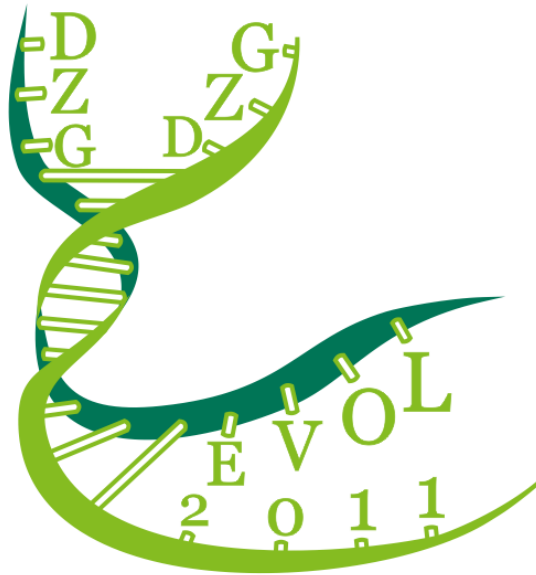


16th Graduate Meeting of
Evolutionary Biology
of the DZG



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Organising Committee
Barbara Caspers, Alexandra Franzke, E. Tobias Krause

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Plenary Talk 1

Genetic consequences of animal behaviour

Jochen B. W. Wolf

Department of Evolutionary Biology, Uppsala University

150 years ago Charles Darwin and Alfred Wallace laid the conceptual foundation for understanding the enormous biodiversity of our planet. In his seminal book “On the origin of species” Darwin challenged the then prevailing view that species are immutable entities. He proposed instead that all organisms are subjected to the forces of natural selection and thereby amenable to change. However, lacking even the most rudimentary understanding of hereditary principles he could not gain further insights into the mechanistic underpinnings of speciation. One century and a half later -following the merger of Mendelian genetic principles with Darwinian evolution - we have entered an era where deciphering the molecular basis of speciation is within reach. Much progress has come from the study of model organism such as *Drosophila* where controlled laboratory experiments paired with ample genomic information allow insights into the genetics of speciation. One central result of these studies is that only few interacting genes need to be involved in speciation. The rationale behind this is that some genes, altered by mutations, slightly differ between recently diverged populations and produce problems in hybrid individuals. Such incompatibility genes guarantee reproductive isolation between young species pairs and several have been successfully identified. However, the problem with such an approach is that it does not tell us much about the initial steps of speciation, as hybrid incompatibilities usually arise only after millions of years of

separation. Therefore, studying the mechanisms at earlier stages of speciation is necessary to gain a comprehensive view of the speciation process and understand under which conditions the speciation process is initiated. Indeed, much research effort has been devoted to such systems including plants (*Capsella*), fish (sticklebacks, cichlids), mammals (mice), insects (butterflies) and birds (Darwin's finches). Until recently, research in these systems was restricted to morphological, ecological and behavioural considerations. Over the last few years sequencing technology has been revolutionized and now endows us with the necessary tools to also address the genetic basis for divergence in these evolutionary model systems in earnest.

I will present two avian study systems where the early processes of speciation can be studied from a manifold perspective. I propose the idea that only a few genes that either directly or indirectly influence individual behaviour may be essential for reducing gene flow and may significantly contribute to the early steps in speciation. In the first system, the European Crow hybrid zone, a complete lack of neutral genetic divergence contrasts a high degree of reproductive isolation documented by discrete morphological differences and strong assortative mating behaviour. Here I will mainly discuss the role for few pigmentation genes and indirect genetic linkage through imprinting behaviour on genetic differentiation. The second part of the talk will revolve around the idea how migration behaviour could influence gene flow in sympatric populations using data from an ongoing study on European swallows. The application of novel sequencing approaches for the first time enables us to sally out and identify the genomic components contributing to the divergence of this textbook example of speciation. Still, it is clear that a blend of approaches is necessary to comprehensively address these questions. These include field

work, ecological monitoring, candidate genes, large scale genomic sequencing and gene expression profiling.

Plenary Talk 2

Cuckoo- host co-evolution

Nick Davies

Behavioural Ecology Group, Dept of Zoology, School of
Biological Sciences, University of Cambridge

Naturalists are familiar with the often exquisite fit between an organism's behaviour and the demands of its physical and social environment. So the sight of a little warbler busily feeding a young cuckoo ten times its own body mass comes as a shock. Why is the warbler apparently being so stupid? I shall use studies of cuckoo- host interactions to illustrate how ideas from Behavioural Ecology have evolved during the past 50 years. In particular, I shall celebrate the fruitful interplay between natural history observation and theory, comparative studies and experiments, and questions concerning mechanism, function and evolution.

Talk Session 1 Friday 15:30 -18:00

Talk 1

Darwinian 's selection drives adaptive evolution of *MPF2-like-A* MADS-box genes controlling calyx inflation in *Withania*

*Muhammad R. Khan¹⁺, Jin-Yong Hu¹, Simone Riss¹,
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The Chinese lantern, which is the inflated calyx syndrome (ICS) of *Physalis*, is formed by *MPF2* in the presence of the plant hormones, cytokinin and gibberellin. *MPF2* knockdown mutants of *Physalis* have small leaves, no ICS, and are male sterile, thus, revealing three *MPF2* related functions. Of the close relatives of *Physalis*, *Tubocapsicum* has only a rudimentary calyx, while others, like the *Withania* species, have ICS. Two classes of *MPF2-like* orthologs, *MPF2-like-A* and *MPF2-like-B*, were isolated from tetraploid *Withania*, whereas only one class was detached from tetraploid *Tubocapsicum*, namely *MPF2-like-B*. *MPF2-like-A* proteins have an aberrant structure in that they have a three amino acid deletion in their C-domain and an eight amino acid extension at the C-

terminal end. Positive Darwinian 's selection was observed in the branch leading to *Physalis* MPF2-like and *Withania* MPF2-like-A proteins, while both MPF2-like proteins of non-ICS forming species, as well as all MPF2-like-B proteins, underwent purifying selection. Unlike *MPF2-like-B*, the over expression of *MPF2-like-A* in *Arabidopsis* revealed extra large sepals suggesting that the functions of the two proteins are different. This conclusion is supported by their differing native expression patterns. In *Withania*, the *MPF2-like-A* gene is expressed in vegetative and flower tissues, and thus correlates with ICS formation, whereas *MPF2-like-B* gene is expressed only in vegetative tissues. This is different in *Tubocapsicum*, where the *MPF2-like-B* gene was found in all the tissues tested. The contribution of allo-tetraploidization to the sub-functionalization of *MPF2-like* genes is discussed, as is the positive Darwinian 's selection in the evolution of the *Physaleae*.

