



IV CENTRAL EUROPEAN MEETING

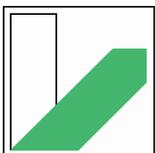
IUSSI

2015

LICHTENFELS, GERMANY

Program and abstracts

26th to 29th March 2015



UNIVERSITÄT
BAYREUTH

Bayceer

Bayreuth Center of Ecology
and Environmental Research

**The 4th Central European Section Meeting
of the
International Union for the Study of Social Insects**

26th to 29th March 2015

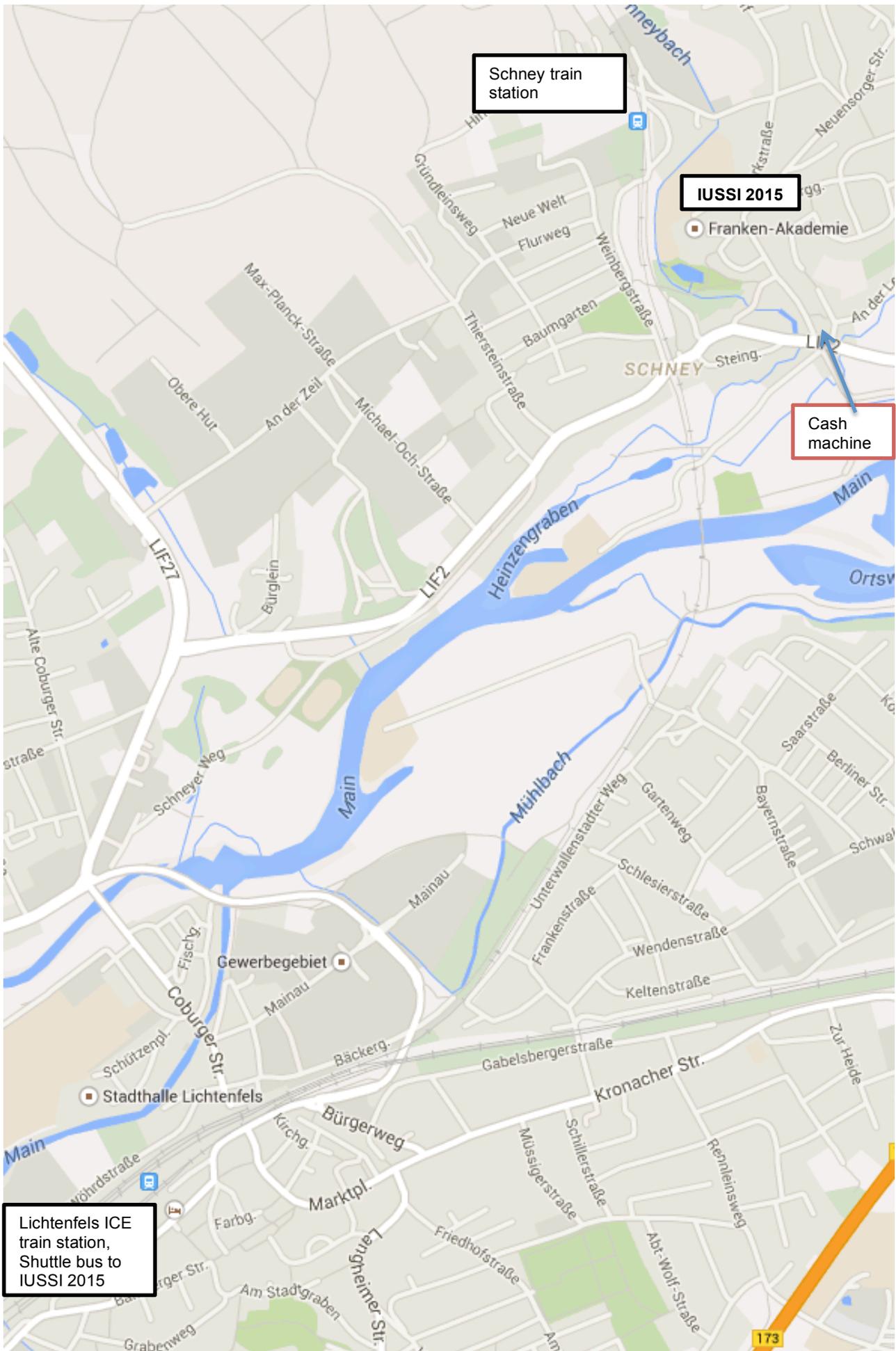
Lichtenfels, Germany

Organized by

Animal Population Ecology, Animal Ecology I, Bayreuth Center of Ecology and Environmental Research (BayCEER), University of Bayreuth

Organising committee

Oliver Otti
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Heike Feldhaar
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Venue

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Program

Thursday, 26.03.2015	
Time	
12:00	Registration
17:00	Welcome reception
19:00	Dinner

Friday, 27.03.2015

Time	
07:30	Breakfast
09:00	Opening
09:15	Plenary talk Audrey Dussutour: Recent advances in the integrative nutrition of ants
10:00	1: Michael Grevé et al.: Dietary and temporal niche differentiation in a rainforest ant community of monsoonal Australia: a comparison with the neotropics
10:15	2: Thomas Parmentier et al.: Trophic interactions in the myrmecophile community associated with red wood ants
10:30	3: Janine Schyra et al.: Which processes govern community assembly of West African savannah termites?
10:45	4: Florian Menzel et al.: Circadian asynchrony in tropical ants - how does it affect on ecosystem stability?
11:00	Coffee break
11:30	5: Gema Trigos Peral et al.: Influence of goldenrod invasion on ant species diversity and colony life history traits
11:45	6: Lisa Heuss et al.: Ant biodiversity in grassland plots
12:00	7: Flavio Roces et al.: Tunnel excavation and the organization of underground traffic flow in leaf-cutting ants
12:15	8: Pina Brinker et al.: Fungal and bacterial communities associated with nests of the ant <i>Lasius fuliginosus</i>
12:30	Lunch
14:00	9: Lena Waidele et al.: A test of substrate adaption via symbiosis in termites
14:15	10: Robert Paxton et al.: Do lactic acid bacteria of the adult honey bee foregut contribute to host defence against pathogens?
14:30	11: Silvio Erler et al.: Honey as self-medication nutrient to combat microparasite infections in the honeybee
14:45	12: Martin Tremmel et al.: An endosymbiont reduces fitness and affects behavior of a haplodiploid beetle
15:00	13: Dino McMahon et al.: Interdependent parasite pressures on social bees
15:15	14: Myrsini Eirini Natsopoulou et al.: <i>Varroa destructor</i> virus (VDV-1) causes elevated rates of overwinter decline of honey bees (<i>Apis mellifera</i>)
15:30	Coffee break
16:00	15: Sophie Helbing et al.: Collective strength - Social context impacts gene expression in bumblebees
16:15	16: Magdalena Witek et al.: Could fungal infection make ant societies more open?
16:30	17: Enikő Csata et al.: The effects of age and fungal infection on the activity of the ant <i>Myrmica scabrinodis</i>
16:45	18: Tobias Pamminger et al.: Pleiotropic effects of juvenile hormone in ant queens and the escape from the reproduction-survival trade-off
17:00	Poster session
19:00	Dinner
21:00	Disco, Disco!!!

Saturday, 28.03.2015

Time	
07:30	Breakfast
09:00	Opening
09:15	Plenary talk Christoph Grüter : The evolution of worker differentiation in social insects: insights from stingless bees
10:00	19 : Abel Bernadou et al.: Division of reproductive labor in the clonal ant, <i>Platythyrea punctata</i>
10:15	20 : Michael Lattorff et al.: Sociality influences patterns of selection in social genes in bumblebees
10:30	21 : Antje Jarosch-Perlow et al.: Regulation of queen pheromone production in honeybee workers via alternate splicing of a CP2 transcription factor
10:45	22 : Tomer Czaczkes: How individual level complexity affects group level behaviour – negative feedback and memory as examples
11:00	Coffee break
11:30	23 : Iris Albrecht et al.: Function- and population-specific odor bouquets of the halictine bee <i>Halictus rubicundus</i> (Hymenoptera: Halictidae) and the evolution of fertility signals
11:45	24 : Volker Nehring et al.: The ecology of nestmate recognition in <i>Lasius flavus</i> ants
12:00	25 : Kathrin Krausa et al.: Olfactory associative learning in two African Stingless Bee Species, <i>Meliponula ferruginea</i> and <i>M. bocandei</i>
12:15	26 : Tim Gernat et al.: Temporal correlations, not network structure, promote information flow in honey bee social networks
12:30	Lunch
14:00	27 : Christina Blut: Automated tracking of honeybee behaviors
14:15	28 : Florentine Schaub: Juvenile hormone and ageing of workers and queens in the termite <i>Cryptotermes secundus</i>
14:30	29 : Uli Ernst et al.: Fountain of youth for flies, worms and bees- effects and mode of action of royalactin
14:45	30 : Anja Buttstedt et al.: Major royal jelly proteins in the honeybee <i>Apis mellifera</i>
15:00	31 : Denise Aumer et al.: Polymorphism for the type of parthenogenesis in laying workers of <i>Apis mellifera capensis</i>
15:15	32 : Annika Roth et al.: A conserved program of sexual regulation in honeybees relies on evolved control mechanisms
15:30	Coffee break
16:00	33 : Jürgen Heinze et al.: High skew in the Caucasus: functional monogyny in the ant <i>Leptothorax scamni</i>
16:15	34 : Susanne Jacobs et al.: Male “territoriality” in African and Caribbean populations of <i>Cardiocondyla venustula</i>
16:30	35 : Balint Marko et al.: Variation in sperm length and viability in males of two <i>Myrmica</i> (Hymenoptera: Formicidae) species
16:45	Short break
17:00	General Assembly of the Central European Section of the IUSI
19:00	Dinner
21:00	Disco, Disco!!!

