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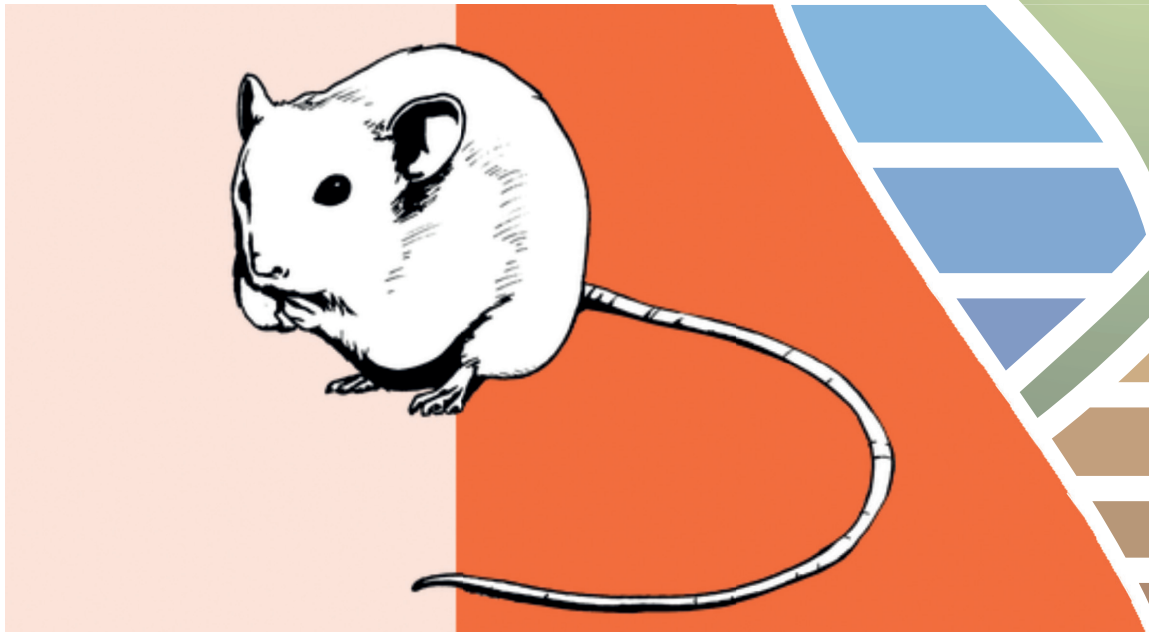
Julius-Kühn-Archiv

Jens Jacob, Jana Eccard (Editors)

6th International Conference of Rodent
Biology and Management
and
16th Rodens et Spatium

Potsdam, Germany, 3-7 September 2018

Book of Abstracts



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Bundesforschungsinstitut für Kulturpflanzen

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Preface

Since the foundation of the two conference series Rodens et Spatium (R&S) in 1987 and International Conference of Rodent Biology and Management (ICRBM) in 1998, there have been mostly biannual meetings mostly in Europe (R&S) and meetings about every four years in Asia, Australia and Africa (ICRBM). After many highly successful meetings in the past we now have the great pleasure to welcome you to the first joint meeting of the conference series that combines the 16th R&S and the 6th ICRBM.

The joint meeting provides the fantastic opportunity to bring together about 300 participants from five continents. In about 300 contributions experts and students of rodent biology and management as well as participants from industry, NGOs and from national and international authorities present and discuss recent findings and issues, develop networks and identify future research priorities.

By combining the two conference series we aim to join forces of the R&S that is traditionally more geared towards basic science and the ICRBM that also has rodent management in its focus. We trust that this is a suitable approach to have management benefit from science and vice versa. Properly managing overabundant rodent populations is highly relevant not only for crop protection that affect food security in developing countries but also for health protection regarding rodent-borne diseases and for the conservation of native flora and fauna that can be negatively affected by invasive rodent species. In addition, rare rodent species also require management to bring populations up to the desired level. The summaries presented in this book of abstracts demonstrate the diversity of regions, rodent species and research questions involved. They also show that interest and quality research is spread across the globe because participants from well over 50 countries attend the conference.