Talk 2

MHC heterozygosity enhances reproductive success

Michaela Thoß

Konrad Lorenz Institute for Ethology, Department of Integrative Biology and Evolution, Veterinary University Vienna

We investigated how heterozygosity at the major histocompatibility complex (MHC) affects fitness in wild-derived (F2) house mice (*Mus musculus musculus*). To compare and control for potential confounding effects from close inbreeding and genome-wide heterozygosity, we used mice that were systematically outbred. We assessed how

heterozygosity at MHC and background loci (using 15 microsatellite markers on 11 different chromosomes) affects individual survival and reproductive success (RS) in large, semi-natural population enclosures. We found that overall heterozygosity significantly increased RS, and this correlation was entirely explained by heterozygosity at two MHC loci. Moreover, we found that the effects of MHC heterozygosity depend on the level of background heterozygosity, and the benefits of maximal MHC heterozygosity show a curvilinear effect with increasing background heterozygosity. The enhanced RS from MHC heterozygosity was not due to increased survival, and although MHC heterozygosity was correlated with body mass, body mass did not correlate with RS when heterozygosity is controlled. Breeders were more MHC heterozygous than non-breeders for both sexes, indicating that MHC heterozygosity enhanced fecundity, mating success, or both. Our results show that (1) MHC heterozygosity enhances fitness among wild, outbred as well as congenic laboratory mice; (2) heterozygosity-fitness correlations can potentially be explained by a few loci, such as MHC; (3) MHC heterozygosity can increase fitness, even without affecting survival, by increasing mating and RS; and (4) MHC effects depend on background genes, and maximal MHC heterozygosity is most beneficial at intermediate or optimal levels of background heterozygosity.

Talk 3

Evolutionary divergence and limits of conserved non-coding sequence detection in plants

Anna Reineke, Erich Bornberg-Bauer, Jenny Gu

Institute for Evolution and Biodiversity, University of Muenster, Germany

Three main problems obstruct the investigation of upstream regions in plants. Firstly, the search for clear orthologous gene pairs between plants is difficult due to many in- and outparalogs arising from frequent duplication events. Secondly, the search for conserved non-coding sequences (CNS) is difficult, because they occur less frequently and are much shorter in upstream regions of plants compared to animals. Thirdly, transposable elements lead to many insertions in the regulatory region.

This study investigates the limitations of comparing upstream region of plants. Our findings identify the divergence time, where significant similarity of upstream regions becomes difficult to distinguish, is approximately 100 mya for plants. Similarity of upstream regions also decreases with distance to transcription start site (TSS), where the signal is lost with a distance over 1.5 kb to TSS. Significantly different, and therefore hard to compare, are the similarities between dicots and monocots. Amounts of transposable elements differ strongly between different plants, but they are decreased in the proximal promoter region compared to further upstream. These results should be considered for future upstream region investigations in plants. Furthermore these fundamental issues must be addressed before

meaningful investigation of stress response regulation in noncoding regions can begin.

Talk 4

Chicken or egg? A modern toolkit to answer question of "which came first?"

Martina Boerner

Department of Animal Behaviour, Bielefeld University

A central problem in studying adaptive strategies is to distinguish the results of true co-evolutionary processes from mere correlations often found in large data sets. Using the large cuckoo family (Cuculidae), I demonstrate a novel approach to test hypotheses of causal relationships between correlated traits. Despite strong demands on their spatial and temporary memory, brood parasitic cuckoos possess smaller relative brain sizes than their non-parasitic counterparts. Combining several evolutionary pathway models, the most likely evolutionary sequence of trait changes correlating with changes in brain size is built. This sequence shows that brain size was not reduced as a consequence of a loss of cognitive skills related to chick provisioning and it offers no support for the hypothesis that an increase in energetic demands or a reduction in energy availability selected for a reduction of brain size. Instead, the sequence suggests that the reduction in energetic demands due to the smaller brain size and parasitic breeding strategy may have enabled parasitic cuckoos to colonize new niches.

Talk 5

Niche differentiation of the parthenogenetic oribatid mite *Oppiella nova* (Acari, Oribatida) investigated by molecular markers

Helge von Saltzwedel

Georg-August University Göttingen, J. F. Blumenbach Institute of Zoology and Anthropology, Dept. Ecology (AG Scheu)

Parthenogenetic species are doomed to extinction due to their limited adaptive potential to environmental changes. Yet, the cosmopolitan oribatid mite species *Oppiella nova* (Acari, Oribatida) reproduces parthenogenetically and occurs in a variety of habitats: in temperate forest soils, on mosses, lichens, dead wood, rocks, the bark of trees and also in grasslands. To explain the evolutionary success of parthenogenetic taxa two hypotheses have been proposed. The “Frozen-Niche Variation” (FNV) theory states that parthenogenetic organisms consist of several genotypes that each occupies a narrow niche. In contrast, the “General Purpose Genotype” (GPG) theory postulates that a single clonal lineage with broad ecological amplitude dominates in a range of habitats. Using phylogenetic methods we investigated whether the genetic structure in *O. nova* populations is conform to the FNV or GPG theory. Different clonal lineages were determined, based on intraspecific variance of the mitochondrial COI gene; additionally, the D3 region (28S rDNA) was used as species marker. *Oppiella nova* was collected at five different locations in Germany. At each locality two habitats were investigated, grassland and forest. The results show that conform to the FNV theory the two habitats were inhabited by different lineages of *O. nova*. High

genetic distance of 14% between forest and grassland haplotypes suggests that the lineages separated 6 – 9 million years ago. Congruent with habitat-specific molecular haplotypes, individuals from forest and grassland sites differed significantly in body size, indicating that in spite of parthenogenetic reproduction *O. nova* lineages adapted to different environments. This suggests that parthenogenetic species evolve in a similar way as sexual species. Propagation of well adapted genotypes via parthenogenesis likely is the reason for the evolutionary success of *O. nova*.

Talk 6

Stock separation in lobsters: An active decision or a question of genetic equipment

Jana Deppermann¹, Ann M. Tarrant³, Gabriele Gerlach^{1,2},
Jelle Atema^{2,3,4}

¹Carl von Ossietzky University, Oldenburg, Germany, ² Marine Biological Laboratory, Woods Hole, MA, USA, ³ Woods Hole Oceanographic Institution, Woods Hole, MA, USA, ⁴ Boston University Marine Program, Boston, MA, USA

The American Lobster (*Homarus americanus*) inhabits the American East Coast up to Labrador, Canada. Lobster larvae spent approx. 3-4 weeks in the pelagic before they become benthic and settle; migration of adults contribute to the distribution of the species. Understanding stock connectivity and dispersal mechanisms is important for sustainable management of this economical valuable species. Using microsatellite markers we unraveled the patterns of stock separation in the Gulf of Maine and south of Cape Cod. Despite larval dispersal and adult migration, we found a

surprisingly complex population structure. The question arises how population structure is achieved and maintained in such a dynamic environment. With focus on the dispersing stages we developed two hypotheses: 1. Stock structure is influenced by sensory and behavioral preferences of settling lobsters for conspecific or 2. Stock structure develops due to environmental selection pressure on the larvae which favors specific locally adapted genotypes. We conducted behavioral experiments to test for the hypothesis on active choice during settlement and used a gene expression approach to verify whether selection might be a driving force to establish and maintain population structure. Our results indicate that in the dispersing stages of lobsters natural selection is important for the distribution of animals.