Sunday, 29.03.2015

Time	
07:00	Breakfast

List of Sessions

- [1](#) Ecology, Environment, Ecosystem (27.03.2015 09:15-12:00, Seminar room E2)
- [2](#) Nest construction (27.03.2015 12:00-14:15, Seminar room E2)
- [3](#) Host-parasite interaction and immunity (27.03.2015 14:15-17:00, Seminar room E2)
- [4](#) Division of labour (28.03.2015 09:15-11:00, Seminar room E2)
- [5](#) Behaviour and communication (28.03.2015 11:30-14:15, Seminar room E2)
- [6](#) Ageing (28.03.2015 14:15-14:30, Seminar room E2)
- [7](#) Reproduction (28.03.2015 14:30-16:45, Seminar room E2)

Friday, 27.03.2015

PLENARY TALK: Seminar room E2, 27.03.2015, 09:15-10:00

Recent advances in the integrative nutrition of ants

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Nutritional homeostasis results from the fine-tuned interactions within a tightly integrated network of behavioural, physiological, morphological and developmental traits. Achieving this is a complicated challenge, given that animals need to ingest a large number of nutrients simultaneously, each at its own particular level. Considering the importance of nutrition for fitness, as well ecological interactions, understanding how animals solve these challenges is a high priority. In recent years an integrative framework, termed nutritional geometry, has been applied to investigate how individuals of a wide range of species solve the challenges of nutritional homeostasis. More complex yet are social animals, such as social insects, where individuals cooperate to provide nutrition for others. Only recently, however, have studies begun to investigate nutritional homeostasis in this more complex, group-level, context. In this talk we demonstrate how nutritional geometry has been applied to investigate nutrition in ants.

Dietary and temporal niche differentiation in a rainforest ant community of monsoonal Australia: a comparison with the neotropics

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Niche differentiation is seen as a central mechanism for species coexistence, and two key niche dimensions are food preferences and time of activity. Ants are the most abundant animals in tropical rainforests and show interspecific competition and competitive exclusion, which might lead to niche differentiation. The aim of this study is to assess trophic and temporal niches of a rainforest ant community in Australia, and to compare the extent of niche differentiation with that previously found using the same methodology in a secondary rainforest fragment in French Guyana. I studied temporal and trophic niche differentiation in a ground ant community, in a monsoon forest patch in northern Australia. I used different baits designed to reflect the natural range of key food resources like sugar, carcasses, live prey, seeds and excrement. These baits were displayed at night and day to evaluate dietary and temporal niches of the occurring species. In addition, pitfall traps were used to provide a background measure of ant diversity and species relative abundances. Although the sites varied greatly in their structure and species diversity, preliminary results show similar niche differentiation. The species assemblages varied between day and night, with a higher diversity in diurnal species. They also differed between the baits, however, no species was restricted to single bait. The most dominant species were generalists with preferences for proteins and carbohydrates.

Trophic interactions in the myrmecophile community associated with red wood ants

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Many arthropods, commonly known as myrmecophiles, are associated with ants. A highly diverse community of myrmecophiles is associated with red wood ants. The trophic benefits of living in ant nests are poorly studied. Moreover feeding interactions among myrmecophiles are mostly totally unknown.

In this study we want to highlight in-depth the possible food sources for a large myrmecophilic community associated with red wood ants. On one hand we analyze trophic sources associated with ants and their nest (ant brood, dead ants, trophallaxis, ant prey). Additionally, we study the trophic interactions among myrmecophiles themselves. We combine those direct cafeteria experiments with stable isotope analysis. The direct offering of different food sources allows to clarify all potential trophic relations. By including stable isotope analysis, we can also track nutritional fluxes and the relative importance of different trophic links. The results of the cafeteria experiments demonstrate a complex food web. Surprisingly, most myrmecophiles, including species commonly categorized as commensals, parasitize on ant brood. Moreover there are multiple trophic prey-predator links among the myrmecophiles. This contradicts clearly with the traditional view of ant nests as an enemy free space for myrmecophiles. The results of the stable-isotope analysis complement these findings and reveal distinct trophic levels. This analysis also suggests that most species only facultatively prey on ant brood.

Which processes govern community assembly of West African savannah termites?

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What are the determinants of species community assembly in tropical ecosystems? This is a challenging question because here many similar species coexist at the local scale. There are two major theories that can explain community assembly. First, the classical niche theory, which states that species have to differ in their niches to coexist. Here deterministic processes structure communities (e.g. environmental filtering and species interactions). On the other side, there is the unified neutral theory of biodiversity, which says that species are demographically equivalent and niche differences are not essential for coexistence. Here species distribution is due to random effects like dispersal, disturbance and stochastic processes. Our study organisms, termites, seem to have nearly identical niche requirements but still more than 20 species coexist in African savannah regions. We tested the importance of deterministic vs. neutral processes for termites in a West African savannah, where they are important ecosystem engineers. We combined specific pattern analyses of termite communities in natural, undisturbed ecosystems with cross-sectional studies of communities representing different assembly stages after anthropogenic disturbance. We analysed community structure across assembly stages to show the impact of phylogeny, niche traits, and environmental factors on community assembly. With this we can test whether and how community structure changes during the assembly process.

Circadian asynchrony in tropical ants - how does it affect on ecosystem stability?

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The diversity-stability relationship has been under intense scrutiny for the past decades, and temporal asynchrony is recognised as an important aspect of ecosystem stability. In contrast to relatively well-studied inter-annual and seasonal asynchrony, few studies investigate the role of circadian cycles for ecosystem stability. Here, we studied multifunctional redundancy of diurnal and nocturnal ant communities in four tropical rainforest sites. We analysed how it was influenced by species richness, functional performance, and circadian asynchrony. In two neotropical sites, species richness and functional redundancy were lower at night. In contrast, these parameters did not differ in two paleotropical sites we studied. Circadian asynchrony between species was pronounced in the neotropical sites, and increased circadian functional redundancy. In general, species richness positively affected functional redundancy, but the effect size depended on the overall functional performance of the local ant communities and on the presence of highly performing species. Our study highlights that diurnal and nocturnal ecosystem properties of the very same habitat can markedly differ in terms of species richness and functional redundancy. Consequently, like the need to study multiple ecosystem functions, multiple periods of the circadian cycle need to be assessed in order to fully understand the diversity-stability-relationship in an ecosystem.

Influence of goldenrod invasion on ant species diversity and colony life history traits

GEMA TRIGOS PERAL¹, HANNA BABIK¹, IRENA GRZEŚ¹, DAWID MOROŃ¹, LUCA PIETRO CASACCI¹, BARTOSZ WALTER¹, PIOTR ŚLIPPIŃSKI¹, MAGDALENA WITEK¹

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The exotic goldenrods *Solidago* spp. is among the most successful invasive plant species in the world. The negative effect of goldenrods on birds or pollinators has been demonstrated recently. It was also shown that invasion of *Solidago* affects ant colony richness, colony density and foraging distance. The aim of our study was to assess how *Solidago* plant invasion can change ant community and diversity of other pedofauna that can be potentially used by ants as the food resources. We also studied the ability of *Myrmica* ants to use *Solidago* pollen as food. Finally, we checked how *Solidago* invasion influence productivity parameters of *Myrmica rubra* colonies. Our studies were conducted in southern Poland in a vast complex of wet grasslands invaded and non-invaded by goldenrods. Our preliminary results indicate that presence of *Solidago* change ant community structure and the highest difference concerns the abundance of ants belonging to *Myrmica* and *Lasius* genus. *Myrmica* ants are the most abundant on meadows non-invaded by goldenrod, whereas on invaded grasslands the most dominant ant species is *Lasius platythorax*. Ants together with beetles and spiders are the most important taxa that allow differentiating the two types of meadows. Indirect evidence suggests that *Myrmica* ants are not able to use *Solidago* pollen as food but the mean dry mass of pedofauna, which can be potential resource of protein for ants, doesn't differ between invaded and non-invaded meadows.

Ant biodiversity in grassland plots

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Ants are important ecosystem engineers as they infiltrate the soil with water, modify the soil structure and the composition of soil microorganisms. Additionally ants provide important ecosystem services such as seed dispersal and may influence the composition of plant species through seed consumption.

Land use intensification in grasslands has already been shown to have a negative influence on ant diversity, but the mechanisms leading to these effects are not well understood. As ant species differ in foraging strategies and trophic niches, land use intensity may affect different species in different ways. To investigate these effects, we sampled temperate grassland plots with a gradient of land use intensification within the framework of the Biodiversity Exploratories.

We hypothesise that land use intensification results in a decrease in ant abundance as well as ant species diversity. The present ant species in more intensively used plots are expected to be more omnivorous. Ant species, which are not able to adjust to variable food resources, could get extinct in intensively used grasslands.

Here we will present first results on diversity and abundance of ants sampled in summer 2014 in 45 plots each in two sites in Germany (Hainich and Swabian Alb) with respect to known land use intensity. We conducted baiting experiments using two agar-based diets differing in carbohydrate to protein ratio to infer food preferences of ants within plots.

