%d) (*significantly not different values are marked by the same letter for mite and honeybee mortality separately – two dates*) was founded for etalon, the lowest for control (4.2±1.38%a*). Average mite's mortality was 69.5±3.16%b*, 73.7±3.02%bc* and 78.4±1.02%c* after dimethan treatments in 0.025, 0.05 and 0.1% concentrations respectively. For the same concentrations of omite the mite's mortality was 71.8±3.08%bc*, 75.1±2.96%bc* and 79.3±2.77%cd*. At the same time the honeybee's mortality on the first day after bipin treatment was 2.6±1.50%fgh*, after dipping in the water – 0+0.489%f*. After dimethan treatments in 0.025, 0.05 and 0.1% concentrations honeybee's mortality was 1.3±0.74%fgh*, 1.7±0.85%fgh* and 2.6±1.03%gh* respectively and after omite treatments 0.8±0.54%fg*, 2.7±1.00%gh* and 3.8±1.19%h*. The honeybee's mortality on the eight day after treatments was for bipin - 6.1±2.45%ijk*, for water - 2.9±1.18%i*, for 0.025, 0.05, 0.1% concentrations of dimethan - 6.8±1.65%i*, 9.4±1.91%jk*, 12.0±2.12%k* and for omite - 6.1±1.49%ij*, 8.1±1.68%j*, 11.1±1.95%k* respectively.

Some differences in mortality dynamics after mite treatments by different chemicals have been founded. From this point of view dimethan is much closer to etalon than omite. There is no any regularity in honeybee mortality dynamics except significantly less control level in contrast to all variants with chemical treatments at the first day.

In general, it seems that dimethan and omite are the perspective new chemicals for *Varroa* mite control in honeybee families. They show near the same effects on mites and on honeybees as officially recommended preparation. Anyway, for final recommendation the tests in apiaries are needed (see Razumovsky and Anisimov, p. 165).

Central projections and electrophysiological characterization of taste hairs s in the honeybee *Apis mellifera*

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Keywords: insect, antenna, proboscis, gustatory sensilla, subesophageal ganglion, sweet taste, bitter taste

Taste receptors in the honeybee are found on the legs, antennae and mouthparts. They consist of two types of sensillae, the basiconic and chaeticae sensillae, bearing a single pore at the tip. Under laboratory conditions, sweet or bitter tastants are used as reinforcers in appetitive or aversive conditioning of the proboscis extension reflex in learning experiments. However little is known about the individual taste hairs responses to different gustatory stimuli and on central processing of gustatory information.

Backfilling of axonal taste hairs was performed in adult honeybees using dextran-rhodamine or biocytin in order to retrace their projections into the brain. Chaeticae sensillae of the forelegs project ipsilaterally to the prothoracic ganglion with a probable linked to the subesophageal ganglion via interneurons. Taste hairs from the proboscis ramify ipsilaterally into the subesophageal ganglion, with few contralateral projections. Axons also project extensively to the tritocerebrum. The antennal nerve stained from the tip of the antenna where are mainly localized the taste receptors projects to the dorsal lobe of the deutocerebrum. Mechanosensory axons could not be distinguished from chemosensory axons. Some collaterals of these axons spread to the subesophageal ganglion. Gustatory information from primary sensory cells of the antenna and the proboscis converge at the level of three close neuropiles: the dorsal lobe, the tritocerebrum and the subesopageal ganglion. These regions constitute the first-order gustatory neuropiles of the honeybee brain.

Electrophysiological recordings were performed at the antennal tip from sensillae chaeticae (also named trichodea Type II) (Whithead & Larsen, 1976) which are the only sensillae found at the antennal level. Taste hairs responded specifically to sucrose (see also Haupt 2004) or saline solutions with concentration-dependent responses. No tested hairs assayed responded to the bitter substances quinine and salicin whatever the concentration tested. The response of sensilla to sucrose solution was inhibited when quinine, but not salicin, was added to sucrose solution. A ten-fold higher quinine concentration was necessary to inhibit sensilla responding to salts. No bitter receptors for the bitter substances tested seem to exist at the antennal tip. However a honeybee could detect the presence of quinine solution due to its inhibitory effect on response to sugar solution.

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Proteinaceous defensive potential in honeybee (*Apis mellifera* L.) larval food

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Keywords: antimicrobial peptides, honey bee, royal jelly, immunostimulation

Honeybee, similarly to other insects, response to bacterial infection by inducing higher expression of the genes coding for antimicrobial peptides, which are subsequently secreted into haemolymph. Such an immune response is very fast (occurs in a few hours), but is often non-specific. A special case of defence of honeybee is antibiotic proteins and peptides present in royal jelly (RJ), the honeybee larval food. While honeybee antimicrobial peptides like apidaecin, abaecin, and hymenoptaecin, are induced specifically and are released into haemolymph only after bacterial infection, antimicrobial peptides of honeybee RJ are synthesised through the whole honeybee lifetime and thus protect the developing larvae against microbial pathogens.

We have characterized an antimicrobial RJ proteins and peptides, which have a crucial defensive role in the first phase of infection of Paenibacillus larvae larvae, the honeybee pathogen which cause honeybee disease - American fouldbrood and we have found out the antifungal activity of the peptides as well. Our preliminary experiments indicate potential biological activity of the RJ proteins and peptides as stimulators of tumour necrosis factor-alfa in mouse macrophages and haemolytic activity.

The knowledge on the molecular and the biological properties of antibiotic peptides in larval nutrition is significant for beekeeping. It is the basis for obtaining molecular-genetic determinants necessary for targeted breeding of honeybee colonies with purpose to obtain lines resistant to diseases and thus, would eliminate the use of antibiotics and chemicals in prevention of honeybee diseases. Moreover, biologically active proteins and peptides can also be utilised in pharmacy as well as in human nutrition as a components of functional food.

The control of nest ventilation: dry air as releaser of building behavior in the leaf-cutting ant *Acromyrmex ambiguus*

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Keywords: *Acromyrmex ambiguus*, nest ventilation, building behavior, trigger, cues

Social homeostasis, i.e. the control of the internal nest environment by the colony, is supposed to be related with the workers' abilities to regulate the disparity between the nest climate and the external environmental conditions. Workers would be able to perceive undesired changes in nest climate, and react to restore the homeostatic equilibrium by modifying nest structure in order to control nest ventilation. Unfortunately, the question about which cues workers use to initiate those building processes still remains unanswered. It seems likely that air circulating within the nest, as medium that contains the information about its homeostatic outcome, may play a role in the control of building behavior. In order to explore whether circulating air acts as a releaser of building behavior, an experimental design using a laboratory colony of the leaf-cutting ant *Acromyrmex ambiguus* was developed. Colonies of *Acromyrmex ambiguus* occur in the coastal borders of Uruguay and inhabit underground superficial nests excavated in sandy soil. Such nests possess a peculiar structure consisting of leaf pieces that plug the short tunnels that connect the humid nest environment (fungus chambers) with the outside. In the laboratory, we tried to elucidate whether the humidity content of the air that circulates through these tunnels, and the direction of air flow, trigger the workers' decisions about when and where should they build a leaf plug in order to control nest climate. The experiments were carried out using a one-year old *Acromyrmex ambiguus* colony placed in an artificial nest, which allowed us to control temperature, relative humidity and air circulation in all nest boxes and connecting tunnels. Results showed that circulation of humid air between nest and environment did not suffice to trigger building behavior by workers. However, workers started to build leaf plugs when dry air flowing into the nest was present. In this case, workers built leaf plugs only at the nest entrance through which dry air entered into the nest. The other nest entrances remained open and no building activity occurred there. Interestingly workers did not avoid humidity losses of the fungus by plugging those nest entrances that allow outflow of humid air coming from the fungus chamber. Taken together, the results indicate that *Acromyrmex ambiguus* workers use the inflow of dry air as a cue to determine when and where a leaf plug, as an expression of building behavior, should be constructed, thus making evident the importance of air ventilation in the nest. From this point of view, it seems reasonable that workers allow air coming from the fungus chambers to leave the nest, so as to get rid of carbon dioxide, even at the expense of humidity losses. Likewise, it is expected that external, oxygen-rich air would be allowed to enter, and only when the air is extremely dry, it would be considered harmful for nest homeostasis and it inflow would therefore be avoided through the construction of a leaf plug.

Thermoregulation in the nest mound of the thatching grass-cutting ant *Acromyrmex heyeri*

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Keywords: thermoregulation, nest mound, solar radiation, fungus garden, *Acromyrmex heyeri*

Since long time the energy sources responsible for nest heating in mound-building ants inhabiting temperate zones are under discussion. At first, an external heat sources was suggested, i.e., the mound would act as a collector of solar radiation. Later, it was suggested that in addition, the mound material or the ants would act as an endogenous heat source, so that the nest mound would retain the produced heat because of its insulation properties. Leaf-cutting ants of the genus *Acromyrmex* includes several species with a great diversity of nest types. The species inhabiting the tropical and subtropical zones generally construct hypogeous (underground) nests, but some species that occur in temperate zones build an epigeous, mound-shaped nest located entirely above the ground. To investigate which could be the function of nest mounds in *Acromyrmex*, field investigations were performed with the thatching grass-cutting ant *Acromyrmex heyeri* during the years 2001, 2002 and 2003. The study area was located in the southern part of Uruguay (34° 33?26'' S; 56° 15' 59'' W). *Acromyrmex heyeri* colonies occur in open habitats of Uruguay, southern Brazil and the Pampean grasslands of Argentina, all regions with a marked daily temperature variation. For that, the control of fungus-garden temperature is expected to be particularly developed in the mound-building species *Acromyrmex heyeri*. Colonies usually construct a thatch mound with dry grasses and soil that protects a central and single fungus garden usually located at the superficial soil level (epigeous nest), but sometimes the nest is entirely located underground (hypogeous nest), with no mound. During the study, fungus-chamber temperature was comparatively measured for both the nest types, as well soil temperature at 1 cm deep and air temperature at 1 meter above the ground. To assess the efficiency of the nest mound as a solar collector, the fungus garden temperature and its dependence on the daily accumulated direct solar radiation was evaluated. To identify the mechanism through which a nest mound achieves its temperature, some nests were shaded to avoid their direct exposure to solar radiation. Empty mounds were also measured, to control for the function of nest inhabitants during nest thermoregulation (fungus and ants). Results showed that during winter, the daily mean temperature of both nest types did not differ from soil and air temperature. During spring, however, the epigeous nest was able to maintain higher temperatures than those of air and soil. Such temperature difference depended on the nest type, and was independent of the daily amount of incoming solar energy received by the nest mound. In addition, the temperature difference depended on the presence of the fungus garden and ants. Field observations indicate that the epigeous nests were able to produce sexual individuals, while the hypogeous nest failed. Taken together, results showed that even though the *Acromyrmex heyeri* nest can not be considered a collector of solar radiation, it implies a thermoregulatory benefit for the colony. However, this benefit is achieved only when the fungus garden and ants are present inside the mound.

Genetic structure and diversity of Argentine ant (*Linepithema humile*) populations introduced in Chile

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Keywords: Argentine ant, supercolony, microsatellites, mtDNA

The Argentine ant *Linepithema humile* is a highly successful invader of many areas worldwide. The ecological dominance of this species is thought to stem from its unicolonial social system, characterized by the absence of aggressive behaviour between individuals from separated nests leading to the formation of extensive supercolonies (Suarez *et al.* 1999, Tsutsui & Case 2001, Giraud *et al.* 2002). In Chile the Argentine ant has been first observed in 1910, and field studies conducted in this area showed that ants taken from different nests were never aggressive to each other, suggesting the occurrence of one single colony.

Our analysis of one mtDNA marker (cytochrome *b*) revealed that the genetic diversity was weak since only one single mitochondrial haplotype has been found in the 23 studied populations of Chile. In comparison, the populations from native Argentina were genetically more diverse with 12 haplotypes (Pedersen JS *et al.* submitted).

The genetic structure of the Argentine ant populations were investigated using ten microsatellite loci. The global estimate F_{ST} value was low but significantly greater than zero ($F_{ST} = 0.086$), and of the same order of what it has been reported within supercolonies in prior studies. As well, we found no significant isolation by distance, according to the dispersal mode in the Argentine ant within their introduced ranges, which may include human-mediated long-distance jumps (Holway 1998). At last, assignment tests indicated that the Chilean populations were not genetically distinct groups.

Preliminary findings at local scale (< 300 m) also support unicolonial social system of the populations introduced in Chile. We observed low relatedness and the intermixing of individuals between neighbouring nests within this distance. All together these issues confirm that a lot of what we know from introduced populations of Argentine ants is going on in Chile, that is the occurrence of one single supercolony. Further this study yields a first description of a supercolony in South America.