Talk Session 2 Saturday 9:00 -10:40

Talk 7

Mate-choice copying in female zebra finches (*Taeniopygia guttata castanotis*): Does previous mating experience play a role?

Nina Kniel, Lilia Zimmermann & Klaudia Witte

Department of Biology and Didactics, Research Group Ecology
and Behavioral Biology, University of Siegen

Mate-choice copying is a form of social learning in which an individual gains information about potential mates by observing conspecifics. It occurs when an individual observes a sexual interaction between two heterosexual conspecifics and chooses the individual as a mate as the observed individual did before. Up to now, it is known that female

zebra finches copy the mate choice decision of other females. But whether sexual experience can influence mate-choice copying is still unknown. Therefore we tested two groups of zebra finch females of similar age: One group consisted of sexually experienced females and the other group consisted of females without sexual experience. In a binary choice test zebra finch females could choose between two males of two different phenotypes: one male of the natural phenotype (wild-type), the other male was artificially adorned with a red feather on the forehead. After this preference test females could observe a single wild-type male and a pair of zebra finches, i.e. a wild-type female and her mate adorned with the red feather. Following the observation period females could again choose between other males of both phenotypes in two consecutive preference tests. In the first preference test unexperienced females did not discriminate between males of both phenotypes and spent a similar amount of time in front of those males, whereas experienced females had a tendency to prefer the natural phenotype. Directly after the observation period, both groups of females significantly preferred the adorned over the natural phenotype. This difference vanished in the last preference test, where all females spent a similar amount of time with the respective males. In a control experiment we presented single males of both phenotypes during the observation phase. Here we found that females chose consistently without the opportunity to copy, overall preferring wild-type males. Therefore sexual experience of a female did not influence mate-choice copying.

Talk 8

Never forget where you came from: or new insights in the use of olfaction in zebra finches

Philip Kohlmeier, E. Tobias Krause, Barbara A. Caspers

Department of Animal Behaviour, Bielefeld University

Mammals are well known for their highly developed olfactory abilities, whereas in contrast birds were assumed to be unable to perceive olfactory signals. However, only recently it was shown, that even several bird species use olfactory signals for foraging or orientation. These cases of avian olfaction have been mainly described in non Passeriformes species like seabirds, pigeons and kiwis. In an earlier study we revealed that the zebra finch (*Taeniopygia guttata*), a songbird and one of the most important model organisms in behavioural biology, uses olfactory cues for natal nest recognition. Here, we are trying to get a deeper understanding of the mechanism and usage of olfaction in songbirds, specifically its role for nest and kin recognition.

Therefore we cross fostered zebra finch hatchlings from their natal nest to a foreign conspecific nest. After fledging we tested the fostered chicks in an olfactory preference test, in which these chicks could choose between the odours of their genetic and their foster nest. The results indicate that they significantly preferred their genetic over the foster nest in which they were reared. The results are a first hint that olfactory cues may represent a sufficient cue for kin recognition in songbirds.

Talk 9

Prey identification in the polyphagous digger wasp species *Cerceris sabulosa* (Hymenoptera: Crabronidae)

Verena Kasper

In order to identify an appropriate prey, a predator has to decide which one to choose and which to decline.

While monophagous predators are specialised on one single prey species and may identify that prey by various specific cues, polyphagous species, in contrast, have two possibilities: because of their broad prey spectrum, these predators may be able to identify every one of their prey species by a species specific cue or they recognize all prey species by a common cue. Apart from visual prey recognition, many insects rely on chemical stimuli. In those cases, chemical compounds on the cuticle of a prey species can serve as kairomones for predator species. The digger wasp *Cerceris sabulosa* is considered a polyphagous hunter. The females of our model hunt a variety of different bee species including the genera *Halictus* and *Lasioglossum* (Hymenoptera: Halictidae). Either, each huntress has learned to identify all those species or a common signal must allow the discrimination of these prey species from the non-prey bees of comparable visual appearance. In this study, we investigate the chemical profiles of different bee species using gas chromatography coupled with mass spectrometry (GC-MS). Additionally, we use behavioural assays with cuticular extracts of prey bees in dummy tests to characterise a common kairomone. We can show that polar fractions of extracts of *Lasioglossum* and *Halictus* bees are responsible for prey acceptance. Analyses of cuticular profiles verify a differentiation in the composition of polar compounds between prey and non-prey species.

In case of *C. sabulosa*, quantitative or qualitative differences of the polar compounds may represent a common kairomone. Other polyphagous predator species, too, may chemically recognize and identify their various prey species by a common cue. Thus, these generalistic predators may in reality be “chemical” specialists.

Talk 10

Expensive chicks: sex allocation in a reversed sexually size-dimorphic bird

Nayden Chakarov, Oliver Krüger

Department of Animal Behaviour, Bielefeld University

Sex allocation can be optimized with respect to many variables, e.g. resource availability, age and condition of the parent and the costliness of offspring of each sex. While normally males are larger and more demanding, in birds of prey this is true for females. Therefore this group can present many interesting examples for testing sex allocation theory. I will present data from a long-term study on common buzzard (*Buteo buteo*) reproduction and discuss possible explanations for the emerging patterns.

Talk 11

Does risk-sensitive behaviour depend on the benefits of additional opportunities?

Thilo Liesenjohann, Tatjana Knopp, Antje Herde, Jana Eccard

Adaptive decision-making of active individuals should be based on several factors influencing their performance in survival and reproductive success. These factors include the internal state (e.g., nutritional state or reproductive state) and the perception of risks and chances while active. According to this, the acceptance of risks while active should differ between males and females as the two sexes connect different alternative opportunities to their activity phases. In multivoltin, polygynous species such as *Microtus arvalis*, the common vole, we expect males to accept higher risks e.g., while foraging and travelling, because there is always a chance of meeting fertile females or a need to engage in territory defence actions. Females on the other hand might change their risk-taking behaviour with their reproductive status, for example with the ongoing lactation or oestrous / non-oestrous phases. In outdoor enclosures with permanent automatic radio telemetry surveillance, we analysed activity patterns of male voles while being confronted with females at different reproductive states (from virgin to lactating). At the very beginning of the experimental cycles of three weeks, these females should represent a valuable “opportunity”, and males should take high risks while active as long as there are oestrous females around. Later, males should become more cautious or try to reach other males habitats (e.g., become “facultative dispersers”), until females reach the next post-partum oestrous. Our studies provide insight into sex- and

status-dependent adaptive strategies and provide further explanations for the highly skewed operational sex ratios found in natural populations in small mammals.