Tunnel excavation and the organization of underground traffic flow in leaf-cutting ants

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Atta laevigata leaf-cutting ants construct large nests and excavate a system of underground foraging tunnels leading to food patches located up to 100 m away from the nest. Since excavation is energetically costly, it is expected that the dimensions of a foraging tunnel are adjusted to the prevailing ant traffic flow leading to the foraging patch, and that workers widen existing tunnels to prevent congestions and to accommodate changes in traffic. The development and maintenance of underground foraging tunnels was investigated in the laboratory under conditions of varying traffic flows and in the presence of bottlenecks. To reach the foraging area, workers needed to walk through a pre-given tunnel excavated in a clay box with a narrowed section, which allowed workers to pass through but caused crowding. Workers were expected to dig and widen the narrowed tunnel so as to facilitate the traffic flow. Results showed that ants mainly excavated at the narrowed tunnel section and quantitatively widened the tunnel in relation to the existing traffic flow, which resulted in an increase in the individual speed of load leaf carriage as compared to the conditions without tunnel constrictions. The results are discussed in the context of traffic dynamics and foraging efficiency.

Fungal and bacterial communities associated with nests of the ant *Lasius fuliginosus*

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Ants are known to entertain diverse associations with other organisms for their own benefit. The ant *Lasius fuliginosus* for example stabilizes its complex nest structures through the growth of different fungi. However not much is known about the specificity of this symbiosis. We investigated whether nests of *L. fuliginosus* harbor a specific fungal community. We collected nest material and surrounding soil in August 2013 (summer) and June 2014 (spring) from nine colonies around Bayreuth. Through the fingerprinting method ARISA we profiled the fungal and bacterial community in these samples. The fungal communities between nest material and soil differed significantly. For the bacteria the community of soil and nest material cluster together. Season had no effect on fungal communities in the nest material, while in the soil the fungal communities differed over the year. The soil community of bacteria did not change over the season, while the community of the nest material differed between the spring and summer. These results suggest that *L. fuliginosus* influences the fungal community within their nest and support the hypothesis that *L. fuliginosus* lives in symbiosis with specific fungal communities.

A test of substrate adaption via symbiosis in termites

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Lower Termites depend on microorganisms in their gut to digest wood. Because these microorganisms are directly involved in digestion of the food substrate, they could play an important role when termites adapt to a new substrate. If the microbial community plays a role in substrate adaption of termites, we would expect that microorganisms that are especially advantageous on the new food substrate are favored by the termite host. Hence, the microbial communities of termite species adapting to a new substrate should strongly diverge from the communities of termites that are adapted to the ancestral substrate. As a first test of this hypothesis, we leveraged illumina based 16S rRNA gene sequencing to compare the bacterial communities of a set of lower termite species. This set includes species adapted to soil foraging as well as species that adhere to the ancestral life style of wood dwelling.

Do lactic acid bacteria of the adult honey bee foregut contribute to host defence against pathogens?

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Insects harbour a diversity of bacteria in their gut, some of which may be of benefit to the adult in terms of digestion, resource acquisition or defence against pathogens. They are considered to play an important role in social insect biology because sociality promotes their transmission. Honey bees carry a rich foregut flora comprising specialised lactic acid bacteria (LAB) that inhibit the growth of pathogenic bacteria of honey bee larvae. However, the role of LAB in the defence of adult honey bees against pathogens has yet to be demonstrated. We undertook a carefully controlled experiment in the laboratory in which we inoculated naïve honey bee workers with LAB and then challenged them to microsporidian (*Nosema ceranae*) or viral pathogens. LAB significantly extended the lifespan of worker honey bees. Yet honey bees challenged by pathogens did not benefit from inoculation with LAB, at least not in terms of extending host survival. These data suggest LAB are primarily of nutritional benefit to adult honey bees.

Honey as self-medication nutrient to combat microparasite infections in the honeybee

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Honeybees, *Apis mellifera*, developed several prophylactic disease defense strategies known as 'social immunity'. These strategies also include behavioral traits, such as the foraging of antibiotic, antifungal, and antiviral compounds of plant products. The main nutrient of a bee colony, honey and pollen, contain many compounds that prevent microparasite and pathogen growth, and inhibit viral replication. These compounds are used by the individual worker honeybee and are transmitted via trophallaxis to the whole colony. Furthermore, they are also fed to the larvae by nurse bees; who play a central role for colony health inside the hive.

Here, we show that nurse honeybees, infected with the microsporidian gut parasite *Nosema ceranae*, show different preference for various types of honey in a simultaneous choice assay. Infected workers preferred honeys with the highest antibiotic activity that also reduced the microsporidian infection after the consumption of the honey. Since nurse bees not only feed the larvae but also other colony members, this behavior might be a highly adaptive form of therapeutic medication at both the individual and the colony level.

An endosymbiont reduces fitness and affects behavior of a haplodiploid beetle

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Endosymbionts are known to affect the fitness of their host and to manipulate their offspring sex ratio and behavior, thereby influencing their life-histories. The inbred, haplodiploid, beetle *Coccotrypes dactyliperda* (Coleoptera: Scolytidae) has variable maternal and kin care of youngs and dispersal behaviors. We postulated that variation in presence of endosymbionts influences nursing behavior and life-history traits in this species, in particular decisions regarding the choice between remaining to care for offspring versus dispersing. Here, we report the influence of the composition of endosymbionts on developmental parameters and behavior of this beetle. We collected individuals from two distant field populations with virtually no migration between them. Males of both populations were used to obtain inbred and outbred offspring. Molecular biological techniques were combined to gain insights into the bacterial fauna. We determined development time, adult body mass, and number of offspring of inbred and outbred females and performed behavioral tests of activity level. We identified a number of endosymbionts including *Wolbachia* and *Rickettsia*. Whereas *Wolbachia* - an obligate symbiont of this beetle and essential for egg production was present in all individuals, *Rickettsia* could be identified only in fewer individuals. We found that individuals without *Rickettsia* had lower adult body mass, fewer offspring and reduced activity level. Presently we are examining the effect of *Rickettsia* on dispersal tendencies.

Interdependent parasite pressures on social bees

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There is increasing appreciation that hosts in natural populations are subject to infection by multiple parasite species, and that parasites are able to infect multiple hosts. The epidemiological and ecological processes underpinning these interactions in established host-parasite communities in the field are poorly understood. For emerging infectious diseases (EIDs), knowledge of complex host-parasite dynamics is even scarcer, but is critical for making predictions about the potential threat posed by emerging parasites. We present research on EIDs in social bee pollinators, focusing on microsporidian and viral EIDs in managed honey bees (*Apis mellifera*) and wild bumble bees (*Bombus* spp.). Our findings demonstrate the importance of considering interactions between i) multiple parasite species in single hosts and ii) single parasites infecting multiple hosts, for furthering understanding of disease ecology and evolution.

***Varroa destructor* virus (VDV-1) causes elevated rates of overwinter decline of honey bees (*Apis mellifera*)**

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Overwinter colony losses of the most important commercial pollinator, the honey bee, are an ongoing major concern in the Northern Hemisphere. Pathogens have always been suspected as key drivers in these losses but explicit causes of decline have proven difficult to pinpoint. In the current study we combine field observations with laboratory experiments to address the extent to which overwinter honey bee loss is caused by pathogens. From field observations we find that, of several pathogens, only prevalence of an emerging virus, *Varroa destructor* virus (VDV-1), at the individual-bee level is closely correlated with overwinter mortality within colonies. This virus is widespread in British honey bees. To investigate further whether VDV-1 is in fact causally responsible for field mortality, we conducted a host survival experiment under controlled conditions in the laboratory, comparing the virulence of VDV-1 with a closely related genotype: deformed wing virus (DWV). We found that VDV-1 severely impacts honey bees in the laboratory and, surprisingly, that it is significantly more virulent than DWV. Our report highlights an emerging pathogen as causal in honey bee decline. It furthermore demonstrates the importance of understanding the true extent of pathogen genetic diversity when investigating drivers of species decline.

Collective strength - Social context impacts gene expression in bumblebees

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The ecological success of eusocial insects is mainly attributable to social organization and thus, strongly depends on social interactions mediated by complex social behaviours and their plasticity with respect to environmental changes. The importance of plasticity becomes obvious with regard to the high infection risk associated with sociality, as changes in group size will affect pathogen transmission probability. We studied how bumblebees (*Bombus terrestris*) respond to changes in group size, contrasting the gene expression patterns of workers that differed with respect to their social context (single vs. group-kept bees) as well as their infection status (infected vs. non-infected) by means of RNAseq. The gene expression patterns between single and group-kept bumblebees remarkably differed with up to 76 differentially expressed genes - almost all of them being higher expressed in single-kept bees. This indicates bumblebee's ability to sense and respond to changes in the social environment. Furthermore, within-social-treatment comparisons revealed remarkable differences when coping with an infection: in group-kept bees only 15 genes were up-regulated upon infection, while infected, single-kept workers showed an up-regulation of 30 genes compared to non-infected ones. These differences might indicate the importance and effectiveness of group-level behaviors aiming at reducing pathogen load.

Could fungal infection make ant societies more open?

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Ant colonies are a highly rewarding target for many pathogens and parasites and they also host various species of social parasites that exploit their social system. *Myrmica* ants seem to be particularly susceptible to exploitation by social parasites and by ecto- and endoparasites. Also many *Myrmica* colonies frequently adopt unrelated gynes, which can be interpreted as temporary social parasites. *Myrmica scabrinodis* is a common host of the ectoparasitic fungus *Rickia wasmannii* and its colonies are used by socially parasitic butterfly larvae of *Maculinea* genus. In some *M. scabrinodis* populations both *R. wasmannii* and *Maculinea* butterflies occur together using the same host colonies. In our study we used such population to check whether fungal infection change the threshold of acceptance of social parasites and unrelated queens by ants and make colonies more open for strangers. For this purpose we performed experiments during which we tested how infection by *R. wasmannii* affects frequency and time of *Maculinea* larva adoption and adoption of unrelated ant queens. We also carried out aggression tests where we used *M. scabrinodis* workers originating from infected and uninfected colonies to check if fungal infection influences the amount of adverse reactions. Our preliminary results indicate that ants infected by the fungus are more readily adopting social parasites, while being less aggressive towards foreign queens. Thus, infected colonies could be more prone for social parasitism.