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Early learning of volatiles chemical cues leads to interspecific tolerance between two ant species

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Keywords: ants, recognition, chemical cues, artificial mixed groups

The role of early learning of volatile chemical cues in interspecific tolerance in ants was investigated. Workers of *Manica rubida* (Myrmicinae) and *Formica selysi* (Formicinae) were reared in single-species groups or in artificial mixed-species groups created 5 h after their emergence. The artificial mixed-groups included three groups in which the two species were in contact, and two others that were separated by a single mesh or by a double mesh preventing any contact between the two species. After 3 months, "nestmate" recognition of species was evaluated in dyadic encounters for allospecific individuals from single-species groups and mixed-species groups reared without or with single/double meshes. *Manica rubida* workers reared in mixed-species groups recognized familiar allospecific ants, even though they were reared behind a single or a double mesh, without any contact. Moreover, when *Manica rubida* were reared without allospecific contact, their cuticular profiles possessed no trace amounts of allospecific hydrocarbons as opposed when they were reared in contact with *Formica selysi*. These results suggest that *Manica rubida* recognized *Formica selysi* by their volatile chemical cues they learned during their early life. The analyses of the *Formica selysi* volatile cues showed that the major compound of the Dufour gland (C11, Undecane) could act upon the recognition process.

Signal-to-noise ratio and information capacity in the eyes of halictid bees

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Keywords: vision, bees, signal-to-noise ratio, information capacity

Vision in dim light is a major challenge for small insects with apposition eyes, as light can only reach the photoreceptors through the tiny apertures defined by the ommatidial lenses. Because photons are rare, the visual signal-to-noise ratio is low and this leads to a less accurate detection of contrast and lower visual acuity. In other words, vision becomes less reliable in dim light. In spite of this, many animals have become nocturnal or crepuscular, to reap the benefits that come with exploiting a new niche.

The halictid bee *Megalopta genalis* is a nocturnal bee that uses visual landmarks to navigate through the rainforest and to find its nest entrance at starlight intensities (Warrant et al., 2004). In order to do this the apposition eyes of these nocturnal bees have evolved large apertures, wide angular sensitivity functions and slow photoreceptors.

Using Gaussian modulated white noise as a stimulus (Kouvalainen et al., 1994) we have recorded the signal-to-noise ratio and information capacity of photoreceptors in nocturnal halictid bees of the genus *Megalopta* and diurnal bees of the genus *Lassioglossum*.

We have found differences in the frequency responses between the nocturnal and diurnal bees that appear to reflect their different life styles. As an adaptation to dim light the nocturnal bees have a slow frequency response compared to the diurnal bees. This is also reflected in the signal-to-noise ratio and information capacity of dark-adapted animals. *Megalopta* has a higher signal-to-noise ratio in dim light compared to *Lassioglossum*. However, the signal-to-noise ratio of a nocturnal, dark-adapted bee photoreceptor is not as high as would be expected for life at night. Our results suggest that additional spatial summation of photons in the lamina may further enhance vision (Greiner et al., 2004).

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AmCREB in memory consolidation of the honeybee *(Apis mellifera)*

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The transcription factor CREB (cAMP response element binding protein) is required for the switch from short-term to long-term synaptic plasticity and from short-term to long-term memory. It is believed to mediate this switch by inducing gene expression that underlies the formation of long-term synaptic plasticity and long-term memory. CREB is phosphorylated by several kinases, like PKA, PKC, CaMkinase IV and MAPK at a conserved consensus phosphorylation site (Ser 133) in the kinase inducible domain (=KID domain) of the protein. The degree of phosphorylation is determining the CREB-activation and the expression of its target genes.

We want to analyze the role of CREB in memory consolidation of the honeybee. So far we identified several CREB homologs, AmCREB 1-8, from the honeybee central brain and we characterized costume made and commercially available CREB-antibodies. Three antibodies detect different epitops and are used to identify different AmCREB splicing variants. One of them detects the phosphorylated site in the KID-domain of the protein. Using these three antibodies we are examining changes in the quantity of AmCREB and Phospho-AmCREB at different time points after learning. Yet, we found that the amount of at least one protein variant is reduced 3 hours after learning.

Furthermore, we found that an injection of antisense oligonucleotides against the start codon region of all known splicing variants influences the behavioural response of the bees after learning as well as the AmCREB quantity of untrained bees in the range of several hours after injection.

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The using of nontoxic doses of bee venom for protection from fractional gamma-radiation

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Keywords: bee venom, fractional gamma-radiation, reaction activation

The technogenic accidents at radiogenic objects have put the new problems in search and evaluation of protection means from chronic and fractional radiation. The stimulators of radioresistance or adaptogenes the one of their groups is zootoxins have longlasting radioprotective action. Mechanism of radioprotective action of these means is connected directly with adaptational reactions on organismic and cellular levels.

The goal of this work was the study of ability of repeated introduction of small doses bee venom (*Apis mellifera L.*) to raise the resistance of organism to fractional gamma-radiation. The experiments were carried out on 32 white nonlineal rats. Animals of skilled group within 7 days with periodicity of 1 times in day entered poison of a bee in a doze of 0,1 mg/kg. The control animals were introduced venom dissolvent – physiological solution. In day after the end of injections animals were exposed to total fractional gamma-radiation for 5 days (0,6 Gy/day). Power of dose is 1 Gy/min. Total dose of radiation composed 3 Gy. In day after the end of radiation we determined the general amount of bone marrow cells, the amount of different types cells of bone marrow, the general amount leucocytes, erythrocytes and the amount of haemoglobin.

The results of investigation showed that bee venom rendered clearly expressed radioprotective action. The general amount of bone marrow cells was on 55% higher in animals of experimental group in comparison with control. Besides the animals of experimental group were marked more higher in comparison with control quantity of cells of the basic pools a bone brain ($p<0.05$). The general amount of leucocytes in blood in experiment was on 63% higher then in control. The used dose of radiation did not influence practically on the amount of erythrocytes and hemoglobin. These indexes in all groups did not differ statistically that confirm more higher resistance of red blood to ionizing radiation. Therefore bee venom at repeated introduction in nontoxic dose (0,1 mg/kg) is radoprotector of longlasting action that is capable to defend effectively from fractional gamma-radiation. We assume that the principle of radioprotective effect of zootoxin is nonspecific mechanisms of reaction activation. We showed that repeated introduction of bee venom in the used dose lead to formation of phase of steady activation for which is characteristic the prolonged rise of protective systems activity of organism. The steady activation is supposed to raise the power of stress – limited systems (antioxidant, reparation system et al.). Apparently these effects are the basis of radioresistance of bone marrow heamatopoesis tissue and blood by bee venom.

Crop loading and recruitment behavior in the nectar-feeding ant *Camponotus rufipes*

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Keywords: *Camponotus*, foraging, crop loading, information transfer, recruitment, trail-laying behavior

Foraging in social insects comprises individual food collecting activities as well as a sophisticated recruitment communication. The exchange of information among nestmates has enabled these animals to generate complex foraging patterns at the colony level. A fast information transfer allows a colony to allocate foragers in a short time to newly discovered food sources. One could expect that the exchange of information is particularly important during the initial phase of the foraging process in order to start the recruitment of nestmates as quick as possible. Consequently, foragers discovering new food sources are faced with two competing activities: either continue collecting food, or leaving the source to inform nestmates. This trade-off was investigated by analyzing the effects of food quality and colony starvation on crop-loading and trail-laying behavior in the nectar-feeding ant *Camponotus rufipes*.

Individual workers from a laboratory colony were allowed to feed at an *ad libitum* sucrose solution for 15 consecutive visits. By weighing the ant before and after drinking for each foraging bout, both the collected volume and the delivered amount at the nest could be measured. Additionally, the trail-laying behavior to the source as well as to the nest for each visit was recorded laterally with a high-speed camera.

In all visits the ant returned from the feeder with the same crop-load, but did not totally deliver the collected food to the nestmates during the first foraging bouts, i.e. the ant left the nest with a partially filled crop. The volume of this “remaining crop-load” decreased with increasing number of visits to the feeder. Due to this strategy, the foragers spent less time at the feeder to refill their crop again. Furthermore, increasing sucrose concentration as well as rising starvation time led to variations in the amounts retained in the crop after unloading.

Trail-laying activity depended on the direction. The frequency of depositing pheromone-marks on the way back to the nest was equal for each visit. But the number of gaster tips on the way to the source increased during the first foraging bouts and then remained constant. This “rising-phase” became shorter and finally disappeared when ants exploited a more profitable food source. Colony starvation had the same effect. The performance of intensive trail-laying behavior is a time consuming activity and slows down traveling speed between feeder and nest considerably.

Results indicate that at the initial phase of foraging, ants spend less time collecting food, but invest more time in the transmission of information by displaying more intense recruiting behavior.

Formica exsecta (Formicidae) in headstream of Kolyma river

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Keywords: ants, ecological conditions, superfamilia structures

Material was collected in headstream region of Kolyma river between Ozerny and Sibit-Tyallakh streams near "Aborigen" biological station. The studied area is situated on the slopes of several knolls (600-800 m a.s.l.) covered by sparse growth of larch trees, which disappears on hilltops. The second vegetation layer is dense, formed by creeping cedar. The nests of *Formica exsecta* occupied nearly any place free of cedar and other shrubs. *F. exsecta* formicaries were found even on north-facing slops, where they did not occur 20 years ago. Two other ant species may potentially compete with *F. exsecta* at studied area: *Camponotus herculianus* and *F. sunguinea*. However, the fist species seemingly avoids contacts with *F. exsecta*, dwells in neutral zones and have low number of nests. The second species is very rare.

In August 2004 six nest complexes were mapped, that included 104 formicaries in total, and 5 solitary formicaries. The connection between nests was investigated in a series of experiments with sugar and protein baits. The sugar baits (pieces of bread sopped with syrup) were placed between the pares of nests in series of 9 item in 3 rows. The number of ants and the direction in which they leaved the baits were recorded during 6 hours. Protein baits (5 mosquitoes on plastic plate) we placed between nests in series of 5 items. The nests in which ants carried mosquitoes were registered.

We did not find any sign of direct relationships between formicaries. There were clear neutral zones between the tested pares of ant-hills, which were avoided by ants. The distance between formicaries in Kolyma complexes was significantly larger than in western part of the species area (Moscow, Kostroma and Ryazan regions). In contrast to the western populations, in Kolyma complexes we did not find nests with base diameter less than 20 cm and larger than 95 cm. A few nests with larger diameter did not belong to any complex and were situated on isolated small meadows. There were many abandoned nests with diameter >30 cm in Kolyma complexes in comparison with western ones. Long-term researches in Moskow region have shown that in ant settlements with superfamilia structures the nest material from abandoned ant-hills is quickly re-utilized in other nests. It may be suggested that in the conditions of Kolyma river region the families of *F. exsecta* do not attain the size sufficient for the formation of superfamilia structures.

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Local mate competition in the female palm stone borer beetle

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Keywords: Local mate competition, *Coccotrypes dactyliperda*, sex ratio, relatedness, founders

Sex ratio deviation from 1:1 is often explained by local mate competition (LMC), when related males compete for access to females. In the haplodiploid palm stone borer beetles, *Coccotrypes dactyliperda* (Coleoptera: Scolytidae), mated females disperse, and females excavate brood chambers in the palm stones (seeds). Unfertilized eggs develop into haploid males, which are smaller than females and have reduced, nonfunctional flight wings. Mating mostly occurs within the natal gallery. Under these conditions, single founder mothers are expected to benefit most from producing just enough males to guarantee the insemination of all their daughters. Thus the progeny sex ratio should be highly female-biased. It has been argued that a mother should increase percentage of males in the brood only if an extra son will outbreed. This is expected to occur when unrelated females colonize the same stone. We studied the effect of local mate competition in *C. dactyliperda* on sibling sex ratio by controlling the number of mated female founders and their relatedness. Our treatments included: (a) solitary females (b) related females (from the same population), and (3) unrelated females (from different populations). In accordance with the local mate competition model, related females produced broods with highly biased female sex ratios, whereas unrelated females had the highest percentage of male offspring, albeit with no relation to the number of founders. We discuss the fertilization success of males in broods with female-biased sex ratio.

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Polarisation vision in a nocturnal bee

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During twilight light levels drop drastically making it extremely difficult for small animals to navigate visually. Nevertheless, the halictid bee *Megalopta genalis* is able to use landmark navigation to find its nest entrance at mere starlight intensities (Warrant et al. 2004, *Curr Biol* 14, 1309-1318). For long-distance foraging flightsorientation is probably achieved using both landmarks and a compass.