The organisers of the meeting thankfully acknowledge the financial support provided by their home institutions, as well as by the German Phytomedical Society, the International Society of Zoological Sciences, the German Research Platform for Zoonoses funded by the German Federal Ministry of Education and Research, and the German Research Foundation.

All summaries in this book of abstracts are available online via www.julius-kuehn.de/en and can also be accessed through the conference website www.rodents2018.org.

We sincerely thank all colleagues that were involved in organising the joint meeting. We are indebted to organisers of the symposia, the plenary speakers and all other presenters. Thank you for making the conference a productive and enjoyable meeting.

Potsdam, September 2018

Jens Jacob and Jana Eccard

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Plenary Talks

Predator – prey interaction in the boreal vole community – behavioral and survival game in the changing world

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Climate change and habitat fragmentation cause major threat for populations and challenge for individuals and their interactions. Predator-prey interaction is especially in our northern latitudes with strong seasonality modified by climate processes. I review results of a series of experiments in the cyclic bank vole – least weasel system, focusing also changing habitat or climate conditions affecting the interaction. Complicated network of predation cues, risk recognition by prey and behavioral and reproductive effects on prey voles is illustrated and discussed. In climate change scenarios the major expected change is happening in duration and stability of winter and snow cover. Snow provides thermoregulation, shelter for nest sites and hide from most predators. Predicted increase in instability of winter forms a major challenge, both for small mammal prey but also their small specialist predators in northern latitudes. Future studies focus on how the fear along the changing environment is experienced both by the vole prey when confronted by weasels, and by weasels when confronted by larger predators.

Plenary Talks

Rat-free New Zealand 2050 – fantasy or reality?

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Rats introduced into previously mammal-free New Zealand (NZ) seriously impact our vulnerable native flora and fauna. As a result, considerable research effort has focused on developing control techniques for reducing and/or eradicating rats with excellent success in the eradication of both Norway rats and ship rats from many offshore islands (n = 105 mammal-free islands). This control work has created numerous predator-free sanctuaries thus enabling the translocation of many endangered native bird species. Unfortunately, we have run out of defendable, non-human occupied islands and the current focus is on the NZ mainland, with a new government goal of ridding NZ of rats, brush-tail possums and stoats by 2050 (called Predator Free NZ 2050 Ltd). During 2010-15, the Centre for Wildlife Management and Conservation (CWMC; based at Lincoln University) began a research programme investigating alternatives to brodifacoum for environmentally-safer rat control, with a focus on tools that could be used on the NZ mainland. In addition to this work, we also investigated the attractiveness of social lures for ship rats and species-specific delivery options for sustained ground-based rat control. In 2015, a privately-funded research and development entity called Zero Invasive Predators Ltd (ZIP; also at Lincoln University) was established with the goal of developing technologies to remove predators from large areas and then defending those areas from reinvasion. In addition to the results from the above CWMC research programme we will also present the results from recent ZIP research investigating the use of “virtual” and geographical barriers designed to prevent reinvasion of rodents back into predator-free areas. ZIP have also developed modified techniques for applying aerial 1080 cereal bait that has potentially removed all rats from a 2,300-ha NZ mainland field site.

Plenary Talks

5 critical areas for rodent population biology

Charles J. Krebs

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I will review briefly the strong inference approach that has characterized the great progress population ecology has maintained for the last 60 years. Population ecology is the cornerstone of all ecological studies, and without good population studies we cannot make progress in answering the scientific problems that confront us today. I concentrate my talk on 5 areas of rodent population ecology - population dynamics, the problem of rarity, pest management, the economic impacts of rodents, and landscape ecology. I will highlight the progress we have made and the major questions that are not yet resolved, including the impacts of climate change, the regulation of breeding seasons, the problem of infanticide, and the role of chronic stress in rodent demography. The problem of rarity in rodents is rarely discussed, and yet is so critical for the conservation of rare species. We have no clear ideas about why so many species are so rare. I will cover some highlights of progress in pest management, with an overview of fertility control issues and the use of poisons. The economic impacts of rodents in forestry are important in many countries, as are landscape ecology issues that are most difficult to study yet most important in our human-modified landscapes. The importance of long-term monitoring underlies much of what we need to do in our future research. All these areas of rodent population biology will be addressed in more detail in the plenary talks and in many of the presentations at this conference. Much has been achieved and much remains to be done.