The effects of age and fungal infection on the activity of the ant *Myrmica scabrinodis*

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Several fungi exploit ants, most of them are from the tropics, but some fungi are known from Europe. *Rickia wasmannii* (Ascomycetes: Laboulbeniales) is an ectoparasitic fungus living on different species of the ant genus *Myrmica*. Little is known about the effect of *R. wasmannii* on their hosts. Infected workers with high abundance of fungus thalli have reduced lifespan compared to un-infected ones. These facts led us to put some questions regarding the effect of infection and of age on the activity of *M. scabrinodis* ants. We performed behavioral essays in laboratory conditions, where we compared the locomotory activity of young and old individuals of *M. scabrinodis*, both un-infected and infected (altogether 140 individuals). Activity observations were carried out for ten minutes. The fat content of each individual was measured, and the number of fungal thalli was counted on the cuticle of infected individuals. We analyzed five parameters during our research: the location of the individuals, their general activity, the distance moved in different zones, the velocity of the individuals, and the meandrous pattern of their movement. Our results suggest that the age and infection indeed affect the general activity, and the spatial distribution of *M. scabrinodis* individuals.

Pleiotropic effects of juvenile hormone in ant queens and the escape from the reproduction-survival trade-off

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Reproduction is costly in terms of survival, an effect known as the reproduction-survival trade-off. Despite being a widespread phenomenon, the reproductive individuals of many eusocial insects defy this trade-off and live both long and prosper. Due to their pleiotropic nature as key regulator of many fitness relevant processes, hormones have emerged as potential trade-off mediators and juvenile hormone (JH) is such a prime candidate in insects. In solitary insects JH often stimulates reproduction, while at the same time functions as a potent suppressor of key pathways of the innate immune system. These antagonistic effects result in reproduction-immunocompetence trade-off which is a likely mechanistic candidate underlying the reproduction-survival trade-off. Using an integrated methodological approach we investigate the behavioural-, physiological- and gene regulatory function of JH in the long-lived queens of the black garden ant *Lasius niger*. We demonstrate that in contrast to most solitary insects JH has lost its stimulatory function on the reproductive process, but still acts as a potent suppressor of the innate immune system. This regulatory adaptation enables *L. niger* to sustain a high reproductive output without elevated JH titres and the associated risks of infection. This modification offers a potential escape from the reproduction-survival trade-off and likely contributes to the extraordinary lifespan of the queens in this social insect.

Saturday, 28.03.2015

PLENARY TALK: Seminar room E2, 28.03.2015, 09:15-10:00

The evolution of worker differentiation in social insects: insights from stingless bees

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The differentiation of workers into morphologically different functional castes represents an important evolutionary transition and is thought to improve division of labour in insect colonies. Workers with morphological adaptations for certain tasks, e.g. large soldiers in ants and termites, are likely to perform these tasks more efficiently than generalist workers and we would expect specialist castes to be common in social insects. However, worker differentiation is conspicuous by its absence in practically all bees and wasps and the majority of ant species. Several hypothesis have been proposed to explain why division of labour based on morphological sub-castes is relatively uncommon: colony size, individual-level selection, genetic diversity, developmental constraints and ecological factors have all been suggested to favour or prevent the evolution of worker differentiation. However, the importance of each of these factors remains unclear.

At first sight, stingless bees (Meliponini) are an unlikely group to provide significant insights into the evolution of worker differentiation because of the absence of the extreme worker differentiation that is found in some ants and termites. However, recent research suggests that colony organisation is more complex and diverse than currently acknowledged. With more than 600 described (and many undescribed) species, they represent the largest group of eusocial bees and their tropical distribution means that most species have not been studied in detail. I discuss the evidence for task-related worker differentiation in stingless bees and explore the role of different factors (e.g. colony size, developmental constraints) in explaining differences between species in the degree of worker differentiation.

Division of reproductive labor in the clonal ant, *Platythyrea punctata*

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Division of labor in insect societies is one of the tenets of eusociality. However, the proximate factors underlying task allocation and specialization in social insects are not yet fully understood. For example, there is firm evidence for a role of genetic variation, morphology, individual experience or developmental factors in the propensity of individuals to take over particular tasks. Nevertheless, division of labor even exists among individuals that lack these differences as in clonal ants. Little is known about the factors causing task allocation in such species. In the tropical ant *Platythyrea punctata*, colonies are characterized by a division of labor between one reproductive worker and non-reproductive workers. Reproductive division of labor is based on rank orders established by fighting, but what determines rank differences among nestmates remains unknown.

In this study, we investigated first whether division of labor in *P. punctata* is based on age-polyethism among nestmates. In a second experiment, we tested whether clone origin of workers influences their propensity to become dominant, i.e., the reproductive division of labor. Our results reveal that there appears to be an age-based division of labor between nurses and foragers. By chimeric assemblies of clones, we followed the formation of hierarchies in groups of young workers. Our results show that a hierarchy readily appears between workers within a few days but their clonal origin does not affect division of labor.

Sociality influences patterns of selection in social genes in bumblebees

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Insect societies are extremely successful within ecosystems due to division of labour amongst individuals. Reproductive division of labour occurs between queens and workers with queen monopolizing reproduction whereas workers remain functionally sterile, but contribute to nest construction and maintenance, brood care, foraging and defence of the colony. Genes with queen biased expression are evolving at high rates, compared to genes with worker-biased expression patterns, as they are exposed to selection directly within the queen caste. Genes that influence social behaviour within the worker caste evolve much more slowly, as their exposure to selection is indirect through queens. Hence, it is expected that these genes, along with low evolutionary rates harbour more intraspecific polymorphisms due to inefficient selection.

We tested this hypothesis using a suitable test system of social bumblebees and socially parasitic cuckoo bumblebees, which are effectively solitary due to the lack of a worker caste. We tested three genes, which are known to influence social behaviour. Genes were sequenced in haploid males of two social and two socially parasitic species using NGS technology at ultra-deep coverage. Social genes evolve at high rates, but show expected patterns of high intraspecific polymorphism within social species. High evolutionary rates are expected to occur due to relaxed selection caused by indirect exposure to selection.

Regulation of queen pheromone production in honeybee workers via alternate splicing of a CP2 transcription factor

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In honeybees the reproductive division of labour is regulated by the queen via the production of a pheromonal blend. Especially a five component blend produced in the mandibular glands (QMP) which consists of 9-ODA, (R) - and (S)-9-HDA, HOB and HVA is able to inhibit worker ovary activation. As soon as the queen and her pheromonal restrictions get lost workers are able to establish dominance at pheromonal level by producing higher amounts of 9-ODA and 9-HDA and to activate their ovaries. Ovarian development was shown to be regulated by alternative splicing of *gemini*. This gene is located within a genomic region mapped in the Cape honeybee *Apis mellifera capensis* which pleiotropically controls the production of diploid female offspring via thelytokous parthenogenesis, the early onset of egg-laying and the production of QMPs. As transcription factors are known to control several traits at once, we studied the CP2 transcription factor homologue *gemini*. RNAi knock-down studies revealed a certain exon to be directly involved in the regulation of ovarian development. To test whether *gemini* also controls the production of QMPs we knocked-down specific *gemini* transcripts by RNAi. Indeed shifting the ratio of unspliced versus spliced transcript variants led to an increased production of QMPs in arrhenotokous honeybee workers. It may thus be a key regulatory element enabling workers to become reproductive dominants and may thus be central to the regulation of worker fertility.

How individual level complexity affects group level behaviour – negative feedback and memory as examples

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Social insects are a key system for studying emergent behaviour. Interacting individuals result in group level behaviours. Small variations in the behavioural rules followed by individuals may dramatically affect colony-level behaviour.

In one example, ants may become “trapped” exploiting a poor quality food source if they find it first. However, recently behavioural rules which result in a reduction of pheromone deposition in response to high traffic were discovered. By implementing these rules in an agent based model, I showed that the addition of a simple negative feedback rule can save colonies from becoming “trapped”.

In a second example, I ask how individual complexity – in the form of route memories – affects collective decision making at the colony level. Memory plasticity in the ant *Lasius niger* is examined, and used to build an agent based model. Memory and trail pheromones are activated or deactivated. The combined use of memory and pheromones by individuals results in greater efficiency at the group level. The ants combine consensus decision making, allowing them to quickly exploit high-quality food sources, and combined decision making, allowing different individuals to specialise in exploiting different resource patches. Such a composite collective decision making system reaps the benefits of both its constituent parts.

In conclusion, while viewing individual social insects as rather simple, identical automatons has provided great insight, the devil is often in the details.