Polarisation patterns are used for compass navigation by many diurnal insects, including the worker honeybee *Apis mellifera*. During late twilight, when *Megalopta* is mostly active, simple, unidirectional polarisation patterns are present in the sky. Thus, we hypothesise that the nocturnal bees are able to use these polarised patterns for compass navigation.

Indeed, the anatomy of *Megalopta*'s apposition eyes reveals an area of specialised visual units (ommatidia) in its most dorsal region (*left figure*). This part of the compound eye known as the dorsal rim area (DRA) has 4-5 rows of ommatidia with large odd-shaped rhabdoms (*right figure*). In these specialized ommatidia the microvilli (*mv*) of the rhabdom are straight and aligned parallel. These are necessary requirements for the detection of polarised light. Furthermore, to enhance polarisation contrast, the microvilli from the nine photoreceptors are arranged only in two orthogonal directions.

Electrophysiological recordings from different eye regions of the nocturnal bee confirm that photoreceptors within the DRA are highly sensitive to the e-vector orientation of polarised light (PS>10), whereas, cells outside the DRA have very low polarisation sensitivity values (PS<2). Spectral sensitivity recordings indicate that photoreceptors detecting polarised light are UV and UV-green sensitive.

We conclude that *Megalopta* is able to detect the e-vector orientation of light and probably uses polarised patterns for navigation at night.

Propagation of olfactory information within honeybee hives (*Apis mellifera*)

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Keywords: honeybee, trophallaxis, communication, PER

Information exchange within honeybee hives is essential for collective foraging success of the insect societies. It has been shown that bees recruited by successful foragers learn the odour of the corresponding food source inside the hive during mouth-to-mouth contacts (trophallaxis) by means of associative learning. Via mouth-to-mouth contacts the collected liquid food becomes distributed amongst members of different age groups performing different tasks inside the hive during food processing. We tested whether the distribution of food amongst hive mates via trophallaxis leads to a propagation of olfactory information inside the hive. We captured bee workers of known age and task and tested their response for an odour previously collected by a few foragers using the proboscis extension response (PER) paradigm. All 4 groups (4-9 day old bees, normally nurse bees; 12-16 day old bees, normally food processors; foragers and recruits) showed significantly higher spontaneous response frequencies for the incoming food odour in the PER assay, after offering scented solution for a few days, compared to bees of control hives. The results show that the rapid distribution of food amongst hive members via trophallaxis leads to a fast propagation of olfactory information by means of associative learning, i.e. a large number of bees has been conditioned to a floral scent during food processing within the hive.

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Ontogeny of soldiers in *Prorhinotermes simplex* (Isoptera: Rhinotermitidae)

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***Keywords*:** termite soldier, *Prorhinotermes*, ontogeny, anatomy, biochemistry, defensive secretion

The ontogeny of the soldier caste in *Prorhinotermes simplex* was studied with emphasis on the instar origin of soldiers, the duration of presoldier stage, and changes in external anatomy during soldier morphogenesis. The soldiers of different instar origin were compared morphometrically and by analysis of the soldier defensive secretion. The soldiers were found to develop from larvae of the second up to the eighth instar, via a short (13-17 days) presoldier stage. The early soldier instars were found exclusively in incipient colonies while the mature colony contained late instar soldiers only. The abrupt change in external anatomy occurs in two steps. During the larva-presoldier moult, the head increases in length but only slightly in width. During the presoldier-soldier moult, both the length and width of the head increase markedly and the typical cordate shape is attained. The relative size of the pronotum increases considerably. The long falcate mandibles develop particularly during the larva-presoldier moult. One antennal segment is added during these two moults. With increasing instar age of soldiers a relative increase of pronotum size and head size in its posterior region was observed. No functional differences in external anatomy were found among the six soldier instars. The composition of the frontal gland secretion is similar in the six soldier instars, an extraordinarily high amount of a defensive substance, (*E*)-1-nitropentadecene, was detected together with (*Z*,*E*)-α-farnesene, presumably an alarm substance. The strategy of soldier production is discussed. The acquired data served as a base for further reasearch of soldier caste differentiation in *P. simplex* under the influence of the juvenile hormone analogues.

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Role of visual centre of gravity for landmark navigation in wood ants

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Keywords: ants, navigation, landmarks, learning, memory, vision, snapshot models

Wood ants can use visual landmarks to guide their journey from the nest to a food source and back again (e.g. Durier et al., 2003). Computer-based video tracking allows us to record the routes taken by foraging ants at high spatial and temporal resolution. In turn, detailed analysis of foraging paths makes it possible to infer the algorithms ants use during their navigation behaviour.

We have recently been studying which features of visual landmarks ants use to guide their path to a point defined by a single landmark. Ants were trained to feed at a fixed distance from the base of a tall black rectangular landmark within a large white walled arena. The trajectories of trained ants ran straight from the start to the feeding site. Remarkably, trajectories continued to be straight when the rectangular landmark was replaced by an intensity gradient that provided the ants with no more than a single vertical edge to orient by. The desired position of the edge on the retina migrates peripherally as the ant approaches the feeding site. By varying the slope of the intensity gradient we found that the direction of the trajectories was biased away from the target position towards the horizontal centre of gravity of the stimulus. Our data are consistent with ants using the angle between the horizontal centre of gravity and the vertical edge to determine the desired retinal position of the edge.

It is known that insects can compute and learn the centre of gravity of shapes (e.g. Brackenbury, 1996, Tang et al., 2004). Our data suggest that local edges and COGs are linked together during visually-guided navigation.

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Round-the-clock visual navigation of a subsocial shield bug, *Parastrachia japonensis* using path integration

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Keywords: subsocial shield bug, homing, path integration, navigation, visual cue

We found that females of a subsocial shield bug, *Parastrachia japonensis* (Heteroptera: Parastrachiidae) were central place foragers collecting drupes for their young on the ground in the forest around the clock and/or under various weather conditions. Because its burrow is often at some distance from the host tree that sheds drupes, the bug is required to search for the drupes and return to the burrow. After the bug left its burrow, it searched tortuously until it encountered a drupe. After finding one, it took the shortest route back to its burrow. When the bug was displaced to another position, it walked straight toward the fictive burrow and then displayed searching behavior in the vicinity of the fictive burrow in all experiments. These results indicate that *P. japonensis* orients to the burrow using path integration. To test whether the bug uses visual cues, we covered the compound eyes and ocelli with opaque or clear paint just before the start of homing. During the day and at night, and under all weather conditions, the homing direction of blind bugs was disoriented, but that of the bugs with clear-painted eyes was not, indicating that this species uses visual cues dominantly under all photic conditions. Such homing behavior, regardless of the time of day and weather conditions, has not been reported for any other case of insect navigation.

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Spatial and temporal nest distribution in *Myrmica* ant community, hosting *Maculinea alcon* – preliminary results

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Keywords: ants, *Myrmica*, nest distribution, spatial pattern, K function, population dynamics, *Maculinea*

The myrmecophilous butterfly *Maculinea alcon* depends to great extent on local populations of its host ants. The recent interest in *Maculinea* conservation has revealed significant gaps in our knowledge of *Myrmica* ants. Although the life cycle of individual *Myrmica* colony is well known, the populations of colonies are little studied. Our aim was to evaluate the distribution of ant nests within a *Maculinea alcon* site, and its changes throughout the year. This was done at two spatial scales. We have used general methods of community ecology for description of whole locality.

For the detailed analysis of nest distribution within plots, the spatial pattern analysis was used. We have chosen a fragment (2 ha) of abandoned wet pasture in south-west Bohemia as a study site. All ant nests in thirteen 2x4m plots were recorded at five sampling periods (VII, IX 2003 and V, VII, IX 2004).

Eight ant species were recorded, with *Myrmica rubra*, *Formica picea*, *M. scabrinodis* and *Lasius flavus* being the most common. The ant community was dominated by *F. picea* which coexisted with other species or *M. rubra*, which formed monoculture. These two species coexisted only in one plot, where they showed spatial and temporal repulsion.

Ant nest density at the study site was unusually high; reaching more than 4 nests/m^2 for *M. rubra* and 2.5 nests/m^2 for *F. picea*. This was caused by strong heterogeneity of tuft-like pasture. The analysis of nest spatial pattern was carried out using K function, which allowed us to describe nest distribution on wide range of scales (10-100 cm in this study), compared to nearest neighbor methods. Generally, the nests were distributed within plots randomly, showing tendency to uniform distribution only at the scale of 10-30cm. This accounts for competition as well as environmental heterogeneity.

Total number of nests was stable during the season (about 270), but the nests moved frequently. Half of the nests had moved between autumn 2003 and spring 2004, and one third had moved between other sampling periods. Good predictors of nest stability were its size and location. Nests located in smaller tufts tended to move more frequently.

The populations of *M. rubra* and *M. scabrinodis* cover most of the locality, which makes it suitable for *Maculinea alcon* survival.

Unknown properties of queen substance of *Apis mellifera*

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Keywords: pheromone, 9-oxo-2E-decenoic acid, pharmacological and antidote properties

For a total synthetic analog of numerous functional pheromone (queen substance) *Apis mellifera* L. – 9-oxo-2E-decenoic acid – novel before unknown important pharmacological properties have been revealed: antibacterial (on infections caused by *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*), antiinflammatory (on formalin, protein and lidocaine inflammation models), as an accelerant of healing of graft wounds and as an immune modulator, as well an antidotal activity (on intoxication caused by fungicides and herbicides). This properties testified the thesis of classic beekeeping «bed queen is bed family», because, by our opinion, besides numerous known functions, a queen of beehive executes also healing one, which, in one's turn, correlates with amount 9-oxo-2E-decenoic acid and with quality of the queen in the end.

Ants in New Guinea rainforest canopy

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Keywords: ants, New Guinea, canopy, bait traps

Ants foraging on two locally widespread tree species (*Ficus subtrinervia*, *Pouteria sp.*) were collected using bait traps and single-rope technique. We have studied totally 19 trees from two different localities in primary lowland forests around Madang, Papua New Guinea. Tuna baits were set in regular intervals from the bottom of the tree up to its crown. Ants present on baits were counted and collected after one and three hours. We found rather low diversity of ants foraging in canopy; with 4 ant species per tree on average. Most dominant species, occupying highest proportion of baits and trees were *Crematogaster* (*major* group) sp.1; *Camponotus vitreus*, *Oecophylla smaragdina* and other representatives of *Camponotus* and *Crematogaster* genera. Ant species richness didn't differ significantly neither between the two localities nor between the tree species.

How do ants dig? : Emergence of functional nest structures in leaf-cutting ants

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***Keywords*:** ants, nest architecture, self-organisation

Internal nest architecture of many ant species and especially its emergence and ontogeny are still subjects that remain unexplained (Tschinkel 2005). Leaf-cutting ants are well known for the complex architecture of their nests (Moreira et al., 2004), nevertheless it is unknown how their building process is organized. The objective of this study is to determine which behavioural mechanisms are involved in the building of functional nest structures, e.g. chambers and tunnels. In laboratory conditions subcolonies of *Acromyrmex lundi* were presented with a three-dimensional arena, so the ants could dig without spatial constraints. After 7 days of digging, the subcolony was separated from the arena and all of the ants removed. The structure of the digging was reconstructed, using casts of various materials, whereas latex milk proved itself to be most suitable. Analysis of the casts showed that ants were indeed able to build complex tunnel structures, however no clearly defined chamber structures were found. In order to investigate the response of digging ants to pre-existing structures with different geometry and the expansion of those, a two-dimensional experimental setup was used. A subcolony was presented with a so-called "motivation box" filled with soil in order to promote digging behaviour. Ants in context of digging were transferred to a pre-existing chamber within a two dimensional arena consisting of a thin layer of soil pressed between organic glass plates. After 24 hours ants were removed and digital photography combined with graphical analysis were used to quantify the structure of the digging site. Structures excavated by ant groups of different sizes where compared in order to prove, whether group size correlates with their functional character and complexity. It is suggested that self-organising mechanisms are responsible for the enlargement of pre existing structures.

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Bumble bee pollen forage on different colour morphs of hybrid lucerne

(Medicago x varia) flowers

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Keywords: bumble bees, flower colour, pollen amount, pollen caloric value

Colour is an important floral attribute. It functions as a signal especially for bees. Bumble bees seem to visit different flowers without revealing innate colour preferences, but they are capable to learn profitable flower types and develop the constancy in purpose to cut down foraging expenses (Gumbert, 2000). The aim of our study was to determine whether bumblebees discriminate between different flower colours. For this purpose we studied bumble bee visits to different colour morphs of hybrid lucerne (*Medicago x varia*) cultivars 'Karlu' and 'Jõgeva 118' that differ in the proportions of yellow, blue and purple inflorescences. We estimated the number of inflorescences belonging to different colour morphs and the frequency of bumble bee visits to each of these morphs.