Plenary Talks

The ecology of emerging tick-borne diseases in a changing world

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Most emerging infectious diseases of humans are transmitted to us from non-human mammals and birds, that is, they are zoonotic. For any given disease, only a small group of species maintains and transmits the disease agent; these are called “reservoir hosts”. The abundance and distribution of these reservoir hosts affects the probability of disease emergence and epidemics. Recent research reveals that, while reservoir hosts can amplify disease risk, many other species can reduce transmission and disease risk. They can do this, for example, by regulating the abundance of reservoir hosts or by absorbing but not transmitting the disease agents. A prominent example is Lyme disease, for which the white-footed mouse, eastern chipmunk, and

are the main reservoirs of the bacterial agent and prominent hosts for the tick vector. Other hosts, such as foxes and opossums, can reduce abundance of the small mammals or the ticks. Humans inadvertently increase abundance of some small mammals and decrease that of other mammals when they destroy or fragment natural habitat, for instance by suburbanizing the landscape. This presentation will use three tick-borne diseases, all of which are rapidly emerging in the United States and Europe, as case studies to illustrate general principles relating biodiversity to infectious diseases. Meta-analysis of the published literature shows that the loss of biodiversity generally increases the transmission of infectious diseases of humans, animals, and plants worldwide. In addition to the effects of biodiversity, risk of human exposure to tick-borne diseases is predictable from bottom up forces (e.g., acorn masting) and top-down effects of specific mammalian predators on small-mammal reservoir hosts. The community ecology of mammals is clearly relevant to public health policy.

Plenary Talks

Responses to human-induced changes - ecological and genomic drivers of wildlife health

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Anthropogenic environmental change and loss of biodiversity has been shown to increase the infection prevalence in wildlife reservoirs and drive zoonotic diseases. However, despite recent advances in theoretical concepts and mathematical models, empirical data concerning the ecological and genomic drivers of pathogen transmission in wild animal populations, especially from the tropics, remain scarce. We have studied small mammal populations in three tropical landscapes in central Panama differing in their degree of human-induced changes to test whether shifts in species richness affect host population density, species ecology and virus prevalence. We furthermore investigated the effects of host adaptive (TLR, MHC) diversity on infection and resistance pattern to infer the impact of genomic constraints and reduced genetic diversity. Our study has revealed ecological and genomic mechanisms by which human-induced landscape change can have significant effects on pathogen transmission and infection susceptibility.

Form and Function

Changing invaders: the evolution of alien rodents on islands

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Introduced species often adapt their behaviour, morphology, and ecological niche in response to variables that differ from those of their native range. We analysed body size and island data for 241 rodent populations belonging to 16 species on 212 islands worldwide to test whether body size of insular populations of introduced rodents is correlated with the geographical and ecological characteristics of the islands as well as time in isolation. Introduced rodents follow the predicted island rule trend, with body size shifts more pronounced for populations with greater residence times on the islands. Body size of insular populations is positively correlated with latitude, consistent with thermoregulatory predictions based on Bergmann's rule. Body size of insular populations is negatively correlated with number of co-occurring mammalian species, especially other aliens, confirming an ecological hypothesis of the island rule. Carnivory in rats and mice in the form of predation on nesting seabird colonies seems to promote 1.4- to 1.9-fold increases in body size: Henderson Island (Pitcairn Islands) and Gough Island (South Atlantic) are home to rats and mice (respectively) almost twice the size of their mainland conspecifics. The island rule is a pervasive pattern in rodents, exhibited across a broad span of geographical regions, time periods and for introduced as well as native populations. Time in isolation impacts body size evolution profoundly. All insular populations of Polynesian rats (*Rattus exulans*) and Asian house rats (*Rattus tanezumi*), both Holocene introductions, evolve larger body sizes, whereas almost all Anthropocene populations of the brown rat (*Rattus norvegicus*) evolved smaller body sizes. Individual populations, however, varied substantially in their rate of body size evolution, with some populations exhibiting significant body size change in less than 400 years, here proposed as likely coinciding with increased levels of carnivory.