Function- and population-specific odor bouquets of the halictine bee *Halictus rubicundus* (Hymenoptera: Halictidae) and the evolution of fertility signals

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Chemical communication systems are a major precondition for the evolution of insect sociality. So-called fertility signals are produced by females with developed ovaries and have been identified in queens of many eusocial insects, however not yet in primitively eusocial halictine bees. In order to offer new insights into the evolution of sociality, the major aim of this study was to characterize fertility signals in the socially polymorphic halictine bee *Halictus rubicundus*. We investigated population-, caste- and function-specific differences in cuticle surface bouquets of *H. rubicundus* females collected at solitary and social populations and characterized substances correlating with the ovary development of females. In chemical and electroantennographic analyses we identified 34 electrophysiologically active compounds, mainly n-alkanes, n-alkenes, macrocyclic lactones and ethyl esters that showed caste- and population-specific differences. While non-breeding females of solitary and social populations were in part similar, breeding queens of social nests showed a unique odor bouquet distinct from all other groups indicating the evolution of a queen-specific signal in social populations. The separation of functional female groups, castes and populations were due to different relative proportions of macrocyclic lactones, n-alkanes and n-alkenes, which also correlated with the ovary development. Therefore, these substances may have a key function as fertility signals.

The ecology of nestmate recognition in *Lasius flavus* ants

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Social groups can only be stable when they are closed: non-members must be kept at bay. This simple premise seems to be generally fulfilled in eusocial hymenoptera, which mostly live in closed nests and employ robust nestmate recognition processes. Still, a significant amount of variation remains in whether or not group-members attack non-nestmates. Part of the variation can be attributed to functional differences between individuals. For example, soldiers are expected to be more aggressive than queens. However, a fraction of the variation may also be noise – recognition errors. Ecological conditions are known to influence an individual's cuticular odour, which is the basis for nestmate recognition. We thus hypothesised that ecological variation may introduce noise into nestmate recognition systems. In a field population of the ant *Lasius flavus* we studied the covariation of ecology, nestmate recognition cues, and nestmate recognition behaviour. We further targeted candidate correlations in specific controlled chemical and behavioural experiments to understand in how far ecological variation may affect nestmate recognition, and what potential adaptations are against ecological noise.

Olfactory associative learning in two African Stingless Bee Species, *Meliponula ferruginea* and *M. bocandei*

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Foraging success in stingless bees relies to a great extent on olfactory cues or signals. A prerequisite to foraging *via* odors is that the bees are able to associate odors with a nectar-reward and memorize this information. Most studies on stingless bees have been conducted in the Neotropics whereas very few have been undertaken in Africa. This study examines for the first time the olfactory learning abilities of African stingless bees. A differential proboscis extension reflex (PER) conditioning assay was used to study learning and memory of *Meliponula ferruginea* and *M. bocandei* and compared to the learning performance of the local honey bee *Apis mellifera scutellata*. Our results clearly show that both stingless bee species associate odors with a reward. This information is memorized for at least 15 minutes. Responses in PER assays of both stingless bee species were poorer compared to honey bees. This might reflect that the experimental procedure has been optimized for *A. mellifera*. However the PER paradigm is suitable to study learning, memory and olfactory perception in stingless bees. Just like in honeybees, this will open a new way for answering ecological, psychological and neurobiological questions in stingless bees.

Temporal correlations, not network structure, promote information flow in honey bee social networks

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Honey bees regulate the size and activities of their foraging force via signals transmitted during liquid food exchange (trophallaxis). Analysis of these social interactions is limited by high colony population density and similar individual appearance, making it difficult to study how bees achieve fast information flow and robust network operation. To address these questions we developed a novel machine vision method that acquires images of an entire colony of barcoded bees kept in a single-sided, glass-walled observation hive every second and automatically infers trophallaxis from the images. Using temporal network analysis, we measured maximum information flow through the trophallaxis network over the course of 10-12 days, replicated over 5 colonies. We found that information spread further in the empirical networks compared to a variety of randomized reference networks, demonstrating that trophallaxis is not random. Surprisingly, the increased information spread was largely due to temporal correlations between successive interactions and not overall network structure. Removing a large fraction of the colony's foragers revealed that honey bees are able to maintain information flow by quickly establishing new connections. These results provide new insights into how trophallaxis coordinates behavior in insect societies and highlight hitherto underappreciated general mechanisms for promoting information flow and maintaining robustness in social networks.

Automated tracking of honeybee behaviors

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In honeybees (*Apis mellifera*) work is allocated amongst the thousands of worker bees within a colony. The collective behaviors of these worker bees produce colony level patterns and outcomes far exceeding the abilities of single worker bees. We have little knowledge of how these collective behaviors are organized amongst the colony's members. To understand the mechanisms underlying regulation of work allocation in honeybee colonies we must first understand the behavioral rules and social interactions regulating individual task engagements. With data provided by an automated tracking system my aim is to automatically identify individual task engagements and social interactions among nest mates within the hive. To continuously monitor honeybees' behaviors I use a tracking system originally implemented for ants by Mersch et al. (2013). Compared to previous bee-monitoring techniques, this study's tracking system now allows automated and simultaneous tracking of hundreds of individually tagged bees. For behavior analysis the tracking data is input to behavior annotating programs providing further data that I will use to identify the behavioral rules regulating individual bees' activities. I will present my first tracking results and will discuss how these and following tracking results will help to achieve a better understanding of the rules underlying regulation of work allocation in honeybee colonies.

Juvenile hormone and ageing of workers and queens in the termite *Cryptotermes secundus*

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Ageing of organisms has been fascinating researchers for decades. Social insects are promising new models to improve our understanding of senescence because queens have extended lifespans compared to solitary insects, despite being highly fecund. One of the most important and highly conserved molecular pathways implicated in senescence across animals is the insulin/insulin-like growth factor signaling (IIS) pathway. This pathway interacts with juvenile hormone (JH), a major insect hormone and regulator of fertility. Short lifespans of fruit flies are associated with high JH titers and high fecundity. In the honeybee, high JH titers are also associated with ageing but the long-lived queens have low titers. This contrasts with termites, where queens have high JH titers despite their long lifespan. We studied the interaction between JH and the IIS 'ageing pathway' in the lower termite *Cryptotermes secundus* to test whether it differs compared to those of other organisms. Manipulating JH titers only affected the expression of IIS genes in workers, but not in (neotenic) queens, implicating a potential uncoupling between fecundity and longevity. This uncoupling seems to occur with the development of workers into queens. Moreover, we could narrow down this switch to few IIS candidate genes. Our studies provide first insights how termites convergently evolved long-lived reproductive.

Fountain of youth for flies, worms and bees- effects and mode of action of royalactin

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Caste determination in honeybees depends entirely on environmental cues, i.e. the food supplied to the young larvae. The glycoprotein royalactin contained in the larval food royal jelly is necessary for the development of long-lived queens and acts via the Epithelial Growth Factor (EGF) signalling pathway, leading to epigenetic modifications and subsequent changes in physiology. Surprisingly, royal jelly extends lifespan also in mice and flies. However, it remains elusive how exactly royalactin activates EGF receptors. We used the roundworm *Caenorhabditis elegans* to further investigate the effects and mode of action of royalactin. We show that royalactin extends both lifespan and healthspan in this non-insect model organism. Additionally, royalactin increases heat stress tolerance. These effects are independent of royalactin's sugar chains. However, not only EGF receptor (LET-23 in *C. elegans*), but also its ligand EGF (LIN-3) are indispensable. We discuss additional pathways involved in lifespan extension in *C. elegans* and its significance for other organisms, including humans.

Major royal jelly proteins in the honeybee *Apis mellifera*

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In the honeybee *Apis mellifera*, female larvae destined to become a queen are fed with royal jelly, a secretion of the hypopharyngeal glands of young nurse bees that rear the brood. The protein moiety of royal jelly comprises mostly major royal jelly proteins of which the coding genes (*mrjp1-9*) have been identified on chromosome 11 in the honeybee's genome. We determined the expression of *mrjp1-9* among the honeybee worker caste and the sexuals in various body parts. Specific *mrjp* expression was not only found in brood rearing nurse bees, but also in foragers and the sexuals. The expression of *mrjp1* to *7* is characteristic for the heads of worker bees, with an elevated expression of *mrjp1-4* and *7* in nurse bees compared to foragers. *Mrjp5* and *6* were higher in foragers compared to nurses suggesting functions in addition to those of brood food proteins. Furthermore, the expression of *mrjp9* was high in the heads, thoraces and abdomen of almost all female bees, suggesting a function irrespective of body section. This completely different expression profile suggests *mrjp9* to code for the most ancestral major royal jelly protein of the honeybee.

Polymorphism for the type of parthenogenesis in laying workers of *Apis mellifera capensis*

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In eusocial insects the production of female offspring is restricted to the queen, typically the only individual with activated ovaries in the colony. However, once the pheromonal restrictions of the queen and her brood get lost, workers are able to reproduce. Such a reproduction of unmated workers normally leads to exclusively haploid males produced via arrhenotokous parthenogenesis. An exception are laying workers of the South African Cape bee *Apis mellifera capensis*, which are able to produce female progeny due to an abnormal spindle rotation during meiosis via thelytokous parthenogenesis. This trait is controlled by a recessive allele at the *thelytoky* locus. So far it is generally accepted that all laying workers of *A. m. capensis* reproduce exclusively thelytokously (*th/th*). However, field studies have always been done in a colony context. But in the colony there is a strong intracolony selection for thelytokous workers, because they can pheromonally suppress reproduction of other workers. We here test for the mode of parthenogenesis of individual *A. m. capensis* workers from a colony of the endemic wild population from the Cape of Good Hope Nature Reserve. Worker parthenogenesis was dimorphic, segregating in 50% thelytokous and 50% arrhenotokous workers. This Mendelian segregation suggests the queen to be heterozygous at the *thelytoky* locus and all siring males to carry the *th* allele, which implies a high frequency but not a fixation of the *th* allele in the population.