Our results show that flower-visiting rate corresponded to the proportions of differently coloured flowers in the fields in both observation years. Moreover, when the proportions of either yellow or blue flowers increased during the flowering period, the proportion of bees visiting those flowers increased significantly, too. In addition bumble bees' behaviour was flexible depending on the year: in first year they preferred blue flowers and in second year yellow flowers over the other colour morphs. Although the cause of the selectivity is mostly referred as various food resources, bumble bees' flower colour choice in our experiment was only partly consistent with flower rewards. The results showed significant pollen content difference between the colour morphs merely in the second year when yellow flowers contained more pollen than the other morphs in either cultivar. We could not find any significant difference neither in the mean caloric values of pollen gathered from differently coloured flowers nor in the nectar amount or sugar concentration.

According to our results we deduce that bumble bees' selective flower colour choice is influenced both by the flower rewards and the alternating proportions of differently coloured flowers during the flowering period. Because of the selectivity, the pollinators' behaviour can be a contributing factor to the survival rate of some flower types of hybrid lucerne if the environmental conditions were stable over years.

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Ants of the genus *Myrmica* adapt to local climates by changing the duration and the thermal reaction norms of their brood development

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Keywords: *Myrmica*, latitudinal variation, thermal reaction norms, temperature, development time, thermal threshold

It is generally supposed that arctic and subarctic poikilotherms should be better adapted to grow and develop at low temperatures compared to their temperate counterparts. Indeed, the threshold temperatures for respiration, activity, feeding, development and emergence have long been shown to be very low in many arthropod species of northern origin. One more goal of our study was, therefore, to examine if this could holds also for *Myrmica* ants which are rather common and numerous in boreal habitats.

During several years the thermal reaction norms for worker brood development have been studied in *M. rubra*, *M ruginodis* and *M. scabrinodis* from 9 regions situated along a latitudinal gradient from 50.5 to 69.1°N. The development times at 5-7 constant temperatures (from 14 to 24°C) were measured for overwintered larvae and pupae as well as for eggs, larvae and pupae of summer brood. From values of individual development times at different temperatures we calculated the coefficient of linear regression (CLR) of development rate (the inverse value of the duration) on temperature and the thermal threshold for development (TTD) for development. Most geographical populations studied significantly differed from each other by mean development times as well as by CLR and TTD values for all developmental stages. Some definite patterns in latitudinal variation of thermal reaction norms for development were found. The values of CLR and TTD for all stages gradually increase from South to North except at 68–69°N where they decreased a bit for larvae and pupae. It means that brood development becomes more temperature dependent along South-North direction. As a result of this mean development times of all stages of overwintered and summer brood development at temperatures above 15-16°C generally and substantially decrease from South to North. We regard this as a way of climatic adaptation allowing ants to speed up brood development and to produce enough new adults even in northernmost regions.

We conclude that the reaction norm of *Myrmica* colonies, in response to temperature, changes according to the local climate in such a way that brood rearing, growth and development of individuals become more temperature dependent in more severe environments with colder and shorter summers. This leads to the increase of the physiological and developmental responses at higher temperatures at the expense of a decrease within lower temperature range. In fact *Myrmica* colonies from northern populations need on average higher temperatures in their nests for successful production of new adults as compared to southern ants.

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First demonstration of the latitudinal variation of stress protein HSP70 content and expression after cold shock in ants of the genus *Myrmica*

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Keywords: heat shock proteins, HSP70, cold shock, latitudinal variation, *Myrmica*

Colonies of *M. rubra* L. and *M. ruginodis* were collected in July 2004 in three regions: Borisovka, Belgorod prov. (50°36'N, 36°01'E), Petergof (60°00'N, 30°00'E) and Kandalaksha, Murmansk prov. (67°06'N, 32°43'E). They were maintained at 20°C and long days (20 h) for min. two weeks before the experiments for acclimation. Groups of 50-100 workers were subjected to cold shock at 5 or 0°C during one hour and then were returned to 20°C. Two hours later workers were decapitated, their head capsules were homogenized and homogenates were refrigerated at -20°C for future analysis. In order to reveal heat shock proteins of HSP70 family by method of immunoblotting we used non-commercial rabbit polyclonal anti-HSP70 antibodies which were obtained against cattle heat shock proteins and exhibited the cross-reactivity with HSPs of wide range of animal species (the antibodies were kindly provided by Dr. B. Margulis, Institute of Cytology, RAS).

Some initial HSP70 content has been always revealed in intact (control) ants from all populations of both species. In the most southern population of *M. rubra* (from Borisovka) the constitutive HSP70 level was revealed to be higher than in ants of both Petergof and Kandalaksha populations. On the contrary, in *M. ruginodis* workers from Borisovka population the level of constitutive HSP70 was lower than in ants from Kandalaksha population.

One-hour cold shock, both at 5°C and 0°C, was found to be effective in inducing HSP70 expression in workers from all populations of both species. Some differences between populations living at different latitudes in initial HSP70 content and in the effects of cold shock on HSP70 expression in the workers were found. For example, the temperature of 0°C was more effective than that of 5°C in inducing HSP70 synthesis in the *M. rubra* ants of Kandalaksha population. The same population demonstrates the lower induction of HSP70 after cold shock at 0°C in comparison with Petergof population.

Cold shock at 5°C appeared to be more effective in inducing HSP70 synthesis in *M. rubra* workers from Kandalaksha (northern) population, to compare with Borisovka (southern) one, whereas in *M. ruginodis* workers, the difference between these two populations after cold shock at 5°C was practically absent.

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Dynamics of *Varroa destructor* mites drops from honey bees belonging to different rases

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Keywords ***Varroa destructor*,** bees, grooming.

The need for non-chemical measures to control *Varroa* populations in honey bee colonies is increasingly important for beekeeping. One of the natural defence mechanisms of honeybees against the *Varroa* parasite is the grooming behaviour of adult bees. We have investigated the dynamics of *Varroa destructor* mite drops from bees with different genetic background and studied the proportion of falling mites being damaged by the bees.

Maximal mite drops were recorded with Polessian bees – the local kind of Middle-Russian bee (10.4±4.5 by 7 days). The Carpathian bee showed the second largest drop of mites from the bees (8.5±3.9 and -4.2±2.7 by 7 days). Local hybrid bee had the lowest drop of mites from adult bees (3.1±0.9). The Middle-Russian bee had the largest proportion of damaged mites in the mite drops, whereas the local hybrid bee and Ukrainian bee had the lowest proportion of damaged mites.

Our data show, that among the investigated bees the Middle-Russian and Carpathian honeybee have the most developed grooming behaviour of adult bees and that this behaviour is less developed in local bees and Ukrainian bees.

There is a tendency in the data that high mite drops are associated with a large proportion of damaged mites. Grooming behaviour is probably an important characteristic for the adaptation of honey bees to the mite *V. destructor*.

The peculiarities of the honeybee perception of two-coloured near entrance marks

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Keywords: Honey bees, colour vision, two-coloured marks

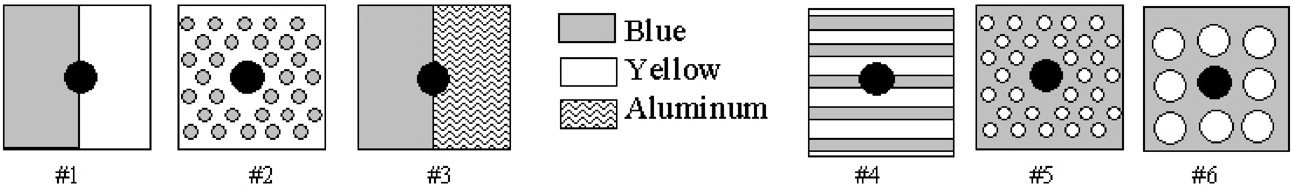
Four colours were recommended for painting of near-entrance marks of extra multiple mating hives, which have several entrances at every hive wall. These were yellow, white or blue (but not together), aluminum and red (or black) colours (Komissar, 1996, 1997, 2003). Decreasing of queen mating success is the usual result of disposition of two identical marks at one hive wall as the accuracy of definition of the mark disposition at hive wall by bees is very low (Komissar, 2004).

The practical purpose of our investigation was the estimation of the possibility of using two-coloured near-entrance marks together with the above enumerated one-coloured ones at the same hive wall. G.Mazohin-Porshnjakov (1967) proposed to use two-coloured hives for improving of bee orientation. But his recommendations were extrapolated from the results obtained at feeder stations, but not from bee drifting studying. Therefore we studied the perception of two-coloured marks by the method of alternative choice by arriving bees without preliminary training to tested marks (undifferential training, Komissar, 2004).

Blue-yellow and blue-aluminium marks with the ratio 50 to 50% of coloured surfaces and entrance hole in the center were used at training. One-coloured marks were used as tested ones in 2004 and two-coloured (including rotated at 90 and 180° #1 and #4) ones will be used in the experiment-2005.

Conclusions at the basement of experiments with marks 1-3 in 2004 (Komissar, 2005):

1. Honey bees clearly differentiate two-coloured marks from one-coloured ones.
2. Blue colour is more significant for bees than yellow or aluminium at two-coloured marks.
3. The way of disposition of the second colour at the mark surface influences the honey bee perception of two-coloured marks.
4. The best way of two-colour painting remains unknown yet and unpredictable.



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Phylogeography of an insular subspecies of termite *Reticulitermes lucifugus corsicus*:

From origins to recent expanses on continental coasts

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Keywords: termites, *Reticulitermes*, phylogeography, hybridization, microsatellite, DNA sequences

Although European populations of *Reticulitermes* have now been much studied, both the taxonomy and the phylogenetic relationships within the genus are still debated. Our study investigates past and recent evolution at the intraspecific level in the insular subspecies *Reticulitermes lucifugus corsicus* and provides new insights into those phenomena. Based on a large sampling in the Tyrrhenian region (from Corsica, France, to Tuscany, Italy), a multidisciplinary approach (microsatellites, mitochondrial and nuclear DNA sequences, cuticular hydrocarbons) enabled us to redraw the subspecies' evolutionary history from its origins to its latest developments on continental coasts. Corsican populations first differentiated by vicariance from peninsular *Reticulitermes lucifugus* during glaciations cycles of the early Pleistocene. Then, more recently, a continental extension in Provence and Tuscany occurred, certainly due to multiple transtyrrhenian crossings helped by human transport. These introductions created several hybrid zones which were the subject of thorough analyses. Present in several forms (asymmetrical introgression, direct hybrids), these hybridizations could favour a new type of evolution known as reticulate, which would be very interesting for the phylogenetic study of the genus *Reticulitermes*.

First demonstration of the differences in the duration and the thermal reaction norms of development between winter and summer brood pupae in two species of *Myrmica* ants

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Keywords: *Myrmica*, seasonal variation, thermal reaction norms, worker size, temperature, development time, thermal threshold

One way to produce more new adults within the same summer season and thus to increase an ant colony's fitness is to speed up the brood development. The acceleration of development might be especially important for ant colonies living in northern regions with shorter summers. It is especially promising to compare the duration and the thermal reaction norms of development in pupae developed from *winter brood* (i.e. larvae delaying their development, overwintering and pupating during the next summer) and *summer brood* (i.e. larvae developing from egg to pupa within the same summer season without overwintering), because pupae produced in late summer, being incapable to overwinter, should particularly hasten their development in order to become adults and thus survive the forthcoming winter. We have done this work using colonies of *Myrmica rubra* L. and *M. ruginodis* Nyl. collected near Borisovka, Belgorod prov. (50°36'N, 36°E) and near Martyshkino, St. Petersburg region (59°53'N, 29°48'E).