Talk Session 3 Saturday 11:00 -12:40

Talk 12

Getting into hot water: seasonally variable marine conditions influence the foraging ontogeny of Galapagos sea lions

Jana. W.E Jeglinski^{1*}, Patrick M. Brock², Patrick Robinson³,
Christiane Werner⁴, Daniel P. Costa³ and Fritz Trillmich¹

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The ontogeny of foraging behaviour of juvenile pinnipeds is shaped by a variety of intrinsic and external constraints. Juveniles operate with a higher metabolic rate but with limited physiological capacities and behavioural skills in comparison to adult animals. The distribution and availability of prey further limits successful juvenile foraging. All these constraints determine the duration of dependency of juvenile animals on maternal milk and through this influence reproduction in species with foraging cycle lactation.

Galapagos sea lion (*Zalophus wollebaeki*) juveniles have one of the slowest growth rates, longest dependency periods and are distributed in a relatively poor habitat with seasonally variable environmental conditions. We hypothesized that these constraints prolong and shape Galapagos juvenile foraging ontogeny: We expected to find different foraging strategies in juvenile and adult animals and a slow and gradual development towards adult behaviour. We deployed time-depth-recorders (TDRs) on four different juvenile age classes and on lactating adult Galapagos sea lion females during two warm and one cold season. We measured Haemoglobin (Hb) and Hematocrit (Hct) of juveniles and determined stable isotope values of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ in tissue of juveniles and adult animals. Juvenile Galapagos sea lions have Hb and Hct values similar to adult females at an age of one year coinciding with the onset of regular diving activity. However, diving variables and stable isotope ratios of juveniles up to an age of two years differ significantly from adult female behaviour. Instead of a gradually increasing performance towards adult levels, we found a period of arrested development in 18 months old juveniles during the warm season. Using mixed effect models we found that age and increased sea surface temperatures were the most important factors influencing juvenile foraging behaviour. We conclude that the pronounced seasonality of the Galapagos ecosystem prolongs the dependency of juveniles on maternal milk and leads to the exceptionally low reproductive rate in this species.

Talk 13

Parental care in lesser black-backed gulls (*Larus fuscus*) is state dependent

Anke Rehling

Ecology & Evolutionary Biology, University of Glasgow

Parents should optimize resource allocation to their offspring with regard to maximal lifetime reproductive success. They are predicted to adjust their effort to variation in their own body condition and in species with biparental care also to variations in their partner's state and effort. In many sea birds, nest attendance time competes with foraging time and incubation is energetically costly. In this field study, female body condition in lesser black-backed gulls was experimentally reduced by inducing the laying of additional eggs resulting in a reduction of female parental care during incubation. Such state dependent changes may be mediated by changes in underlying hormonal states. Here we looked at correlations of care share and prolactin. Conflict theory predicts that parents should only partially compensate for a reduction in their partner's parental care. However, in gulls, a minor reduction in nest attendance is likely to incur high costs due to predation pressure. Consequently, males showed complete compensation for the reduction in female parental care.

Talk 14

Long-distance dispersal as strategy to overcome isolation in a fragmented habitat

Michael Drees¹, Cornelius Becke, Britta Schwerdt, Elisabeth I. Meyer²

WWU Münster, Institute for Evolution and Biodiversity, Dept. of Limnology, Hüfferstr. 1, 48149 Münster

Water bound animals in streams live in a very constrained habitat since movement is mainly possible in upstream or downstream direction. In a karst dominated habitat this fragmentation is even stronger because the longitudinal dispersal is blocked at least temporarily by intermittent sections. For non-flying organisms the use of vectors is a chance to overcome this problem.

We worked with the coexisting amphipod species from the stream system on the Paderborn Highlands. Two of them (*Gammarus fossarum*, *Gammarus pulex*) are native, one (*Echinogammarus berilloni*) has been recently invading this region. *E. berilloni* has a well defined distribution area whereas both native species show a scattered distribution even beyond catchment areas. We used a behavioural experiment with a duck and a muskrat hide to test if these serve as potential biological vectors. The results indicate that the native species have a tendency to use both vertebrates as biological vectors favouring the duck over the muskrat. *E. berilloni* by contrast shows no such behaviour.

In a second step we tried to confirm this result by a microsatellite based analysis using both native species. Samples were taken from both sides of the catchments' border between the river Lippe (Rhine) and river Weser. The

result supports the conclusions of the behavioural experiments as the genetic population structure of both species did not reflect the geographical distribution, the isolation by temporary stretches or the catchment border.

Talk 15

You or your offspring? Immune defense and reproduction under thermal stress

Katja Leicht

EAWAG (Abt. Aquatic Ecology), Überlandstrasse 133, 8600 Dübendorf, Schweiz

Extreme weather conditions (e.g. heat waves) are predicted to become more frequent in future due to climate change. Exposure to high temperature is known to be stressful for many organisms, but detailed information about its influence on ecological interactions is still limited. Here, we examined the effects of high ambient temperature on immune function and reproduction of the great pond snail (*Lymnaea stagnalis*) in order to test whether temperature stress can predispose snails to pathogen infections, and how this is related to other changes in snail life histories. Over a period of 10 days, we exposed snails to a non-stressful temperature (15°C) and to a high temperature (25°C) that occurs in small ponds and in shallow lakes during hot summers. During the experiment, we measured haemocyte concentration, phenoloxidase activity, and antibacterial activity of snail haemolymph in order to estimate snail immune function, and counted the number of produced eggs. We hypothesize that exposure to high temperature reduces snail immune function, and depending on the effect of temperature on reproduction this effect can

be seen as a general stress response or as altered energy allocation between life history traits.

Talk 16

State –dependent use of space and time of reproductive female voles

Tatjana Knopp, Thilo Liesenjohann, Antje Herde, Jana A. Eccard

Department of Animal Ecology, University of Potsdam

Evolution has shaped the behaviour of potential prey species in a manner that individuals reduce predation risk and optimize their individual decision making. For foraging individuals this is based on several factors influencing their performance in survival and reproductive success. These factors include the internal state (e.g., reproductive state) and the perception of predation risks and opportunities while active.