Form and Function

Body size and craniometry of the herb field mouse in the context of a geographical clines

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The herb field mouse (*Apodemus uralensis*) is widely but not continuously distributed across Europe and Asia, with new localities for the species being recently registered in the southern, northern, north-western and eastern parts of the species distribution range. We analyzed geographic variation of body and skull size of *A. uralensis* (over 600 individuals) across the species range, based on published sources and raw data from authors. We found the species to be characterized by high size variability, not following Bergmann's or Murphy's rules and camouflaging latitudinal and longitudinal clines in measurements. Due to wide variations in the body size across the sample, measured characters were size-adjusted using the geometric mean procedure. Distinct size differences were registered on the eastern and southern edges of the distribution range, with these populations having the largest individuals according to average body and skull size. Sex dimorphism in *A. uralensis* is weakly expressed in many populations, while juvenile and subadult individuals also differ in body weight, but not in size. Significant differences in external and cranial measurements were found in *A. uralensis* from different regions of the same country (e.g. Hungary and Slovakia). The smallest, as well as medium and highest average values of the same parameter, such as body length or upper toothrow length, were characteristic to *A. uralensis* populations from Central Europe. We can not attribute these differences to individual measurement errors or biases by different researchers, as high variability of several parameters was also shown in samples processed by a single author.

Form and Function

Evolving teeth within a stable masticatory apparatus in Orkney mice

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Mice from the Orkney archipelago exhibit an important diversity regarding molar shape. While on some islands mice display a usual dental pattern, teeth from other islands display additional cusplets and unusual phenotypes that may constitute case studies for evaluating the potential functional relevance of dental changes. We developed a multifaceted approach combining 2D and 3D geometric morphometrics, dental topography, dental wear, biomechanics, estimations of masticatory muscles force, and in vivo bite force on wild-derived lab descendants exemplifying the two extreme dental morphologies. The two strains differed in the geometry of the upper and lower tooth rows, and in the topography of the upper row only. Surprisingly, the most derived tooth morphology appeared as the least complex because tooth simplification overwhelmed the signal provided by the occurrence of additional cusplets. No difference in bite force nor muscle force was evidenced, showing that the dental innovation was accommodated without changes in the rest of the masticatory apparatus. A 'non-disruptive pathway' may have facilitated the evolution of new phenotypes, together with the isolation of small populations on remote islands of the archipelago.

Form and Function

A morphometric mapping analysis of mice molar morphology

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The mouse dentition has been extensively used as a model for the developmental genetic basis of dental morphology. Phenotypic change and malformation have been reported in a variety of mutant mouse strains. In the case of mutant mice showing drastic morphological change in cusp patterns, however, the conventional quantitative approaches, such as landmark-based methods, cannot be applicable due to the lack of biologically and/or geometrically homologous structures between specimens. Therefore, the phenotype–genotype relationship remains to be tested. Here, we applied a landmark-free approach, morphometric mapping (MM) to quantify mice lower first molars. The sample used in this study comprised two strains of wild type house mouse: ICR and BL6, and mice with either loss or gain of function of different developmental genes. Their lower molars were μ CT-scanned and three-dimensional surface models were reconstructed. These models were quantified by MM, using three morphometric parameters: the mean curvature on the crown surface, the height from the cervical plane, and the radius from the centroid of the cervical line. Principal Components Analysis (PCA) was performed in order to identify and visualize major patterns of shape variation in the morphospace. The MM could detect not only the morphological difference between mouse mutants, but also between two wild type strains. The MM method allowed us to quantify and visualize the complicated mice dental morphology precisely. Applying this method to various types of mice mutants that represent altered cusp patterning promises well for an elucidation of the genotype–phenotype relationship.