As a result, the seasonal variation of the duration and temperature dependence of pupal development was discovered for the first time. It was found that the worker pupae produced from overwintered larvae developed significantly slower and their development rate was less dependent on temperature in comparison with worker pupae produced later in the season from summer brood larvae. The adaptive differences between mean development times of winter and summer brood pupae amounted to 7–12% in *M. ruginodis* from St. Petersburg, 9–11% in *M. rubra* from St. Petersburg and 2–5% in *M. rubra* from Belgorod. The lines of regression of development rate on temperature had greater slopes in summer brood pupae as compared to winter brood pupae. The differences between winter and summer brood pupae appeared greater in northern populations of both species (St. Petersburg region) as compared to southern population of *M. rubra* (Belgorod region), both in development times and in temperature dependence of development. Summer brood pupae were found to be smaller and developed significantly faster compared to winter brood pupae. As far as we know this is the first demonstration of a relation between size and development rate in insect pupae. The mean head width of *M. rubra* (Belgorod region) workers produced from summer brood was almost the same at 20–24°C but substantially decreased at 18 and 16°C. Thus, larvae developing at low temperatures pupate at smaller size in order to finish their development in time before the autumn cold weather. Summer brood workers from St. Petersburg *M. rubra* population was significantly smaller than those from Belgorod population. Size differences between summer brood workers appeared evidently greater in St. Petersburg population as compared to Belgorod region. We suggest that the smaller size of summer brood workers is also an adaptation attained by northern ant populations in order to rear summer brood faster and to produce some adults from summer brood in spite of cooler and shorter summer season.

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A behavioural rule of thumb adjusting ants recruitment to aphid productivity

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Keywords: aphid, ant, foraging, food productivity, trail recruitment.

We test, through experimental and theoretical approaches, the behavioural rule used by ant societies to adjust their foraging response to the honeydew productivity of aphids. The decision to lay a recruitment trail is an all-or-nothing response based on the opportunity for scouts to ingest a desired volume acting as a threshold (independently of the number of food sources visited) (Mailleux et al 2000). Simulations predict that the percentage of trail-laying ants does not depend on the partitioning of food in an aphid colony but is directly related to the total production of honeydew. This all-or-nothing response regulates the fraction of workers laying a trail according to the productivity of the aphid colony. Moreover, a number of foragers optimises the strength of recruitment, this optimum being linearly related to the total productivity of the aphid colony (Mailleux et al 2003).

This decision rule based on local information, without any counting, optimises the recruitment, selects the most rewarding aphid colonies (or other liquid food resources) and adjusts the collective foraging response to the honeydew production. Similar rules must be at work in many task's regulations and should be generic for many ant species.

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Active ventilation in the larva of the bumblebee, *Bombus terrestris* L. (Hymenoptera: Apidae)

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Keywords: *Bombus terrestris* L., larvae, active ventilation, extracardiac pulsations, heartbeat

In many insects, discontinuous gas exchange cycles are associated with active ventilatory movements of the abdomen, during which emission of carbon dioxide and often uptake of oxygen are discontinuous (Lighton, 1996). Active ventilation has been extensively studied in the pupal and adult stages of insects, but little is known about it in the larval stages of terrestrial holometabolous insects. Gas exchange in soft-bodied larvae was thought to be by diffusion alone and without active ventilation (Wasserthal, 1996). The aim of the present study was to investigate the rhythmic abdominal movements and their respiratory responses in mature larvae of *Bombus terrestris.* Active ventilation was recorded using an opto-cardiograph combined with an infrared gas analyzer. Active ventilation occurred in the last instar larvae of *B. terrestris*, 2–3 days before pupal ecdysis. This was of two different forms of extracardiac abdominal movements: regular and uniform abdominal pulsations and less regular abdominal pumping. The frequencies of pulsations and pumping were 25–35 per min and 8–12 per min, respectively. These movements were not continuous but occurred in bouts. The two forms of active ventilation appeared to be fully independent of each other, and thus regulated independently by nerve centres. Cardiac contractions (heartbeats) were continuous (57–63 pulses/min). The study suggests that simple diffusion does not meet the respiratory requirements of *B. terrestris* larvae and that there is also a need for active ventilation.

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Cold tolerance and rapid cold hardening in *Myrmica* ants

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Keywords: cold acclimation, chill coma, latitudinal variation

Ectotherms whose species range spans across several climatic zones may have different ability to withstand cold stress, according to the local climates experienced by their populations. Alternatively, the populations may be similar in cold tolerance if the animals are able to find habitat patches that suit their thermal preferences.

In 2004 we examined *Myrmica rubra* and *Myrmica ruginodis* for the geographic variation of chill coma temperature ($t°_{cc}$), measured at the cooling rate of about 1°C per minute, and the rapid cold hardening ability, detected as change in chill coma temperature after one-hour exposure to +5°C. For each of the species we used sample colonies from three localities along a latitudinal cline: Borisovka (50° 36' N, 36° 01' E), Petergof (59° 53' N, 29° 52' E) and Luvenga (67° 09' N, 32° 24' E), five colonies per species per locality. We kept the colonies at +20°C, 20 h light per day, and conducted the measurements on August 5-6 (both species, Petergof population only), August 22-26 (both species, three populations) and September 27 (*M. ruginodis* only, three populations). Individual $t°_{cc}$ of six worker ants per colony per treatment (control or 1 hour at 5°C) were measured and averaged to obtain colony means (five per treatment), which were used in the analysis of variance.

Treatment means and S.E. (n always = 5) for $t°_{cc}$ in *M. rubra* on August 5-6 were -1.86 ± 0.223 (control) and -2.28 ± 0.344 (after 1 hour at 5°C) compared to, respectively, -0.71 ± 0.429 and -2.65 ± 0.372 in *M. ruginodis* (overall treatment effect highly significant). In the two subsequent experiments results for *M. ruginodis* from Luvenga were flawed and hence excluded from analysis. On August 22-26 *M. rubra* from all the three populations showed a uniform acclimation response similar to that on August 5-6, causing overall significant treatment effect. *M. ruginodis* showed no change in $t°_{cc}$ after exposure to cold (-1.33 ± 0.183 and -1.32 ± 0.405 for Petergof and Borisovka respectively, compared to control -1.20 ± 0.375 and -1.36 ± 0.197). For *M. ruginodis* on September 27 analysis again failed to find any significant treatment effect (values of $t°_{cc}$ were similar to those for *M. ruginodis* on August 22-26). No differences in $t°_{cc}$ among the analysed populations were found for any of the species.

The results indicate that *M. rubra* is normally slightly more cold hardy than *M. ruginodis* and has persistent ability to rapidly change its $t°_{cc}$. Apparently, *M. ruginodis* has the same ability, but loses it due to long laboratory keeping at constant optimal temperature. The evidence for this is that on August 5-6, three days after the collection of colonies, the change in $t°_{cc}$ of *M. ruginodis* workers after cold stress was significantly greater than that of *M. rubra* workers. Within the studied geographic range *M. rubra* seem to demonstrate no latitudinal variation in chill coma temperature. The question remains open about whether such variation exists in *M. ruginodis*.

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Peculiarities of parasite-host relations with *Varroa destructor* mite in the honey bee nest

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Keywords: mite, *Varroa destructor*, honey-bee, developing bees, breeding, female

Investigated features parasite-host attitudes of a honey-bee and mite *Varroa destructor* in view of features of reproductive behaviour of female mites, extensiveness of a lesion developing alveoles, number of a population of mites and size of the space occupied by a honey-bee colony. It is established, that various density of mites in developing alveoles of the host where they propagate, an interrelation between number of adults female and their brooding in one alveole, different age and breeding potential female, entering in developing alveoles, provide populations of mites steady reproduction of a diversification young female. Young females, with other things being equal, differ from each other as connubium, being differentiated on three categories. Daughters from female-foundresses who come in developing alveoles on one and replicate both male and female brooding, having reached a stage imago, relatives inseminated (brothers with sisters), are named relatives inseminated. They differ a high fertility, early producing, fast digenesis. Daughters from females foundresses who come in developing alveoles bunches and as a group replicate both male and female brooding which having reached a stage imago insemination, raising probability of unrelated connubium simplex , are named distant relative. For them the high survival rate, slow digenesis are characteristic an average fertility, late reproductive property. Daughters from female-foundresses who come in developing alveoles it is solitary or bunches and replicate only female brooding which having reached a stage imago has no an opportunity to be inseminated, are named not inseminated. They are characterized by a low fertility, late producing, the highest survival rate. These females replicate only males, providing increase of heterogeneity at a group breeding. Such diversification provides high fitness of a population of mites *Varroa* to a parasitizing on a honey-bee. Pheromones of queen bees inhibit reproduction of mites, increasing quantity of anomalies in brooding and slowing down speed of development females and males. A degree of inhibition inversely proportional to age of queen bees. In monogynopaediums with young uteruses the output inseminated female mites down to their full eliminations in the summer season sharply decreases. Hormones of developing the host influence ontogenetic transformations at educing mites. Metamorphosis deitonimphs female mites in imago is limited by age educing breed: till 19,0-19,5 day in alveoles of educing bees and up to 20,5-21,0 - in alveoles of educing male-bees. The physiological mechanisms, providing acclimatization of the mite to a parasitizing and a breeding on a honey-bee, and also the factors correlating reproduction of mites are discussed.

Estimation of competition between Apoidae and other insect pollinators in biocenosis

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Key words: honey bee, bumblebees, single bees, insects - pollinators, competition, food resources

The big variety of an environment and anthropogenesis factors results in various estimations of a competition between pollinators in biocenosis for food resources. The competition is either denied [1] or proves to be true [2].

Competition between Apoidae and other insects – pollinators have been studied on the basis of definition of density of visiting by insects - pollinators on flower of the entomophilies plants and definition of nectar and pollen productivity of biocenosis.

Researches have shown, that the periods of a strong competition for food resources between Apoidae coincide with low number blossoming entomophilies plants, as a rule, in the beginning and at the end of summer. In the beginning of June practically equal ratio of humble, honey and single bees, wasps, flies and butterflies was observed on monitoring ground (total of food resources of 2-5 kg / ha, a dominant in phytocenozis - *Achillea millefolium*), it testifies to an obvious competition for food resources. Practically equal quantity of pollinators was observed on flower at the end of August also (honey productivity of 2-5 kg / ha and dominant *Tanacetum vilgare*). Direct collisions between insects on flower, as a rule, were not marked at a competition for food resources. In the middle of July - the beginning of August time during mass flowering entomophilies plants honey bees and bumblebees obviously superseded other pollinators from highly productivity plants on low productivity plants. So on flower *Rubus idaeus* and *Chamaenerion angustifolium* (honey productivity of 80-350 kg /ha) the average ratio between honey bees, bumblebees, single bees and other insects was 4.3:1.7:0.1:1.1. At the same time on flower plants with low productivity the average ratio between them was 1:1.7:0.5:1.4:1.0.

Thus, the estimation of competitive relations between Apoidae has shown, that the competition substantially depends on the period of a season, number of populations, nectar and pollen productivity of biocenosis and anthropogenesis factors. However honey bees, as a rule, is wining a competition for food resources in bumblebees, single bees and other insects due to high sociality and more profitable conditions of duplication. Thus, honey and humble bees partly supersede competing species on low productivity honey plants or on edges of an ecological niche. In all periods of a season, within the one-biocenosis limits, ecological niches of pollinators constant are blocked or divided as a result of competitive relations, change of quantity of sources of nectar, flora specialization and flora migration Apoidae.

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North-West Caucasian bee colonies: peculiarities of growth and development

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Keywords: bees, development, zoology, ecology, reproductive diapause

The dynamics of bee families growth during spring-and-fall season under north-western Caucasia conditions are little studied. We have the corresponding data for central and northern regions of Russia.

Vital functions of every single bee, taken in a particular biogeocenosis, are closely connected with different ecological factors that have great influence upon a bee, above all are abiotic factors. Ambient temperature mostly affects a bee family. Consequently, it is essential to place high emphasis on the natural-climatic differentiation of north-western Caucasia.

Krasnodar region makes up the main part of its territory. In this connection, we have tried to classify the different areas of the region. Because of multidimensional methods, viz cluster analysis, we have worked out clusters in compliance with natural-climatic characteristics of Krasnodar region areas. This analysis of the main natural-climatic factors singles out 6 basic natural-climatic areas.

Central area of Krasnodar region is the zone of special importance as the period of bee family development falls on the end of June-July months, but the period of intensive bee colonies growth is from the 1st decade of May to the 1st decade of June inclusive. The highest bee family growth during the years without summer reproductive diapause is recorded to be from the end of the 2d decade of May to the end of the 2d decade of June. According to the peak of bee family growth, it is possible to predict whether there is summer reproductive diapause or bee development is going to be same as it is in the central or northern regions of Russia.

However, under natural conditions of very mild winters in the north-western Caucasia bees are not as exhausted as they are in the northern and central regions of Russia. Thanks to this fact bees are highly effective in bringing up the breeding. Consequently, the period of changing of winter passed bees and the intensive growth period which is the first period happen simultaneously. The intensive bee family growth period usually starts in the 3d decade of February depending on weather conditions. In April there are a lot of young bees working on nectar and pollen collection together with the winter passed bees in the family. The 2d period of growth reduction falls on locust blossoming. The 3d period or summer reproductive diapause, which is typical for 50% of seasonal bee development stages in the north-western Caucasia, fluctuates form the end of the 3d decade of June to the 2d decade of July. The period of young bees accumulation happens when there is no summer reproductive diapause.