In outdoor enclosure studies we measured space use and locomotive activity of female common voles (*Microtus arvalis*) in different reproductive states with automatic radio telemetry. As a multivoltin and polygynous species, female voles are either lactating or pregnant or both during the whole season. Most of the time females are usually engaged in no riskier behaviour than the search for food to cover the high metabolic costs of lactation, nest guarding and foraging. Thus, females might get more cautious with the duration of lactation and might express adaptive strategies according to the relative value of their offspring. In addition to this there are only a few days when females are in (post partum-)

oestrus and they have to adapt their behaviour to the additional missed opportunity costs (**MOC**) of mating in this sensible phase. This entails a trade-off between mating and parental care and foraging. We expect to see a direct impact on space use and locomotive activity and will present preliminary results.

Talk Session 4 Saturday 15:00 -16:20

Talk 17

Developmental shaping of behavioral phenotypes by the social environment experienced during adolescence in zebra finches

Tim Ruploh

Department of Animal Behaviour, Bielefeld University

Phenotypic plasticity is caused by the interplay of external influences and the genetic background. It is thought to allow the individual to adjust to variable environmental conditions. Conditions early in life can predict those in the future and enable the organism to flexibly adjust its development accordingly.

As shown mainly in mammals, the juvenile phase can be very plastic and especially social influences during this phase can have strong impact on developmental trajectories and modify an individual's behaviour, physiology and morphology.

To understand the function of developmental phenotypic plasticity, we need to know about the consequences of these effects in enabling the organism to cope with different conditions as an adult and whether such adjustments reduce

the flexibility to adjust to future changes of the environment or restrict the ability in adjusting to a different context.

We therefore keep zebra finches (*Taeniopygia guttata*) during the juvenile phase in different types of social groups (small and large unisexual and mixed-sex groups) and study how the social environment experienced during adolescence affects the expression of adult traits. We test whether social experience at this developmental stage affect the way adults cope with different reproductive and social challenges, and whether there are consequences for the performance in a non-social context. We also examine whether these changes are permanent or can be modified by new experiences when adult. To understand the mechanistic basis of the expected phenotypic modifications, we study how these relate to hormonal and neural changes.

In this talk I am going to introduce the general idea of my Ph.D. project and will present first results concerning the effect of different early social experiences on reproductive challenges.

Talk 18

Of cuckoos, hosts and red queens

Mareike Wurdack

Brood parasites invade their host's nest to lay eggs where their brood is reared by the host. The host's brood is killed or impaired by loss of provisioned resources. Parasite and host have conflicting interests to either successfully parasitise a nest or to detect the parasite. This situation sets the board for an evolutionary arms race between the two.

The parasite needs to avoid detection by the host in order to neither be attacked while in the nest nor risk the nest to be

abandoned by the host afterwards. While visual recognition can be avoided by entering in the host's absence and brood can be concealed by mimicry, detection of a past intrusion (e.g. in insects, chemical cues from cuticular hydrocarbons (CHC) adsorbed to nest material) may be harder to avert. Avoidance of olfactory detection could be achieved by mimicking the host's CHC profile or by an alternative intrusion strategy.

In this study, a solitary Vespid host and its specific Chrysidid parasitoids serve as a model to evaluate a possible scenario of the evolution of chemical mimicry. We compare the CHC profiles and predict that a parasitoid whose intrusion is detectable by the host should develop chemical mimicry (i.e. should resemble the hosts CHC) while a parasitoid that can avoid detection by developing a new intrusion strategy breaks away from this coevolutionary arms race and may display any CHC pattern.

Talk 19

Love pretender and costs of mate-choice copying in Atlantic molly males, *Poecilia mexicana*

Sabine Nöbel, Katharina Baumgärtner & Klaudia Witte

Department of Biology and Didactics, Research Group Ecology and Behavioral Biology, University of Siegen

Using public information can be a good strategy to assess the quality of other individuals as prospective mates by observing conspecifics during sexual interactions. However, this strategy

can be maladaptive when an observed individual deceives its “true” mate preference in the presence of an audience. Atlantic molly males *Poecilia mexicana* prefer larger over smaller females as mates. In a recent study Plath et al. (2008) have shown that males changed their initial mate choice decision for larger females when a conspecific audience male was watching and spent more time with smaller females. Thus, males conceal their “true” mate preference in the presence of an audience male. It was speculated that males tried to deceive the audience male about their mating preferences to avoid sperm competition, because surrounding males may use public information and copy the focal male’s mate choice. In a recent study we could show that Atlantic molly males indeed copy the choice of other males. Here we tested whether Atlantic molly males can be deceived by other males and copy their “pretended” mate choice. We found that, first, males preferred larger over smaller conspecific females. Second, these males deceived and “pretended” a preference for smaller females when an audience male was presented. And third, audience males copied the wrong preference for smaller females. These experiments showed that mate-choice copying can be costly when the copier is recognized by others as an audience: So, if you want to copy – do not get caught.

Talk 20

Did he stay or did he go – Spatial movement predicts territory defence in nightingales (*Luscinia megarhynchos*)

Philipp Sprau, Marc Naguib

Department of Animal Ecology, Netherlands Institute of Ecology (NIOO-KNAW), Wageningen, The Netherlands

Animals often use signals in competition over resources. In vocal communication, different signaling strategies can be used to successfully expel intruders dependent on the threat the intruder constitutes. Territorial songbirds, for instance, may assess the potential threat of intruders by their song posts and thus by their movements. However, little is known about defense strategies against spatially moving intruders as most studies simulated rivals singing from a single song post. Here we tested whether territorial males integrate information about moving intruders into decision making. Using playback experiments we simulated male nightingales (*Luscinia megarhynchos*) that either stayed within the territory boundaries or that left the territory of a resident after intrusion. One hour later the same intruders were simulated to sing at the territory boundary and resident's defense behavior was measured. Residents approached the loudspeaker closer, changed their song posts more often and sang more songs in close proximity and more trills when the simulated rival had stayed within the territory than when it had been expelled previously. These findings suggest that resident male nightingales distinguish between rivals they

had successfully expelled or not and perceive staying rivals as more threatening. Taken together, by using more realistic playback approaches our experiments give new insights into the ecology of resource maintenance in songbirds.

Talk Session 5 Saturday 16:40 -18:00

Talk 21

Do seasonally distinct life histories influence behavioural phenotypes in a precocial rodent (*Cavia aperea*)?

Anja Guenther & Fritz Trillmich

Behavioural Biology, Bielefeld University

Behavioural phenotypes are often seen as fixed, heritable traits, but may critically be influenced by early experience. Recent theory suggest that individuals within a species display different behavioural phenotypes when their life histories predictably differ. A model (Wolf et al. 2007, 2008) predicts the evolution of distinct behavioural phenotypes within a population associated with fast and slow life histories: bold and short-lived versus shy and long-lived. We begin to test these predictions using a medium-sized rodent, the wild cavy (*Cavia aperea*). By dynamically changing photoperiod during gestation we tested how behavioural phenotypes of juveniles adjust to seasonality. Cavies allocate available resources to growth and reproduction when born into spring, but delay reproduction until the next year and are thereby forced to maximize survival probability over winter when born in autumn. In response to these predictable life-cycle

differences different behavioural phenotypes should be advantageous for animals born into spring versus autumn: spring-born animals are expected to be competitive and risk-prone to succeed with immediate reproduction, while autumn-born animals should be risk-averse to ensure survival until the next breeding season.