A conserved program of sexual regulation in honeybees relies on evolved control mechanisms

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Honeybees (*Apis mellifera*) are highly organized eusocial insects that split different tasks among their colony members. Queen and drones are the sexual reproducing individuals, whereas female worker bees are required to maintain the colony. Hence, sex determination is an essential process to generate castes and the sexes. Sex-determining systems can differ extremely among organisms, but recent studies have shown a conservation of the final effector gene *doublesex* (*dsx*) of the sex-determining cascade. The transcription factor Dsx integrates the sexual information into the general developmental program through the differential activation of downstream genes. Our results show that Fem and *Am-Tra2*, orthologs to *DmTra* and *DmTra2*, are sufficient to direct female specific splicing of *Am-dsx*. Despite this conservation, the molecular regulation of *Am-dsx* splicing has evolved compared to the model organism *Drosophila*. For instance the typical Tra/Tra2-binding motif that activates the 3'-splice site in *Drosophila* is absent in the honeybee. In *Apis mellifera* we have mapped four exonic splicing enhancers that are essential to activate the female 3'-ss resulting in *Am-Tra2*/Fem-dependent exon 5 inclusion. Our results reveal that the splice regulatory proteins Fem and *Am-Tra2* are functionally conserved while the nucleotide sequence, the position and the role of the regulatory elements evolved. The resulting product, the female *dsx* splice variant, is, however, deeply conserved in insects.

High skew in the Caucasus: functional monogyny in the ant *Leptothorax scamni*

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Animal societies vary considerably concerning how reproductive rights are partitioned among individual group members (“reproductive skew”). Queens of most ant species contribute more or less equally to the brood, but queens of a few species of the genus *Leptothorax* form dominance hierarchies in which only the top ranking queen lays eggs (“functional monogyny”). In accordance with optimal skew models, high skew appears to be associated with habitat patchiness. Here we document functional monogyny in the Caucaso-Anatolian ant *Leptothorax scamni* (Ruzsky, 1905), as was previously suggested based on the nesting habits of this species. Like in related species, young female sexuals mate on the ground near their natal nests and thereafter either disperse to found new colonies solitarily or in groups or return into their natal nest, where only one of several mated queens reproduces. A phylogeny based on partial CO I sequences corroborates the view that functional monogyny has evolved convergently in several taxa of *Leptothorax* and is thus a relatively labile trait that rapidly adapts to habitat changes.

Male “territoriality” in African and Caribbean populations of *Cardiocondyla venustula*

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In most ant species, mating is a rather unexciting event with few possibilities for males to evolve alternative reproductive tactics. However, the genus *Cardiocondyla* is characterized by a pronounced male polyphenism with wingless fighter males exhibiting lifelong spermatogenesis and winged disperser males exhibiting the limited sperm supply typical for ant males. In *Cardiocondyla venustula*, as in several other *Cardiocondyla* species, winged males have been lost secondarily. Mating strategies of wingless males range from ancestral lethal fighting in many tropical species to derived mutual tolerance in most palaeartic species. *C. venustula* occupies an intermediate phylogenetic position between these groups and could therefore be a key to understanding the evolution of male strategies in this genus. Wingless males of *C. venustula* only occasionally engage in lethal fighting but defend “territories” in their natal nest. Behavioral observations of 26 colonies from South Africa (native) and Puerto Rico (introduced) revealed high intraspecific variability in male behavior. The occurrence and number of territorial males as well as the degree of aggressiveness varied substantially between the colonies, with South African colonies showing a higher proportion of territorial males. In colonies with territorial males, the number of young queens was significantly higher for chambers occupied by territorial males, indicating a higher rate of possible matings per male.

Variation in sperm length and viability in males of two *Myrmica* (Hymenoptera: Formicidae) species

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The scale of variation in male morphology within a species can offer interesting insights into the reproductive strategy of a given species: male-male competition due to female choice, existence of polyandry, trade-offs between morphological traits etc. can stand at the basis of such variation. Although in ants polyandry is known to occur in many species, variations in male reproductive characteristics are fairly understudied. Specifically in *Myrmica* species, where low degree of polyandry is assumed to exist, data on male traits as e.g. sperm cell, sperm viability or accessory gland size are lacking. In the frame of the current study we analyzed various features of males of two frequently co-occurring *Myrmica* species: *M. scabrinodis* and *M. gallienii*. We found that males of *M. gallienii* have longer sperm in comparison to *M. scabrinodis*, despite similar body size. Moreover, there is already considerable variation between males in sperm cell length, sperm viability and accessory gland size in both species. The evolutionary importance of the variations in all these traits and the relationships among them will be discussed with regard to reproductive strategies in *Myrmica*.

Poster session

Seminar room E1, Friday, 27.03.2015, 17:00-19:00

P1

The first list of ants of Natural Park of Sierra Tejeda, Almijara y Alhama (Andalusia, Spain): A new environment to discover

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The drastic reduction of natural habitats during the last decades have provided special importance to the creation of Natural Parks. The Natural Park of Sierra Tejeda, Almijara y Alhama (located between Málaga and Granada, Andalusia), belong to a mountain system which slopes arrive to the sea. Considered one of the main cores of yew (*Taxus baccata*, L.) of Andalusia and declared a Special Protection Area of Birds, with special geological, orographic and climatic features, this Natural Park has been subject of several biodiversity survey but any study of ant biodiversity has been performed until now. These ecological features, as well as the lack of this data, make us to prepare the first list of ant species occurring in this Natural Park.

The sampling was conducted in August 2014 by tracing a transect of five plots with different altitude in the southwest area of the mountain system, with a average slope of 10.8%, within the limits of Axarquía. Altogether, 50 pitfall traps were placed and we obtained 16 ant species. The most abundant species belong to *Aphaenogaster*, *Messor* and *Formica* genus. A possible new record of *Temnothorax* was found in this survey, but the species name has to be confirmed. The formicids biodiversity was performed for five different plots, showing a maximum value for the Shannon Index of 1.795, which was found in an open and dry pine area. We have to highlight the fact that our study is an initial phase of a multi-year survey in which valuable results are expected.

P2

Impact of heavy metal pollution on ground-dwelling ant communities (Hymenoptera: Formicidae). A case study from Transylvania (Romania)

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The effects of environmental contaminants in both humans and animals raise huge concerns. However, scarce data is available on the impact on ground-dwelling invertebrates, despite being known as reliable bioindicators. We investigated the effect of industrial heavy metal (Pb, Zn) contamination on ground dwelling ant communities in the surrounding of Copșa Mică, a well known highly polluted area. We were interested in the effects of heavy metal pollution on ant diversity, community structure and composition. Ants were sampled with pitfall traps, from different habitats (meadows, forests) alongside a pollution gradient, in one field campaign in July 2014. Altogether we identified 15 ant species belonging to three subfamilies. We observed no pattern in terms of species number alongside the gradient. However, the Equitability index revealed an increased diversity with the distance from the pollution source. Typical ant communities shape the habitats near Copșa Mică. Forest species such as *Myrmica ruginodis* Nylander 1846, *Temnothorax crassispinus* Karavaiev 1926, *Stenamma debile* Förster 1850 or *Lasius platythorax* Seifert, 1991 occurred in the forest sites, whereas *Lasius niger* (Linnaeus, 1758), *Formica cunicularia* Latreille 1798, *Formica rufibarbis* Fabricius 1793 or *Myrmica schenki* Viereck 1903, were identified in the meadow sites. Our preliminary results show that despite the intensive pollution in the past, ant communities slowly recover.

Urban ants on baits – Case study from Southern Transylvania (Romania)

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Urbanization causes the fragmentation of natural habitats into isolated patches surrounded by anthropogenic habitats. These urban characteristics may reduce the dispersal efficiency of many species including ground-dwelling arthropods. Ants can tolerate unfavorable environmental conditions, including urban habitats. Three types of baits were used (tuna, honey and mixed tuna and honey) to investigate ant communities from urban habitats. Baiting observations were carried out in 2012 in: greens spaces, forests, disturbed areas (old fields, industrial areas). Altogether, we identified 11 ant species belonging to 2 subfamilies, most of them ubiquitous. In terms of food preferences, *Myrmica ruginodis*, *M. scabrinodis* and *Formica rufibarbis* were more active on honey baits, whereas *Lasius brunneus* and *L. platythorax* preferred tuna. *Formica cunicularia*, *Lasius niger* and *Tetramorium cf. caespitum* were the most opportunistic species, occurring on all types of baits. Our results show that the urbanization pressure has an impact on ant species diversity and food preference.

Ant community structure of a *Maculinea arion* (Lepidoptera: Lycaenidae) population's habitat

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Maculinea species, obligate social parasites of *Myrmica* ants, are one of the most intensively studied group of Palearctic butterflies. During their development they need particular food plants and host ant species. In the last few decades all *Maculinea* species have experienced severe declines over most of their ranges due to intensive agriculture and fragmentation of their habitats. *Maculinea* species are consequently regarded as flagship species of nature conservation. Our aim was to study the ant community of a *Maculinea arion* population's habitat in Romania. The ant community was assessed by the means of pitfall traps, and we also collected data on the host plant's (*Origanum vulgare*) presence. Altogether 14 ant species were identified, four of which belonged to the genus *Myrmica*, host ants of *Maculinea arion*. The most abundant ant species was *Myrmica scabrinodis*, a known host species of the butterfly. Connected to this the spatial distribution of *Myrmica scabrinodis* and *Formica cunicularia* foragers was the most even on the study site. The presence of host plants did not have a significant effect on the ant community structure or diversity.