High incidence of infection of the microsporidium *Nosema bombi* in the ovaries of spring-caught bumble bee queens (*Bombus terrestris*): a case of vertical transmission?

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Keywords: parasite, *Microspora*, transmission, Malpighian tubule, ventriculus, fat body

The microsporidium *Nosema bombi* is a widespread parasite of many species of bumble bee (Tay *et al.* 2005), where it classically infects Malpighian tubules and also the ventriculus, fat bodies and even brain tissue (Fries *et al.* 2001). We investigated its prevalence in the common Eurasian bumble bee, *Bombus terrestris*, in Northern Ireland in the autumn of 2003 and spring of 2004. In 2003, workers, males and queens were collected at two locations, Belfast and Newcastle (both Northern Ireland), dissected and haemocoel contents examined by light microscopy for the presence of *N. bombi*at x 400 magnification. The incidence of infection did not differ greatly between the two sampling sites and among workers, males and queens, but was relatively high at >50%. Though most infected animals contained few spores, some individuals were very heavily infected and all examined tissue (Malpighian tubules, ventriculus, fat bodies, ovaries of females) contained many spores. Visual inspection of spring caught queens revealed a very low level of infection (<25%). However, molecular genetic detection by PCR amplification of a fragment of the rRNA gene of *N. bombi*, which is a far more sensitive method of detection (Klee *et al.* 2005), revealed a high incidence of infection of ovaries (>25%) but not of other tissue types. Our data suggest that the microsporidium may be vertically transmitted from queen to offspring, thus explaining the enigma of how *N. bombi* survives winter.

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Reproductive competition among queenless workers of dwarf honey bee *Apis florea*

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***Keywords*:** reproductive competition, dwarf honey bee, *Apis florea*

In honey bees (*Apis*) workers cannot mate, but retain functional ovaries. In colonies with a queen, queen pheromones and brood pheromones suppress ovary activation of workers. When colonies have lost their queen, workers begin activate their ovaries and lay eggs which eventually result in a final batch of males that may mate before the colony finally perishes. Because the honey bee queen mates with numerous drones, her colony comprises multiple subfamilies (workers which share the same father are one family). This genetic diversity leads to the possibility of reproductive conflicts among subfamilies over which workers should lay eggs to produce the males.

Over a two year period we collected 41 wild dwarf honey bee (*Apis florea*) colonies. Queens of these colonies were removed to induce the ovary activation of workers. We collected approximately 100 adult workers before queen removal. Thirty nine colonies absconded within a week or so but two remained *in situ.* We sampled 100 workers after one week and again after four weeks of queenlessness. The samples were dissected to determine rate of ovary activation. We used microsatellite loci to determine subfamily of dissected workers. As with *A. mellifera*, we found reproductive competition among queenless workers of *A. florea*. In both colonies, some subfamilies have high proportion of workers with activated ovaries. More interestingly, we found that queenless colonies are parasitized by eggs laid from workers from other colonies.

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Stridulation in the context of digging behaviour in leaf-cutting ants

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Keywords**:** ants, nest construction, digging behavior, stridulation

In Myrmicine and Ponerine ants stridulation is known to occur in several behavioural contexts. It serves as a short-range recruitment signal to attract nest mates during foraging in leaf-cutting ants (Roces *et al.* 1993) or as an alarm signal in agonistic interactions or when workers are prevented from moving freely. Also when slopped in the earth workers use stridulation signals to attract nest mates for aid (Markl 1965). Here we describe for the first time the use of substrate-borne vibrations by ant workers digging in soil. In the laboratory single workers and groups of the leaf-cutting ant *Atta colombica* were allowed to dig in wet clay situated in a plastic cuvette connected to a subcolony. The digging ants were videotaped, the stridulation signals were recorded with an accelerometer and eavesdropped or analysed by Fourier-transformation. The tested workers emitted sequences of stridulation chirps during the actual digging activity. Stridulation signals were produced by the ant workers at a rate between one to five chirps per second with mean carrier frequencies between 800 and 1200 Hz. Signal intensity, and often repetition frequency increased during the penetration movement of the mandibles into the soil. The effect of stridulatory vibrations on the threshold to initiate digging behaviour was investigated by presenting naive workers with filtered playbacks of recorded stridulation signals. The possibility of stridulation acting as a direct recruitment signal to attract additional work force to a digging site was evaluated by choice experiments. In these experiments, the preference of workers for pure soil or soil in combination with a stridulation signal was tested. We also examined the attenuation of stridulation signals in clay as a function of distance.

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About interruption of the “perpetual” life in honey bees

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Keywords**:** honey bees, building behaviour, learning

The advanced eusocial life in insects (after Michener, 1974; Radchenko, Pesenko, 1994), where alone queens can't found new nests and grow brood without assistance, means the perpetual existence of the family in fact, which reproduces itself by division (swarming). The contact between adult members of the family always takes place, and newly emerged bees contact elder ones obligatory. This fact creates necessary prerequisites for potential possibility of the existence of imprinting and overgametal transfer of some behavioural characters by learning. Honey bees have their own "dance" language to signal about location of food source. The ability of bees to perceive various vibration frequencies by touch is a hereditary component on the base of which via development and establishment of spatial conditioned reflex relations the information exchange within a bee family takes place. The conditioned reflex turns out to be a means to realize functional succession between generations, and a regular precision of the signalization of distance occurs during ontogenesis (Lopatina, Nikitina, Chesnokova, 1965, 1966). In this connection the experiments with the honey bee families, formed of young bees, never having contact with adult ones, where "perpetual" life of the family is interrupted, are of interest. Every family may have individual behavioural peculiarities, obtained as a result of learning, and lost at the absence of contact between generations.

In our experiments the building behaviour of young bees in small artificial colonies, having contact with the mother comb during less then 24 hours after emergence but having no contact with elder bees, was investigated. Production of wax scales and building activity began slightly later, than in the normal family, at the age of 12-14 days, and the bees filled all the volume of the observation hives with the combs of complicated configuration. Young bees, which used only hereditary information, were able to build normal combs with various orientations of cells, not following the type of combs in their mother colony. The working hypothesis about the influence of imprinting in the first hours of life on the building behaviour of bees wasn't supported.

Detailed video observations on the movements of bees and their appendages revealed no facts of their interaction in the process of building. Every single bee interacts with the whole comb. So no evidence for overgametal transfer of information in building behavior of honey bees was found. Another aspects of honey bee behaviour should be studied from this point of view.

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Varroa mite and honeybee mortality after treatments by two chemicals preparation (tests in apiary)

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Selection and introduction in agriculture the new preparations for harmful insect and mite control is actual and practically important because of their high possibility to form the resistance to chemical pesticides. Enough actual this problem stay in Russian beekeeping because of not so wide list of officially recommended acaricides for *Varroa* mite control. To make this list more wide two new for beekeeping chemical preparations (dimethan and omite) which are used for control of phytophagous mites in plant protection were tested on a privet apiary in Tula region (Russia), because of laboratory tests were showing their perceptiveness (see Anisimov and Razumovsky, p. 131).

Tests have been carried out in the summer period of 2001-2004 yeas with help of specially prepaid experimental beehives which have one transparent whole. Treatments was done by spraying of preparation water solution (in control only water). As etalon the widely use in Russia for *Varroa* mite control preparation (bipin 0.1%) in officially recommended concentration was taken. The numbers of dead mites on the bottom of each beehive were calculated at 3, 6, 12 and 24 hours after treatments. The numbers of dead honeybees were calculated each 24 hours per 8 days after treatments. The experimental beehives for each variant were choused randomly. Because we had no information about initial number of mites and honeybees in the concrete families on the moment of treating the results are analyzed for each yea separately.

At 2002 in one beehive 198 dead mites and 0 dead honeybees at 24 hours after bipin treatment have been found, after 8 days 3 dead honeybees have been found. After dimethan treatments in 0.05% concentration the same parameters were: (*significantly not different values are marked by the same letter for mite and honeybee mortality in different years separately – two intervals of time*) 221±10.5b, 0.3±0.33c*, 3.3±0.33e*(average by 3 beehives) and in 0.1% concentration - 227±24.4b*, 0.7±0.33c*, 5.0±0.58e*(average by 3 beehives) respectively. In control (average by 8 beehives) 10.1±1.08a* dead mites, 0.25±0.164c* dead honeybees at 24 hours and 1.6±0.32d* dead honeybees at 8 days after treatments have been found.

At 2003 in average by 5 beehives 230±24.2g* dead mites and 2.8±0.37i* dead honeybees at 24 hours after bipin treatment have been found, after 8 days 7.6±0.93k* dead honeybees have been found. After omite treatments in 0.1% concentration the same parameters were 197±25.2g*, 4.0±1.14i*, 9.0±0.71k*(average by 5 beehives) respectively. In control (average by 5 beehives) 1.6±0.50f* dead mites, 1.2±0.37h* dead honeybees at 24 hours and 4.8±0.58j* dead honeybees at 8 days after treatments have been found.

At 2004 in average by 6 beehives 278±13.7n* dead mites and 6.0±1.37p* dead honeybees at 24 hours after bipin treatment have been found, after 8 days 14.3±1.12r* dead honeybees have been found. After dimethan treatments in 0.1% concentration the same parameters were 250±7.2n*, 4.0±0.58p*, 11.5±0.92r*(average by 6 beehives) respectively. In control (average by 6 beehives) 2.8±0.40m* dead mites, 3.0±0.97p* dead honeybees at 24 hours and 13.7±2.20r* dead honeybees at 8 days after treatments have been found.

In a hall, as dimethan, as omite show enough high (near the bipin) acaricide activity against *Varroa* mite in apiary. There negative effect on honeybees (if it is) enough small, not higher then for etalon. All results give us possibility to recommend these preparations for wide examination at different hobby and commercial apiaries.

A comparison of pan traps and transects for the sampling of bumblebees in biodiversity surveys if agricultural landscapes

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Keywords: *Bombus*, insect surveys, farm management and biodiversity

A survey of bumblebees to establish a baseline for bumblebee species diversity in Irish agri-ecosystems was conducted during the summers of 2003-04. Two standard techniques, belt transects and pan trapping, were used. This poster presentation compares the results from the two methods in terms of the bumblebee species caught and their relative abundances. Using sample rarefaction, there is no significant difference between the species diversities estimated from each method's dataset, suggesting that the methods are giving comparable results. The decision of which technique to use can therefore be determined by the aims of the survey and a consideration of the inherent advantages and disadvantages of each method.

Application of computer technologies in myrmecology

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Keywords: myrmecology, computer technologies

The introduction in various orbs of human activity of computer technologies has caused various modifications and has opened new edges. Not eleminations and biological sciences, in particular myrmecology (science about ants). About influence of new technologies in this science also there will be a speech.

As is known many biologists use digital engineering (digital cameras), which much more have facilitated life to the modern scientist, on a comparison with film cameras digital engineering, is more convenient and does not require the large costs. With the help of it can be received enough fast qualitative image, for example that ant, and here to treat it for in graphic editor Adobe Photoshop, to send on E-mail, to locate on site in INTERNET, to include multimedia presentation (which now of steel are very much widespread among the scientist of all world). Among the entomologist, and also myrmecologists deriving an image of an ant, in our case of an ant with the help of scanner has become new.

The apart from it for the entomologist and myrmecologists is developed a set of computer programs facilitating work:

1. Labels 2.1 beta version - program for creation of biological labels;
2. OrthopteraDB and Mantis - the programs which can be taken for a basis for creation of the basis on a biology, ecology, fauna of ants of the region.
3. Formis 2003 - electronic version of the famous bibliography about insects about 32000 references to the literature.

It is necessary also to mark and influence of a web INTERNET to process of development of a biology. On a present moment in INTERNET the large basis of a material about insects is assembled. Both on foreign and on russian pages. An example such sites are:

FOREIGN SITES:
Myrmecology - The Scientific Study of Ants - http://www.myrmecology.org/
FORMIS Ant Bibliography - http://cmave.usda.ufl.edu /~formis/
RUSSIAN SITES:
School, ants and company - http://lasius.narod.ru/
ANTS - http://myrmecology.narod.ru/

The apart from it of INTERNET opens new possibilities of dialogue with the colleagues on means ICQ and E-mail. As in INTERNET is created special Mailing Lists for myrmecologists: myrmecology gt.owl.de, with the help of which you can communicate with the colleagues from all world.