To determine behavioural phenotypes we measure exploratory behaviour in two different open field tests, boldness in a novel object test, resting metabolic rate (RMR) and stress response (cortisol) to an unknown environment. We found persistent different behavioural phenotypes for three generations of caviae, but these were not associated with seasons.

Talk 22

Dynamic sex ratio in the common swift *Apus apus*

Arndt Wellbrock¹, Christina Bauch², Jan Rozman³, Klaudia Witte¹

¹ Department of Biology and Didactics, Research Group Ecology and Behavioral Biology, University of Siegen; ² Institute of Avian Research "Vogelwarte Helgoland", Wilhelmshaven; ³ Institute of Experimental Genetics, Helmholtz Zentrum München - German Research Center for Environmental Health, Munich

The ability to adjust offspring sex ratio according to environmental conditions can be a fitness benefit for species with different costs in producing a female or male offspring. In general, a dynamic sex ratio is not to be expected in a sexually monomorphic species with biparental care like the common swift *Apus apus*. The common swift is a long-living,

long-distance migratory bird extremely adapted to live in the air around the year except for the breeding season. In these three months, swifts depend strongly on the availability of aerial food (mainly flying insects), and this in turn varies due to weather conditions. We investigated the sex ratio in offspring of a swift colony nesting in a highway bridge near Olpe, Germany, in years with different weather conditions previous to the start of egg laying (2008 and 2009). We found a female-biased offspring sex ratio in both years (about one third male and two third female nestlings), but at different times during the hatching period. In 2008, more female than male offspring hatched in the first half of the hatching period whereas the sex ratio did not deviate from parity in the second half. In 2009, it was the other way round. Because there were lower temperatures and less rainfall before the start and during the egg-laying period in 2009 than in 2008, we assume that food availability was lower in 2009. Therefore, we can conclude from these very first results that female swifts may adjust their offspring sex ratio to weather conditions and seemed to invest more in female offspring when food availability is high previous to egg laying.

Talk 23

The relevance of behavioural categories in the laboratory for behaviour in the wild

Antje Herde, Thilo Liesenjohann, Tatjana Knopp, Jana A. Eccard

Department for Animal Ecology, University of Potsdam

Recently there has been an increasing interest in intraspecific variation in animal behaviour. Individual differences that are

correlated and consistent over time and over situations are called animal personality, coping styles, behavioural syndromes or temperament. They cover several components such as boldness, sociability and aggressiveness. Heritability in personality traits and differences in fitness or survival between personality types suggests that personality may reflect ecologically significant variation between individuals. Most of the recent studies were done either in captivity or in the wild. In our study we try to connect these two settings. We live-trapped voles (*Microtus arvalis*) from the wild and measured their personality traits in the laboratory. After quantifying the personality traits we select the extremes (e.g. most active and inactive ones) and create artificial subpopulations in semi-natural enclosures. We recorded individual behaviour in the field as activity, risk-taking and foraging behaviour to investigate the relevance of laboratory results and personality assignment for real life in natural settings.

Talk 24

Neonatal immunity in the Galapagos sea lion (*Zalophus wollebaeki*)

Paddy Brock

An increasing number of tools are available to evolutionary ecologists for the study of immunity in wild populations. We are using a combination of laboratory and field techniques to characterise the development of immunity in the Galapagos sea lion (*Zalophus wollebaeki*). In addition we are investigating the impact of a human settlement (San Cristobal) on the health and immunity of Galapagos sea lions by comparison with a colony relatively isolated from human

influence (Santa Fe). We find that pups from San Cristobal produce more immunoglobulin G than pups from Santa Fe during the first 150 days of life ($t_{1,61} = -2.32$, $p = 0.02$), and that males have lower serum concentrations of immunoglobulin G than females on both islands ($t_{1,62} = -3.25$, $p = 0.001$). Furthermore, we show that the increase in inflammatory response to phytohemagglutinin (PHA) during the first 150 days of life is greater on San Cristobal than on Santa Fe ($t_{1,59} = -2.25$, $p = 0.02$). This talk will briefly describe our attempts to test for a cost of immunity on San Cristobal by taking a multivariate approach to describing growth and condition in our longitudinal dataset.

Poster Session – Saturday 12:40 – 14:00

Poster 1

The Influence of the Photoperiod on the Breeding Behavior of the Zebra Finch (*Taeniopygia gutatta*)

Anjuli Barber, Nikolaus von Engelhardt

Department of Behavioral Biology, Bielefeld University

Optimal adjustment of breeding behavior to environmental conditions is one of the most important challenges in an animals' life. In most vertebrates breeding is restricted to the time of the year with maximal access to specific food resources. Breeding independently from the annual cycle (opportunism) is an adaptation to habitats where the availability of specific resources is unpredictable. The zebra finch (*Taeniopygia gutatta*) is an interesting model organism because it is an opportunistic breeder that breeds rapidly when conditions allow, but there is also evidence that its breeding behavior can be influenced by the photoperiod. This may relate to its wide distribution over the Australian continent, where seasonal changes in the environment and consequently the adaptive significance of adjusting breeding to the season differs strongly depending upon the ecological and geographical region. It is therefore interesting to study how photoperiod and other factors regulate breeding behavior of zebra finches. We studied reproduction in a lab population of zebra finches derived from birds caught in a seasonal habitat (south-east Australia) by breeding birds under long days (18L:6D) or short days (9L:15D). Confirming previous studies, we showed that exposure to short days inhibits breeding: Birds held at short days reduced body mass,

had a decelerated start of breeding, laid fewer eggs and clutches compared to birds held at long days. There was no difference in nest building, egg mass, and hatching time (incubation). We found weak evidence that hatching success was slightly higher, but fledging success slightly lower under short days. Further studies should disentangle in more detail how specific aspects of breeding behavior are regulated by the interplay between photoperiod, food availability, temperature and humidity and whether these may differ between populations of the same species.

Poster 2

Behavioral syndromes of zebra finches reared under long and short days

Ingo Catalano, Nikolaus von Engelhardt

Department of Behavioral Biology, Bielefeld University

Organisms should adjust their behavior to seasonal changes in the environment (e.g. temperature, food availability) to maximize reproduction and survival. Theoretical models suggest that animals with low future fitness expectations benefit from high risk-taking behavior, whereas animal with high future fitness expectations should be more cautious.