Not all that organises is pheromones: no evidence that pheromones affect excavation choice in ants

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Ants can excavate large tunnel systems as part of their nest construction. The size of these nests scales with the number of individuals present. This matching of nest digging effort to need is an example of an efficient allocation of labour to a task. However, the mechanisms that underlie this regulation are not understood. It has been hypothesized that pheromones on the digging face play a key role in this regulation through the processes of application, attraction, and evaporation. This hypothesis has previously been supported by both modelling and evidence. This study tested this theory by presenting groups of 5 *Acromyrmex lundii* with the choice of two tunnel faces in which to dig, one with pheromones (or potentially with pheromones) that had just been exposed to active digging, and the other with little or no pheromone, where digging had also been present but was stopped for one hour to allow any previous pheromone deposition to dissipate. It was expected that more excavation would occur over the course of one hour at the 'fresh' tunnel faces than at 'old' faces. However, this was not the case and the difference in the weight of excavated soil between the two conditions was non-significant (Wilcoxon test, $p=0.523$, $n=96$). This surprising result suggests that pheromones might not be present on the digging face, or at least do not function to regulate group investment in tunnel excavation. This suggests that our understanding of the social regulation of nest construction requires revision.

Anemotactic orientation in leaf-cutting ants: sensitivity to airflow speed and direction

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The giant underground nests of leaf-cutting ants of the species *Atta vollenweideri* are ventilated via a passive wind-induced mechanism that drives air movements inside the nest. On the nest mound, airflow direction differs between central and peripheral openings characterized by outflow and inflow, respectively. Outflowing air is known to stimulate the construction of turrets that improve nest ventilation, making air currents possibly an important factor for nest climate control in this species.

We investigated the sensitivity to air currents of different speeds and directions in *Atta vollenweideri* leaf-cutting ants by performing learning experiments under laboratory conditions. Using absolute conditioning, we tested whether single foragers were able to learn the location of a food reward using air currents of different speed and direction as orientation cue. During training, single workers were led to a platform where they could collect oat flakes while being exposed to an air current (10 cm/s), either frontal or from behind, depending on the experiment. After training, workers were given the choice between two sides, only one providing an air current of the same direction used during training, with speeds of 10, 5 or 3 cm/s. Workers significantly preferred the side providing the air stimulus, thus using the air current as orientation cue. However, they performed better for higher air velocities as well as when being exposed to frontal air currents.

A parasite infection leads to changes in the chemical profile of uninfected ant workers of *Temnothorax nylanderi*

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The sophisticated recognition system of social insects enables them to avoid exploitation by discriminating *friends from foes*. Cuticular hydrocarbons (CHCs) constitute the basic recognition cues in ants, whereby quantitative variations in CHCs are involved in the decision rule whether to reject or integrate an encountered individual. An infection with the tapeworm *Anomotaenia brevis* induces multidimensional changes in *Temnothorax nylanderi* ants, including a quantitative modification of CHCs. Surprisingly, despite the deviant chemical profile that elicits aggressive responses and lower survival of uninfected nest-mates, infected ants do not experience social exclusion. Here, we tracked infection-mediated effects on the chemical profile of different worker types (i.e. infected vs. uninfected) and castes by manipulating the composition of colonies through addition and removal of infected workers. The presence of infected ants induced a shift in the amount of CHCs, leading to lower amounts in uninfected workers of parasitized nests, while infected ants had more CHCs. This effect was stronger in nurses, which have more contact with infected ants than foragers. The alterations could be the consequence of active exchange of CHCs between the worker types or due to stress, which could give an explanation for the higher death rates.

Comparative assessment of the strength of the antimicrobial secretions of different Hymenoptera species

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Antimicrobial gland secretions and their spread by grooming are widely distributed among social insect species. Recent studies have reported a positive connection between the strength of antimicrobial gland secretions and group size in Australian hymenoptera. Social species seem especially prone to disease epidemics because of high contact rates and high relatedness to conspecifics. Additionally poor sanitariness of the nesting substrate can also lead to high pathogen exposure. In this study we have investigated whether the strength of antimicrobial secretions is associated with group size or sanitariness of the nesting substrate in different hymenopterans from Germany. The strength of antimicrobial secretion was measured in the venom gland for each species. Sampling was done across a number of hymenoptera species including the most common wasps, bees and bumblebees in Upper Franconia, Germany. The antimicrobial activity of the venom glands of the sampled species showed a distinct, reproducible and non-varying strength. Antimicrobial strength did only weakly increase with group size and sanitariness of the nest. When correcting for phylogenetic relatedness this weak relationship disappeared. From this we conclude that group size and nesting habit are of minor influence on the antimicrobial strength of gland secretions of hymenopterans. Instead we propose the distribution of this feature to be caused by another not investigated trait or to be a purely phylogenetic effect.

Microstructure of a fungal infection: the myrmecopathogenic *Pandora myrmecophaga* in its *Formica exsecta* ant host

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Pandora myrmecophaga is member of the fungal subphylum Entomophthoromycotina. It obligatorily infects ants, mostly members of the genus *Formica*. Infections are always due to spores, that adhere to the cuticle and form a penetration tube, entering the body cavity of the individuals, where they develop further on. The fungal mycelium grows in the head, mesosoma, gaster, antennae, and legs of the ant. In the final stage, the infection manifests itself in the form of the so-called 'summit disease': the infected worker climb on a grass around its nest, where it attaches itself with the mandibles and legs to distal parts of the plant, and dies. In the frame of our study we present, for the first time, the microstructure of *P. myrmecophaga* based on scanning electron microscope photos. Infected specimens of different stages were collected in a *Formica exsecta* supercolony in Central Romania. Based on the photos within hours after the death of the host the rhizoids of *P. myrmecophaga* grow out of the intersegmental parts of the basisternum and laterocervical plates and attach the ant to the grass blade even more strongly. Then in one or two days, fur-like fungus appears at the intersegmental parts of the mesosoma and gaster, mainly from the dorsal parts, and somewhat later also near the bases of the mandibles and the antennal insertions. Although the infection manifests itself in a very similar way to flukeworms of the genus *Dicrocoelium*, there are clear differences that help myrmecologists differentiate between *Dicrocoelium* and *Pandora* infection.

A new slavemaker avoids recognition and aggression by its hosts to conduct peaceful raids

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Social parasites, such as slavemaking ants, have to break into their host colonies' fortresses. They often use open aggression to overcome the fierce defences of their hosts, which can recognize their enemies by their chemical profile. This holds true for the North American slavemakers, *Protomognathus americanus* and *Temnothorax duloticus*, but a related, newly described slavemaker, *T. pilagens*, uses a different and variable strategy: during most raids, neither *T. pilagens* nor its *Temnothorax* hosts show aggression. Besides stealing brood unmolested, the slavemaker carries and integrate adult host workers into its slave workforce. Occasionally, however, *T. pilagens* changes its behaviour and stings most adult hosts to death. Experiments with the hosts *T. ambiguus* and *T. longispinosus* revealed that *T. pilagens* workers elicit little aggression, even slightly less than host conspecifics and much less than workers of its two slavemaker relatives. This can be explained by camouflage or mimicry of host profiles, as chemical analyses show. The benefit of the dual slavemaker strategy is that if the slavemaker manages to circumvent detection, it can exploit adult host workers as well. Raiding experiments revealed under which circumstances raids escalate. We analysed the importance of slavemaker personality and of host and slave colony personality on the raiding outcome and could demonstrate that fighting and resulting high mortality occurs in raids against highly aggressive hosts.

Molecular evolution of the transcription factor Relish in the genus *Lasius* (Hymenoptera: Formicidae)

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Living in large colonies with genotypically similar individuals exerts substantial pathogen pressure on innate immunity in social insects. Here, we searched for positive selection in the transcription factor Relish in the ant genus *Lasius*. Relish is a component of the *Imd* pathway regulating the synthesis of antimicrobial peptides.

Two-step RT-PCR was performed amplifying the near-complete coding sequence from *L. alienus*, *L. brunneus*, *L. flavus*, *L. fuliginosus*, and *L. niger*. The products were sequenced, and analyses of adaptive evolution were carried out. Findings were compared with the barcoding region of the non-immune gene *COI*.

Compared with *COI*, the ω values of *Relish* were about ten times higher indicating that selection has been acting on *Relish*. A statistically significant likelihood ratio test confirmed that positive selection shaped *Relish*. The evidence of adaptive evolution of *Relish* supports its importance in innate immune systems of social insects.

Influence of queen and worker age composition on colony fitness

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Ant societies show complex division of labor between queens and workers, and also between young and old workers. After the founding phase, colonies usually consist of workers of different age, which assign themselves to different tasks like foraging and nursing. Usually, younger individuals stay in the nest and care for the brood while older workers leave the nest and forage. Yet, there is some plasticity, as e.g. young workers may start foraging earlier when foragers are removed and vice versa. This flexibility has been suggested to be conducive to the fitness of the colony, but little is known about its concrete impact on colony performance. In addition, queens in polygynous colonies may also differ tremendously in age, which may have an impact on individual egg production.

In this study, we investigate to what extent the age composition of queens and workers affects the reproductive success of colonies of the ant *Cardiocondyla obscurior*. We established experimental colonies with combinations of young or old queens and young or old workers and recorded egg number, the growth and reproductive output of the colonies.

Behavioural repertoire and division of labour in a Brazilian stingless bee with two worker sub-castes

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The differentiation of workers into different morphological castes represents an important evolutionary transition and is thought to improve division of labour in social insects. Colonies of the Brazilian stingless bee *Tetragonisca angustula* are defended by a small group of large, specialist guards, representing a physical distinct subcaste. These workers hover and stand in front of the nest. We found that guard-sized workers and actual guards both perform a great variety of tasks than smaller forager-sized workers, particularly during the first half of their life. In the larger guard-sized workers the transition from one task to the next is occurring faster than in the smaller forager-sized workers.