Collective selection of a resting site by a gregarious insect (*Periplaneta americana*)

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Keywords: cockroach, *Periplaneta*, aggregation, collective decision

The spatial and temporal cohesion of individuals leading to specific clustering patterns is a widespread phenomenon in group living organisms. The cluster formation results from the preferences of the individuals for the same environmental conditions and, for gregarious or social species, from the attractions between group members (Amй *et al.*, 2004, Jeanson *et al.*, 2004). In our study, we focused on the collective choice dynamics expressed by a group of cockroaches faced with two resting sites. Whatever the qualities of sites, cockroaches show a strong tendency to aggregate under a single site. Indeed, when the two sites differ in their darkness level, the group selects the darkest one as aggregation site. Besides, when the resting sites are identical, the cockroaches aggregate under only one of them. These results highlight that, whatever the environmental characteristics, social attraction plays a key role in the selection of a common resting site. This strong inter-attraction is confirmed by experiments where the population size exceeded the carrying capacity of each site. Contrary to other cockroaches' studies, even in these overcrowding conditions, only one site is selected. The individuals fill in one site that is surrounded by the exceeding individuals while the second site remains empty. The key mechanisms implied in the collective selection of a site are: (1) a positive feedback modulating the individual resting time under a shelter by the number of neighboring congeners; (2) a higher resting time under the darkest place available in the environment. The collective choice results from the interplay between individual preferences that are amplified by interactions between individuals. Similar mechanisms of aggregation and collective decision (Deneubourg *et al.*, 2002), are known for animals characterized by other degrees of sociality (e.g. for social insects: Deneubourg *et al.*, 2002; Depickиre *et al.*, 2004; Jeanson *et al.*, 2004). or for societies with different level of genetic relatedness.

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Reconsidering the behavioural profile of worker castes in dimorphic ant species

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Keywords: *Pheidole*, ergonomic theory, caste polyethism, sampling size, social regulation

Ecological success of polymorphic ant societies is dependent on caste demography and division of labour within the nest. In New-world species of *Pheidole* ant genus, it is commonly admitted that minor workers perform the majority of colony tasks. On the contrary, majors appear to be specialised on a few behaviours like seed milling and colony defence (Wilson, 1984; Brown and Traniello, 1998). When the caste ratio is experimentally skewed, the majors can increase their behavioural repertoire to compensate for colony labour needs (Wilson, 1984).

However, by putting emphasis on the importance of sampling size in the study of worker castes behavioural specialization through a weighting of the number of observations, our study performed on *Pheidole pallidula* reveals that the behavioural repertoire of majors is broader than reported for other species of the same genus. Indeed, majors are not limited to a few subsets of tasks including only defence, seed milling and food storage since they perform 69% of the minors' behavioural repertoire (Sempo and Detrain, 2004). In undisturbed nests, these majors perform all brood care behaviours (excepted egg handling), though at a lower rate than minors. Skewing the caste ratio towards majors does not significantly affect their individual rate of brood care but increases linearly their proportion in the brood vicinity. On the other hand, our study shows that between species differences in the behavioural repertoire size of majors could simply result from differences in the number of majors observed. Consequently, the ergonomic prediction (Oster and Wilson, 1978) of a correlation between the repertoire size of one caste and its numerical representation in the colony requires a re-examination that takes into account the sampling effort when drawing out between-castes behavioural differences.

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Social regulation of reproductive and pheromone plasticity in worker honeybees

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Keywords: pheromonal plasticity, honeybee, Dufour's gland

Reproductive skew is one of the important features of eusocial insects. In the honeybee (*Apis mellifera*) the queen is the major egg layer while workers are mostly sterile. However, honey bee workers have behavioral and physiological plasticity. The behavioral and physiological changes in the honeybee colony are largely mediated by chemical communication, based on pheromones produced in many exocrine glands in the queen, workers and brood.

One of the exocrine glands is the Dufour's gland, associated with the sting apparatus. In the honey bee the gland is more developed in queens than in workers. Workers secretion is composed by a long chain of hydrocarbons whereas that of queens has complex mixture of long chain esters. It was demonstrated that the glandular secretion is plastic, depending on social factors.

The aim of this study was to test the social regulation of the pheromonal and reproductive plasticity in workers and the correlation between the two.

The experiment was performed in microhives composed of 30 bees. When a queenless (QL) worker housed in microhives aggression is rapidly appears. This aggression is mainly towards workers with developed ovaries. There were no differences in ovarian developments between the attacking and passive workers (nor attacked or attacking). Analysis of the composition of these workers' Dufour's gland revealed that the attacked workers had high levels of queen-like esters.

Additionally, it was found that QL workers that were housed in microhives for 2 weeks (time which 85% of the workers develop overies) and then introduced into QR microhives, show clear regression of ovarian development and reducting in queen-like esters in their Dufour's gland. These results suggest that there is signal reversibility in workers supporting the hypothesis that there is ovary development and queen ester biosynthesis plasticity depending on the social environment.

Natural honey bee combs attached to the vertical surfaces

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Keywords: honey bees, design of wax combs, attaching cells, cells orientation

Natural honeybee combs are attached to the upper, sloped or even vertical surface of the nest cavity and the last case wasn't investigated and described. The hollow in the tree is narrow cylinder like long vertical tube with the hole in the middle in the majority of cases. Honey bees build their nest near the entrance hole and they are forced to the attach the combs to vertical walls of the hollow but not to it's horizontal ceiling.

We (Shumakova, Komissar, 2005) proposed to use the term "attaching cells" for the cells, which connect the comb with any surface. These cells are distinguished from the others (bees', drones' and transitional cells) by the presence of one plane, formed by the material of surface (usually wood or plastic in modern frames). Natural (built without foundation) attaching cells are pentahedral and sometimes they are used by bees as usual bee cells for bee brood rearing and bee bread storage.

Usual form of the comb, attached to vertical surface and perpendicular to it, is shown on the picture. It is possible to name this form as "hanging tongue". We defined orientation of cells in 21 such combs: 6 (28%) had vertical orientation (Fig, A), 8 (38%) had intermediate (B) and 7 (33%) had horizontal one. Attaching cells in first and second cases were identical and bee pentahedral but in the last case were irregular. Shift at intermediate cell orientation was the same and it explained by deformation of the part of cells under influence of gravity.

In the case of the comb parallel to the surface comb, bees start to build usual "hanging tongue", but at distance they turn its edge parallel to the supporting surface and then start to attach the symmetrical wing, but the upper point of this new wing is below of the edge of initial comb.

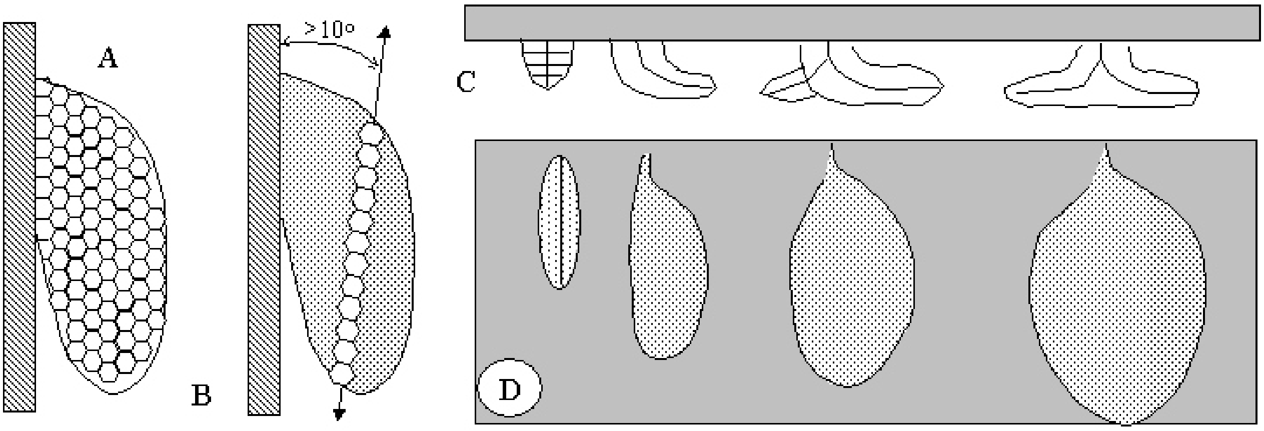

Figure. Combs, attached to the vertical surface. A – Usual shape of the comb, built perpendicular to the surface (horizontal orientation of cells) ; B - gravity deformed part of the cells and their orientation changed to intermediate; C, D - building and growth of comb, built parallel to the surface: C - view from above; D – frontal view.

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Response of larvae and nymphs of *Prorhinotermes simplex* to JHA treatment

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Keywords: Juvenile hormone analogue, W-328, *Prorhinotermes simplex*, larvae, pseudergates, nymphs, soldiers, artificial intercastes, morphometry.

Application of JHA's to groups of termites usually leads to differentiation of soldier intercastes. We set up a force-feeding tests (spruce blocks treated by JHA W-328, i.e. ethyl-*N*-{2-{4-{[2,2-(ethylenedioxy)cyclohexyl]methyl} phenoxy}ethyl}carbamate) using groups of termites of defined instars (larvae from the first to sixth instar and nymphs). No differentiation was observed among the first instars. The second instar larvae differentiate into nearly perfect soldiers while older larvae into intercastes with variably pronounced larval and soldier characters. Application of JHA to nymphal groups lead to differentiation of intercastes revealing diverse characters of nymphs, soldiers and imagoes as well.

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A new social parasite of leaf-cutting ants from Brazil

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Keywords: leaf-cutting ants, social parasitism, *Acromyrmex*

The cultivation of fungus by ants appeared in South America around 50-60 million years ago in an ancestor of the tribe Attini. This tribe is restricted to the American continent and has at present 210 described species in 13 genera, all of which are in symbiosis with a fungus. Socially parasitic ants use the nests and the workforce from other ant species to raise their own offspring. There are three described species of social parasites in Attini : (1) *Pseudoatta argentina argentina* and the other subspecies *Pseudoatta argentina platensis* are parasites of *Acromyrmex lundi* nests and have no worker caste. Their queens and males are morphologically very specialized. (2) *Pseudoatta* sp., the social parasite of *A. rugosus*, occupies a similar position. (3) *Acromyrmex insinuator* is a social parasite very closely related to its host - *A. echinatior* - and produces workers as well as queens and males. Here, we report the occurrence of a new *Acromyrmex* species found in Minas Gerais State, Brazil. It occupies a similar position to *A. insinuator* in the levels of social parasitism, e.g., it produces a worker caste and greatly resembles the two host subspecies, *A. subterraneus subterraneus* and *A. subterraneus brunneus*. It is generally admitted that social parasitism is more unusual in the tropics than in temperate zones, but this may be due to the limited knowledge of the natural history of numerous ant species from the Neotropical region.

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Development of an experimental protocol for the quantification of the attractivity of the male sexual pheromons of the *Bombus terrestris*

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Keywords**:** Labial gland, premating behaviour, sex attractant pheromone, *Bombus terrestris*, *Bombus lucorum*, solvent.

The pre-mating behaviour of the males of *Bombus terrestris* is typical of the great majority of bumblebees species. The most significant element of this behaviour is the marking of a patrolling route. Marking is made by a secretion of the labial cephalic glands. The sexual pheromone from these secretions attracts conspecific unmated queens.

Until now, the secretions of more than thirty bumblebee species have already been described but the compound(s) that really attracts the queens are still unknown.

The main goal of our work is to discover the real pheromonal part that is included in the secretions. In that way, we here present an efficient experimental protocol to quantify the attractivity of the *B.terrestris* sexual pheromone.

Theoretical models of visual summation for night flight in *Megalopta*

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***Keywords**:* bees, vision, nocturnal, summation, flight, theory

Megalopta are neotropical sweat bees that forage during only two time windows: shortly after sunset and shortly before sunrise. Thick forest canopies and the quick onset of darkness at tropical latitudes leave bees in profound darkness for these trips: $2x10^{-5}$ candelas/m^2---or 20 times dimmer than starlight. *Megalopta* possess eyes not optically adapted to collect dim light, but nonetheless they survey the visual scene on exit, fly off to forage, and return to the entrance of a small stick hidden in a forest littered with similar sticks. The implication is that despite the low signal to noise ratios produced by such darkness, they perform difficult visual tasks. With limited optical options, *Megalopta* may use neural mechanisms to improve signal to noise ratio. We investigated the theoretical effects of spatial and temporal pooling as they apply to *Megalopta* in its natural habitat. While these mechanism sacrifice spatial and temporal acuity, we found that they could extend reliable vision down to much lower light intensities. Further, the optimal summation was a close match to estimates derived from physiological and cellular data. We propose that neural mechanisms are critical to *Megalopta*'s ability to forage in the dark, and allow them to exploit the night habitat. This leaves *Megalopta* visually hidden from predators, and with reduced competition from other bees.