In short lived animals that can breed in their year of birth, one can therefore predict that animals born late in the season (i.e. autumn) should be more cautious and risk-averse than animals born early in the season (i.e. spring). Because the photoperiod generally is the most important indicator for the time of the year, the emergence of behavioral syndromes

may depend upon the photoperiod experienced during development.

We therefore investigated the influence of the early photoperiodic experience on the behavior of the Zebra Finch (*Taeniopygia gutatta*). We raised birds under short days (S, 9L:15D, winter) or long days (L, 18L:6D, summer) which were switched for half of the birds after independence (day 35), resulting in four experimental groups (SL, LL, LS and SS). We predicted that birds under short photoperiods (SS or LS) show a more cautious behavioral phenotype than birds under long photoperiodic conditions (LL or SL), which we assessed in four different experiments: the response to a novel object presented in the feeding dish, behavior in a novel environment with caged stimulus birds (2 males, 2 females), tonic immobility behavior (a measure of anxiety) and a catch test, which should show the ability to escape from predators. First analyses show that birds under winter conditions reached the feeding dish faster than the birds living under summer conditions. Tonic immobility was not affected by the photoperiod but higher in birds that experienced a switch in photoperiod (SL and LS). There was no effect on the time to catch birds, and results for behavior in the novel social environment are still pending.

So far our experiments do not find support for a general shift towards a more cautious behavioral phenotype under short or decreasing photoperiods.

Poster 3

Linking the evolution of habitat choice to ecosystem functioning: Direct and indirect effects of pond-breeding fire salamanders on the aquatic-terrestrial coupling

Timm Reinhardt^{1,2}, Sebastian Steifartz² und Markus Weitere¹

¹Helmholtz-Zentrum für Umweltforschung – UFZ, Department Fließgewässerökologie (FLOEK), Magdeburg; ² Department of Animal Behaviour, University of Bielefeld

Shifts in the life history traits and behaviour of species can alter ecosystem functioning. In fish-free habitats, the larva of the Firesalamander (*Salamandra salamandra terrestris*) are considered the only vertebrate top-predators influencing biodiversity and the flux of biomass. Here we estimate the effects of pool-breeding fire salamanders on pool food webs and on the animal-mediated flux of matter between pools and the adjacent terrestrial habitats. Typically Fire Salamanders breed in first order streams and the pool-breeding ecotype is considered a recently evolved local adaptation. Our estimates are based on biomass data of the fauna of different vernal pools as well as data on the stomach content, growth rate and population dynamics of the salamander larvae in these habitats. Due to high mortality rates during larval phase and relatively small metamorphosis size of the pool breeding salamanders (in contrast to stream-breeders of the same species), the biomass export of metamorphosed salamanders in late summer usually falls below the biomass import. This net-import of matter and energy into the aquatic habitat is further accelerated as the salamanders consume both organisms of terrestrial origin

trapped on the water surface (supporting import) and aquatic insect larvae with terrestrial adults (preventing export). All together, the adaptation of fire salamanders to breed in pools leads to strong net increases of animal-mediated import of terrestrial matter into the aquatic habitats and the community structure of macroinvertebrate food organisms. In the light of global decline and ongoing habitat destruction and fragmentation understanding on how single species can influence habitat functioning becomes of special importance, especially for amphibian species.

Poster 4

The Ghost of Nest Predation Past – adaptive behavioural strategies of vole mothers to secure offspring survival

Monique Liesenjohann, Jana Eccard

Nest predation can be seen as a mechanism and extreme case of direct interference or interspecific killing. Semi-fossorial common voles (*Microtus arvalis*) and common shrews (*Sorex araneus*) use the same tunnel systems competing for space by interspecific aggression. Additionally shrews prey on vole's offspring during the sensitive nestling phase. However, the overlap of aggression and predation is unknown. Adaptive behavioural strategies (e.g. nest maintenance behaviour) of mothers in order to secure nestling survival may have the potential to camouflage the "ghost of nest predation past". In an additive set-up we investigated behavioural adaptations of vole mothers having nestlings in the presence of shrews (or another herbivore vole species (*Microtus agrestis*) or a conspecific (control). Experiments were conducted in caged semi-natural 35 sqm outdoor enclosures. Nest sites were

identified with radiotracking and RFID antennas were located at burrow entrances to get information about the activity of all individuals. Nest site characteristics were obtained and the number and condition of offspring.

We found no difference in the loss of vole nestlings among treatments and no differences in their body condition. The presence of both competitor species induced modifications of the vole mother's burrow architecture. But only shrew presence evoked an increase in vole mother's persistence time at burrow entrances. Adjusting their nest maintenance behaviour seems to be a successful adaptive strategy for mothers to secure their future offspring.

Poster 5

Population Structure and Demographic History of Indians from Putatively Neutral Multilocus DNA Fragments

Naazneen Khan, Anita and Aparup Das

The genetic diversity in population are the product of many layers of demographic and evolutionary events acting on timescales including colonization, migration, population expansion, mutation, genetic drift and selection. The influence of westernization in India has increased the prevalence of genetic diseases associated with life style and diets. The origin and high genetic diversity of Indians have been debated extensively.

Modern humans were evolved in Africa around 200kya and migrated to Eurasia 40-80 kya and Americas some 15-30 kya. India acts as a corridor for the dispersal of modern humans out of Africa. The extent to which migrations, caste system have influenced the genetic diversity of India which is a

heartland of Southeast Asia is second that of Africa is still a controversial issue. Indian population is conglomeration of multiple cultures and each region has its own culture, food habits and linguistic behavior.

For this study we have isolated 8 putatively neutral DNA fragments from X chromosome to establish the neutrality standard of nucleotide diversity. As the nucleotide diversity from noncoding regions reflect human history more accurately than coding region. The nucleotide diversity of eight loci in Indian population is then compared with worldwide and various others population genetic parameters will be discussed.

Poster 6

State-dependent differences in attendance patterns - and their expected influence on male reproductive success in polygynous mating systems

Kristine Meise & Fritz Trillmich

Department of Behavioural Biology, University of Bielefeld, Germany.

In previous years reproductive success in polygynous mating systems was supposed to be skewed towards a limited number of highly competitive males. However, genetic analyses have shown that this assumption does not apply to all polygynous mating systems. Across species and taxa less competitive males gain a remarkable number of matings. Therefore, alternative variables such as age, size or number of aggressive interactions have been considered to explain males' reproductive success. In the Galápagos sea lions

(*Zalophus wollebaeki*) the probability to sire offspring increases with the time individuals spend in their colony. In the present study we investigated whether Galápagos sea lion males exhibit different patterns of attendance in connection with their present condition and social status. Analyses of resighting data collected during several reproductive seasons revealed that males differ in the timing of attendance. Young males (< 6 years) were observed more often at the beginning of the season (September) while older males spent more time ashore during the peak of the breeding season (November). However, as the number of males within the colony is high at any time and space is limited, the time spent ashore also depends on the males' ability to deal with the proximity of potential rivals. Preliminary results show that the number of association partners is positively correlated with attendance time. Associations with related individuals or males that share specific characteristics might lessen the aggressive potential among males and thus enable a prolonged attendance. Due to these results males are expected to increase their reproductive success by adapting their attendance patterns to the presence of more competitive males and establishing stable social relationships.