Cooperation under the bark: understanding sociality and symbioses in ambrosia beetles

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Sociality and fungiculture independently evolved multiple times in wood-boring weevils. Interestingly, these lineages vary in ploidy levels (haplodiploidy vs. diploidy) and mating systems (inbreeding vs. outbreeding), which makes them ideal models for testing the importance of these factors for social evolution. Here I present our most recent findings on our focal species, *Xyleborinus saxesenii*, which demonstrate the potential of wood-boring weevils for studies on social evolution and evolution of symbiosis. This species is facultatively eusocial, i.e. given optimal conditions many females decide to delay dispersal from the mother's nest and help to rear their siblings. In a selection experiment on either early dispersal or philopatry, we show that philopatric and cooperative behaviours are jointly selectable in females. Remarkably, this is the first successful selection for cooperative behaviour in an animal and thus unravels important trade-offs and mechanisms underlying the evolution of sociality. In the following, it will be of utmost importance to investigate the underlying genetic mechanisms that facilitate such processes. However, this would be meaningless without investigating the main driver of beetle sociality – fungiculture. Sociality apparently evolved only in weevils nutritionally associated with fungi. Fungal yields are probably higher in socially maintained nests, but to be sure I study also the mechanisms of beetle fungiculture. Several symbiotic fungi and bacteria occur in ambrosia beetle nests and we currently aim (i) to identify the role of the major microbial players, (ii) to understand how those interact with each other and most importantly (iii) to explore how the beneficial crops are maintained and defended against fungal weeds.

Vibratory communication through social insect nests

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An exceptional feature of social insects is that most of them live inside self-build nests. Primarily the nest functions as a fortress to protect against enemies and hostiles environmental conditions, but additionally the nest structure should favor communication with nestmates. Vibratory communication is a very important communication channel for social insects. Vibratory signals are transmitted through various different mediums with very different physical properties. For efficient communication a match between the signal and the medium is essential. Here we show that vibratory signals are well suited for transmission through the corresponding nests, which act as low-pass filters. The study was conducted in the Kakamega Rain Forest, Kenya. Vibratory signals of stingless bees (*Meliponula bocandei* and *Meliponula ferruginea*) and the termite (*Macrotermes* sp.) were recorded using accelerometers. The properties of nests were measured using a laser Doppler vibrometer and accelerometers.

Socially mediated plasticity of circadian rhythms in the ant *Camponotus rufipes*

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In ants, timing between workers and their environment is essential for adaptive collective behavior. To identify their temporal organization, daily activity of forager and nurses of *C. rufipes* was studied in the social context and in isolation. For the former, we analyzed 1656 hours of video recordings of subcolonies consisting of marked workers and brood under a light-dark-cycle and daily pulses of food availability. Under these potential zeitgebers, foragers showed low activity levels due to rhythmic foraging behavior, which was synchronized with the food availability either at day or nighttime. As feeding time is anticipated, food availability can be considered as zeitgeber for foragers. In contrast, nurses were arrhythmic and performed their tasks all around the clock with high activity levels, likely to meet the needs of the brood. When isolated from the colony and observed in locomotor activity monitors, nurses exhibited strong rhythmic activity and nocturnality. This plasticity in switching between rhythmic and arrhythmic behavior was triggered by the contact to brood, as monitoring of social isolated nurses with larvae showed. Against expectations, isolated foragers mainly displayed arrhythmicity. Here, lower survival rates hint on advanced worker ages and its potential impact on synchronization abilities. These results show that endogenous activity patterns can be inhibited in the social context and circadian behavior is flexibly adapted according to task allocation.

Myrmecophilous relationships and host plant preference in the protected and endemic Transylvanian Blue (*Pseudophilotes bavius ssp. hungarica*, Lepidoptera: Lycaenidae)

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The Carpathian Basin, specifically the Transylvanian Basin, is considered to be a hot spot in terms of biodiversity. The Transylvanian Blue is an endemic, protected butterfly subspecies inhabiting forest-steppe patches of the Transylvanian Basin. Its host plant is *Salvia nutans*, a post-glacial relic in the Carpathian Basin. The Transylvanian Blue also developed mutualistic relationship with different ant species. The relationship involves the grooming and protection of the larvae from the part of the ant, while in return the larvae rewards the ants with honeydew. We know, though, very little about the specificity of this relationship, whether it is facultative or obligatory, and how the butterfly chooses the host plant. During our research we have recorded the characteristic of potential host plants, counted the the larvae on them, then we identified the ants found on the plant and we observed their behaviour with the larvae and the aphids. We also carried out aggressiveness essays between the larvae and potential ant hosts that were found on the host plants, as *Lasius paralienus* and *Camponotus aethiops*. We also tested the behaviour of other the ant species as controls, as *Tapinoma* sp., which, usually, does not visit the host plant, and *Myrmica scabrinodis*, that rarely occurs on the study area. We have not noticed aggressive behaviour in the case of the ant species that often visit the host plant contrary to the *Tapinoma* sp., that showed a significantly more aggressive behaviour towards the larva.

Cooperative colony foundation in the ant *Crematogaster scutellaris*

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In several ant species, queens form aggregations that persist throughout the colony foundation phase. Cooperative colony foundation (pleometrosis) is believed to be advantageous especially in highly competitive environments, e.g. in presence of a high density of conspecific nests. In this study we investigated whether pleometrosis occurs in the ant *Crematogaster scutellaris*, a dominant tree-nesting species widely distributed throughout the Mediterranean basin. This species usually adopts an Independent Colony Foundation (ICF), after a cloistral hibernation of single founder queens. Foundresses, hibernating within cynipid and aphid galls, were collected from different forest and park areas in Northern Tuscany (Italy). In the majority of cases (88% of the gall occupied by this species) a gall was occupied by a single queen but in some cases two or more (maximum 5) queens shared the same gall. The behaviour of ants was observed during the following days, assessing the onset of aggressive interactions and the survival probability of the two queens. Results showed little aggressive behaviour during the hibernation and early foundation period, even in presence of the eggs or larvae. Death of one of the queens occurred, however, as soon as the first workers appeared. The possible advantages resulting from a pleometrotic association with respect to independent foundation were investigated measuring the survival probability of queens (independent vs group foundresses), the size of the first brood as well as the relatedness among group founding queens.

Effect of different agricultural management on ants community in organic and non organic vineyards

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In the cultivation of grapevine (*Vitis vinifera*) several management methods are employed, from organic production to intensive conventional farming. In this highly managed ecosystem ants, which may be both pests and pest-control agents at the same time, often represent a large fraction of insect biomass. Ant assemblages often reflect the degree of habitat disturbance, degradation, and may also be used as indicators of biodiversity loss in other taxa. This study investigates how different management options used in vineyards affect ant assemblages. Ten vineyards were selected in the Chianti area near Florence (Northern Tuscany); five of these were managed following conventional protocols (allowing the use of agrochemicals) while five followed organic farming principles. Ants were sampled using pitfall traps during the summer 2014. More than 4000 ants were sampled, representing 19 species. The vineyards under organic management showed greater species density, even though the same species were found in both the types of vineyards. Multivariate analysis confirmed the difference in the structure of these assemblages. The results suggest that pesticide application adversely affected ant diversity and that the effect of insecticide application is greater than that of herbicides. These results agree with the idea that conventionally managed agroecosystems, where intensive use of agrochemicals is made, may undergo an impoverishment of their arthropod fauna.

Aggression in the ant *Cardiocondyla obscurior* mediated by cuticular hydrocarbons

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Aggression is a fundamental behavior in eusocial insects and often serves to discriminate friend from foe. Invasive species have been shown to have lost intraspecific aggression. We use the tramp ant species *Cardiocondyla obscurior* (Formicidae: Myrmicinae) to study aggressive behavior. A previous study showed that ants from Brazil are more aggressive than those from Japan and linked this to colony composition and gene flow within populations. Fatty acid synthase genes and composition of cuticular hydrocarbons also showed distinct differences between those two populations (Schrader et al., 2014). Here, the main goal was to causally link differences in aggressive behavior and nestmate discrimination with the cuticular hydrocarbon composition of the two populations. Furthermore, we present a candidate gene involved in aggression, an orthologue to the *Drosophila tachykinin*, and a first analysis of its localization in worker brains.

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General information

Posters

Poster will be displayed in the Seminar room E1. Each poster has a unique number starting with P given in the abstract booklet. On the poster panels you will find those numbers and you should put your poster next to this number. Please put your poster as soon as possible after your arrival. In case the doors to the Seminar room E1 are locked ask someone in a yellow T-shirt to open it for you.

Poster session

The poster session will start directly after the last talk on the first day. Therefore, we urge the poster presenters to proceed quickly to their posters. To ease the pain of thirst and hunger for all attendees due to the lack of a break drinks and snacks will be provided at the poster session.

WLAN-access

Internet access is available in the seminar rooms free of charge. In Guest House 1 internet access costs 2 EUR per day. If you would like to have access in your room please ask the staff at the reception. Unfortunately, no internet access is available in Guest House 2.

Meals

If you have any special dietary requirements or meal preferences and did not indicate so at the online registration: no worries! Please tell one of the yellow T-shirt wearers and it will be sorted out with the kitchen staff of the Franken-Akademie.

Parking

Limited parking space is available at the Franken-Akademie.

Questions

If you have any questions ask anyone in a yellow Meeting T-shirt or for matters concerning accommodation you can also ask the staff at the Franken-Akademie.