Social interactions in *Xylocopa violacea* (L.) nest in post-emersion phase of offsprings (Hymenoptera: Apidae)

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Keywords: *Xylocopa violacea*, Xylocopini, social interactions, trophallaxis, nest development, mother-offspring interactions, offspring-offspring interactions, Southern Italy

The social interactions observed in a *Xylocopa violacea* (L.) Campanian population (1500 h of observations in 15 years in Southern Italy, Campania) were described and reported for the first time in this Xylocopini species; it is also carried out a qualitative review among Xylocopini in social ethological traits. The main results were the follows. A) In offsprings pre-emersion phase from nest, 20% of nests was attacked by a predator. B) The founding female (= FF) see the emersion of their offsprings and they lives together for 3 weeks about. C) Offsprings lives together in the parental nest, but after FF disappearance there was a rapid decrease of offsping number cohabiting in the parental nest. D) Offsprings lives together at most untill the reproductive period start. E) Nest guarding, defence and grooming were mainly carried out by offspings during post-emersion phase, particularly by sons. F) Offspings nest guarding behaviour cause an increase of FF flight number and duration and eliminate nest predation. G) FF and offspings feeds on pollen paste and pollen stored in the nest. H) Co-nestlings are recognized respect to not co-nestlings. I) FF do not die when nest building is over, but they keep watch over the nest for all the remaining day of nest development; FF see the progeny nest emersion in 78% of nests. J) A clear mouth-mouth interactions or trophallaxis was observed in mother-brood (40 cases) and also in daughter-daughter and daughter-son interactions (16 cases), but sons never are donors; in these mouth-mouth (less than 10 sec. per interaction) interactions the antenna are directed with tips in contact on buccal pieces and a liquid drop is detectable; not udible buzzing was emitted during mouth-mouth interactions; the head of soon or daughter during trophallaxis was in continuos tremor. K) There are 43 Xylocopini species with available social biology bibliographical data, but in 9 only these data are sufficients about. L) *X. violacea* is univoltin in Europe and shows all the behavioural traits of the truth social species as *X. pubescens* and *X. sulcatipes*, but its sociality is very degradate because of two factors: shortness of FF-offsprings social interactions; univoltin biological cycle. These two factors are directly affected both by climate and by trophic resorces availability.

Sex ratio and allocation, founding female investment type per nest, in a South Italian population of *Xylocopa violacea* (L.) (Hymenoptera: Apidae)

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Keywords: *Xylocopa violacea*, Xylocopini, maternal investment, sexual differences, experimental dwarfism and gigantism, larval biological clock, speciation model

The aim of this contribution was to determine the relationships among sex ratio, maternal investment, sex allocation, offspring size, development/mortality, and for experimental alteration of larval food (= PP) mass, imagine size, offsprings pre-imaginal survival and some specific taxonomical characters, in a *Xylocopa violacea* (L.) population of South Italy (Campania). The main results (37 nests; 186 PP), are the following. A) Observed sex ratio 0.684 (59.39% of females on 229 specimens); expected sex ratio based on pollen paste weight 1.264, on imagine weight 1.339, on cell length 1.134; sexual cost ratio based on pollen paste weight 0.791, on imagine weight 0.747, on cell length 0.882. B). With respect to males, females are larger, are allocated after position III (numbered from nest entrance) in the paedotrophic cell (males in outer cells), have a longer total developmental time, consume pollen paste more rapidly, have a larger cells and have a heavier PP. C) Founding females provision outer cells with less pollen paste than inner cells for both sex; both males and females grow large in inner cells compared to outer ones. D) *X. violacea* shows a high energetic conversion value (46%), without sexual differences. E) Egg developmental time is highly variable, but pupal developmental time varies little. F) Offspring size and sex ratio per nest are directly related to nest cell numbers (= nest size). G) The by-cell variation pattern observed for observed-espected sex ratio, PP, cell lenght and in part egg+larva instar duration and total development duration, can be summarized in one pattern with the position III symmetric center position; the following position groups are recognizable: I-II; III; IV-V; VI-VIII; IX-XIV. H) Pre-imaginal death rate is different in two sex. I) Results do not confirm the Fisherian theory of sex ratio nor Local Resource Enhancement theory. J) Larvae can survive until the imaginal instar with about 50% of normal PP mass, creating live dwarves. K) The prepupa larvae with mass $\leq$ 0.4 g shows a very high pre-imaginal mortality rate. L) Larva experimentally provisioned with low PP, exhibits the feeding behaviour for many hour after PP is completely consumed. M) The production of giant individuals is less efficient than dwarf ones. N) Larvae experimentally provisioned with *ad libitum* PP did not consume the entire food reserve. O) Larval feeding behaviour is unmodified by PP presence/absence, but is controlled by a biological clock. P) In several cases an instantaneous mechanical reproductive barrier has been obtained because of great difference between giant and dwarf individuals. Q) Dwarf individuals have a modified clypeal shape compared with normal size individuals. The following two work-hypotheses are proposed. 1) Xylocopini species larger than *X. violacea* have an "extended" biological clock that increases PP consumption in larvae, resulting in larger individuals; it is possible that during speciation events in Xylocopini in which there is size variation between mother and daughter species, the regulation of larval biological clock happens during the speciation event. 2) In species with a wide distribution such as *X. violacea*, dwarf offsprings could be favourable in xerophilic environments results in two possible effects: 2a) speciation, if two populations become reproductively isolated; 2b) intraspecific increase of variation for size, without reproductive isolation, could be incorrectly interpreted as interspecific variation.

Distribution of colours and sugar rewards in the bee's natural environment

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Keywords: bee, colour, vision, flower, reward, foraging

Bees choose their preferred food source on the basis of profitability, but floral food sources advertise themselves in a wide range of colours. Thus during foraging a bee has to sample a number of colour-reward pairings in a flower patch in order to find the most profitable ones. Since sampling represents a cost, it would be reasonable for a short-living insect to have efficient sampling strategies or biases. One sampling bias may manifest itself as a so-called innate colour preference, which has been described for honeybees under experimental conditions in the laboratory (Giurfa et al. 1995). That finding is mitigated by the fact that honeybees can rapidly learn any colour and recall it for a long time (Menzel 1967). Consequently, the hypothesis was suggested that innate colour preferences lead inexperienced foragers to the best-rewarding flowers, ultimately benefiting the young bees (Giurfa et al. 1995). Alternatively, we suggest that colour-reward pairings in the bee's environment might occur as non-continuous patterns, thus reducing the cost of sampling. To test these assumptions, we surveyed the floral colours as perceived through bee eyes, and the nectar rewards in natural areas. We recorded reflectance spectra, display sizes, abundance, types of flower shape, nectar properties and pollinator visits of 10-15 co-flowering species over 5-10 days in each of eight areas. Colour properties were described using the RNL-model of honeybee colour vision (Vorobyev et al. 2001). We found a large range of colours and rewards in simultaneously flowering plants in each area. Subsequent analyses showed that flowers with colours innately preferred by bees are not easier to detect; visiting them does not guarantee the highest probability of finding best or most abundant rewards. We describe how pollinators may rapidly assess colour-reward pairings based on colour generalisation and an averaging reward evaluation (Fülöp and Menzel 2000).

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Nest usurpation and kinship in the primitively eusocial bee, *Lasioglossum malachurum*

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Keywords: microsatellites, kinship, bees

We studied the relatedness of queens and workers in a primitively eusocial sweat bee (Halictidae), *Lasioglossum malachurum* using microsatellites, which are highly variable DNA markers often used for kinship surveys of close relatives such as mothers and daughters. This species is particularly interesting because take-over (usurpation) of obligately haplometrotic nests during the solitary foundress phase in spring is quite common. If a usurper succeeds in chasing away the original foundress, she can either rear the first worker brood which is already present as eggs or larvae or she can destroy all offspring and start to lay her own eggs. The hatching workers may behave differently according to whether the present queen is their mother or a non-relative usurper queen (Paxton et al. 2002).

We examined the kinship structure both in unmanipulated nests as well as in nests from which we had removed the original foundress. Around the time of worker emergence we excavated the nests and collected all specimens. All bees were then genetically analysed using five microsatellite loci. In both unmanipulated and manipulated nests we found workers unrelated to the excavated queen. In manipulated nests, where we had removed the original queen, about 70 more than 80% of all nests included non-related workers whereas in unmanipulated nests these were only found in 279% of nests. Rearing unrelated workers offers advantages in terms of reduced energy expenditure but may result in workers laying their own fertilized eggs later in colony ontogeny (Paxton et al. 2002). However, time constraints may mean that it is impossible for a usurping queen to provision a nest and successfully rear offspring if she takes over a nest late in the foundress phase. Indeed, the time of manipulation may have influenced a usurping queen's decision on whether or not to keep the unrelated brood or replace it with her own.

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Scent trail marking in stingless bees: it's the labial- not the mandibular gland secretion

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Foragers of many species of stingless bees guide nestmates to food sources by means of scent trails laid between the food and the nest. The respective trail pheromones are generally believed to be produced by the mandibular glands, although definitive experiments demonstrating this assumption have never been undertaken so far (see discussion in Jarau et al. 2004a). We therefore studied the recruitment and trail following behaviour as well as the potential role of different glandular secretions in trail marking in the stingless bee *Trigona recursa*.

Foragers of this species recruit nestmates to food very quickly and in great numbers (Jarau et al. 2003). When a bee deposits a scent mark on the food source or along its way back to the nest, she rubs her extended tongue over the substrate (Jarau et al. 2004a). This behaviour points to the possibility, that labial gland secretions, which are released from an opening at the base of the glossa, are smeared onto the substrate. In 'two feeder choice' bioassays we found, that mandibular gland extracts have a strong repellent effect on bees newly arriving at the feeding site and on bees that are already collecting sugar solution. By contrast, newcomers are attracted to feeders baited with labial gland extracts. Similar to scent marks deposited by foragers next to a feeding bee, labial gland extract does not disturb bees already collecting at a feeder. In experiments with artificial scent trails, recruits did not follow control trails composed of pure solvent (pentane) or of mandibular gland extract. They did follow, however, trails baited with labial gland extract or with hexyl decanoate, which is the main compound of labial gland secretions (Jarau et al. 2004b). Hexyl decanoate thus is the first trail pheromone component identified and proven to be behaviourally active in stingless bees.

Our experiments with *T. recursa* clearly demonstrate that labial gland secretions and not compounds from the mandibular glands release trail following behaviour and guide recruits to a food source. We assume that this is also true for other species of stingless bees.

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Aspects of termite biology as revealed by a comprehensive new phylogenetic reconstruction

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Termites are recognized to be the most important decomposer animals in lowland tropical ecosystems, where they often also have the greatest animal biomass. Termite species diversity is greatest in closed-canopy rainforest, where much of the group's radiation has occurred, and one family, the Termitidae, contribute over 90% of the species. These 'higher' termites not only constitute the majority of species, but also exhibit the widest range of biologies, including many fundamental to the evolution of the group, such as true soil feeding.

We have constructed a detailed phylogeny for the Termitidae using molecular and morphological data in a total evidence approach. DNA sequences have been collected from some 250 species for three different gene loci (12S, 28S and COII) chosen for their complementary resolving power. The morphological characters, primarily of the worker gut, were chosen and refined from a variety of existing studies, to be unambiguous, independent of one another, and as free from homoplasy as possible. Using a range of phylogenetic analyses, including optimization alignment, we have produced a robust phylogeny for the higher termites. This is being used to examine existing ideas about termite taxonomy as well as allowing us to explore the biogeographic history of the group, regional assemblage composition, and the evolution of key feeding, defence and nesting strategies.

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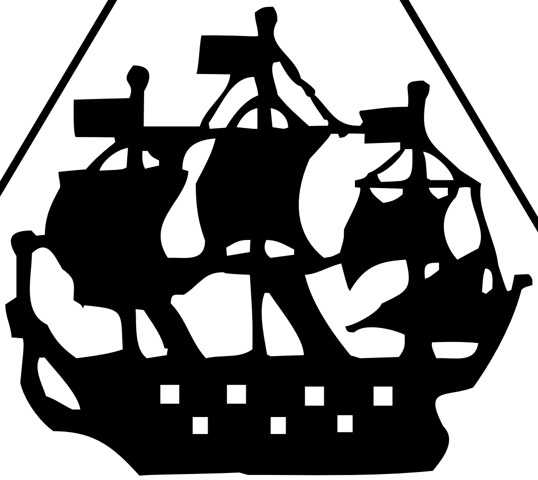

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