Poster 7

Influence of food quality on host plant fixation and personality of a leaf beetle

Martin Tremmel and Caroline Müller

Bielefeld University, Department of Chemical Ecology,

Experiences and environmental conditions during ontogeny can have a strong influence on an animal's behaviour and overall phenotype. In this study we investigated, whether different food qualities experienced during larval development have an influence on adult food preferences and behavioural strategies in the leaf beetle *Phaedon cochleariae*. For that purpose larvae were reared individually either on high or low quality food. Measurements of performance parameters showed that larvae performed better (developed faster and gained higher body masses) when reared on high quality food compared to larvae reared on low quality food. Hence, as different food qualities lead to different performance they may result in different behavioural phenotypes of the adult beetles. Food choice tests demonstrated that adult beetles preferred high quality food when reared on high quality food as larvae, whereas beetles did not show such a strong fixation when reared on low quality food. Furthermore, tests of different behavioural traits showed that individual animals behaved consistently over context and time, which is defined as *behavioural syndrome* or *personality*. A comparison of *personality traits* provided indication that beetles are bolder when they are expected to have lower future perspectives compared to beetles that have "more to lose". As we are able to show that

personality depends on environmental conditions we assume it to be of adaptive value.

Program Friday 04.03.2011

Friday		04.03.2011	
14:00	Registration starts		
15:15	Welcome		
Talk Session 1 - Chair: Dr. Jochen B.W. Wolf			
15:30	Muhammad Ramzan Khan	Darwinian 's selection drives adaptive evolution of <i>MPF2-like-A</i> MADS-box genes controlling calyx inflation in <i>Withania</i>	
15:50	Michaela Thoß	MHC heterozygosity enhances reproductive success	
16:10	Anna Reineke	Evolutionary divergence and limits of conserved non-coding sequence detection in plant genomes.	
16:30	Martina Boerner	Chicken or egg? A modern toolkit to answer question of "which came first?"	
16:50	17:20	Coffee break	
17:20	Helge von Salzwedel	Niche differentiation of the parthenogenetic oribatid mite <i>Oppiella nova</i> (Acari, Oribatida) investigated by molecular markers	
17:40	Jana Deppermann	Stock separation in lobsters: An active decision or a question of genetic equipment	
Plenary talk - Chair: Jochen B.W. Wolf			
18:00	19:00	Jochen B.W. Wolf	Genetic causes and consequences of animal behaviour
19:00	...	Social evening	

Program Saturday 05.03.2011 Part 1

Saturday		05.03.2011
Talk Session 2 - Chair:		
09:00	9:20	Nina Kniel
09:20	9:40	Phillip Kohlmeier
09:40	10:00	Verena Kasper
10:00	10:20	Nayden Chakarov
10:20	10:40	Thilo Liesenlohmann
10:40	11:00	Coffee break
Talk Session 3 - Chair:		
11:00	11:20	Jana Jeglinski
11:20	11:40	Anke Rehling
11:40	12:00	Michael Drees
12:00	12:20	Katja Leicht
12:20	12:40	Tatjana Knopp
12:40	14:00	Lunch break and poster session

Program Saturday 05.03.2011 Part 2

Plenary talk - Chair: Prof. Dr. Oliver Krüger	
14:00	15:00 Nick Davies
	Cuckoo- host co-evolution
Talk Session 4 - Chair:	
15:00	15:20 Tim Ruploh
15:20	15:40 Mareike Wurdack
15:40	16:00 Sabine Wöbel
16:00	16:20 Philipp Sprau
	Developmental shaping of behavioural phenotypes by the social environment experienced during adolescence in zebra finches Of cuckoos, hosts and red queens Love pretender and costs of mate-choice copying in Atlantic molly males, <i>Poecilia mexicana</i> Did he stay or did he go – Spatial movement predicts territory defence in nightingales
16:20	16:40 Coffee break
Talk Session 5 - Chair:	
16:40	17:00 Anja Gunther
17:00	17:20 Berndt Wellbrock
17:20	17:40 Anje Herde
17:40	18:00 Paddy Brock
	Do seasonally distinct life histories influence behavioural phenotypes in a precocial rodent (<i>Cavia aperea</i>)? Dynamic sex ratio in the common swift <i>Apus apus</i> The relevance of behavioural categories in the laboratory for behaviour in the wild Neonatal immunity in the Galapagos sea lion (<i>Zalophus wollebaeki</i>)
18:00	...
	Social evening in the Pappelkrug

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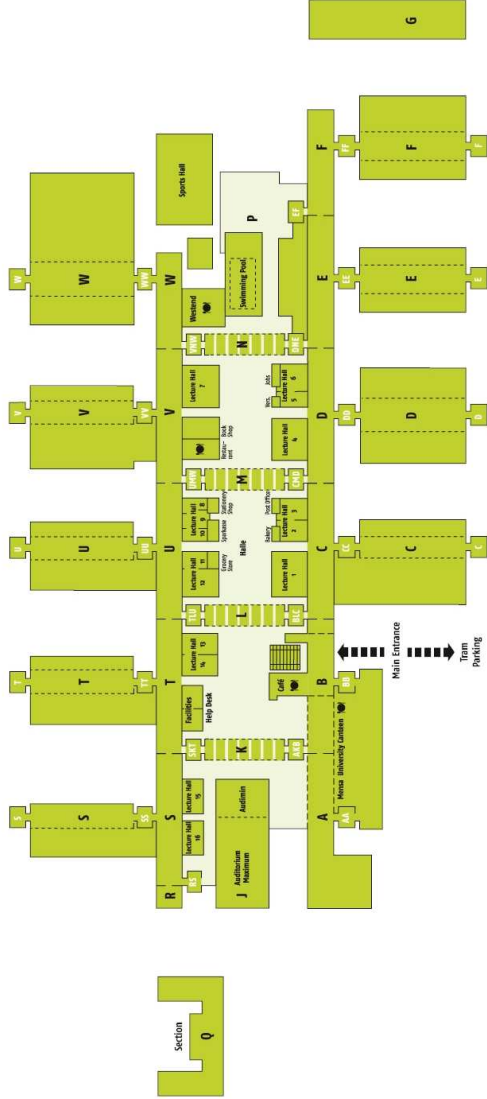
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Main Building



Area Map