Form and Function

Functional morphology of the cochlea of the laminate-toothed rats (family: *Muridae*, subfamily: *Otomyinae*)

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Many species of desert rodents and certain subterranean rodents are known to have hypertrophied auditory bullae. A common functional explanation for this trait is that it is an adaptation to sound amplification that improves low-frequency hearing which is hypothesized to help in both prey capture and predator avoidance; thermoregulation and interspecific communication in burrows and open mostly desert environments. However, besides the hypertrophied bulla, the middle and inner ear are also important in improving low-frequency hearing. Although a plethora of hearing studies in rodents have been conducted, most of these have focused mainly on *Gerbilinae*, *Dipodomysinae*, *Meriones*, and subterranean rodents. However, no studies have looked at the hearing capabilities of *Otomyinae* subfamily in detail only vocalization has been studied on two species (*brantsii* and *littledalei*), although a vague description of *Otomys* (unknown species) malleus and incus and *Parotomys* middle ears basic data have been made. In this study, cochlea morpho-anatomical variation of seven *Otomyinae* species (*Otomys angoniensis*, *Otomys auratus*, *Otomys barbouri*, *Otomys helleri*, *Otomys sloggetti*, *Otomys unisulcatus* and *Parotomys brantsii*) from widely different environments was investigated, focusing on five cochlea features [external cochlear length (ECL), number of turns (TUR), relative length (RECL = ECL/TUR), the curvature gradient (CUR), and the oval window area (OWA)] that play a role in hearing capabilities. Micro-computed tomography and Avizo were used for skull scanning and cochlea segmentation respectively. When correcting for phylogeny and body size OWA and RECL were significantly greater in *P. brantsii*. There was no correlation between cochlea features, bulla and alpine environments.

Form and Function

Torpor in dwarf hamsters, *Phodopus campbelli* and *Phodopus roborovskii*: a comparative study

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Torpor is characterized by a reduction of core body temperature (CBT) and metabolic rate, and in comparison with hibernation lasts less than one day. Comparative analysis of this phenomenon in closely related species may provide useful information to clarify its regulatory mechanisms and evolution. Species of the *Phodopus* genus provide an excellent opportunity for comparative analysis. Two of three *Phodopus* species we used in this study - desert hamsters (*Phodopus roborovskii*) (DH) and Campbell's hamsters (*Phodopus campbelli*) (CH) originated from different parts of the range. Adult males provided with temperature transponders implanted intraperitoneally to record CBT from September to May were kept in an outdoor enclosure under natural light and temperature. Substantial within- an intraspecific difference in torpor expression were observed. Some hamsters never demonstrated torpor as others had multiple regular torpor bouts. In CH the torpor incidents were timed to the beginning of the photophase, as DH demonstrated multiple bouts of torpor during the whole day. The lowest CBT in CH was 11.5 °C as in DH it did not drop below 23 °C. At that, in DH CBT at the majority (about 90%) of torpor incidents was in the range of 30-32 °C. The results indicate that there are remarkable differences in response to low ambient temperatures between CH and DH. DH demonstrated a shallow torpor with CBT that is much higher not only than that in CH, but also in other daily heterotherms. We may assume that such differences in response to winter conditions reflect species-specific physiological adaptations to the different environment. Supported in part by RFBR-GFEN: #17-54-53206.

Form and Function

Seasonal features of humoral immune response to T-cell dependent antigen in palaeartic hamsters (*Rodentia, Cricetinae*)

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It is well documented that immune function varies substantially on a seasonal basis. The autumn–winter season is the most critical period for animals. Non-tropical animals have evolved specific adaptations to cope with winter energy shortages. Animals can overcome periods of unfavorable environmental conditions by physiological hypothermia (daily torpor/ hibernation), characterized by strongly reduced metabolic rate and body temperature. Studies from mammals indicate that hibernation affects both the innate and adaptive immune systems. During winter representatives of subfamily *Cricetinae* demonstrate different types of hypothermia: (a) long-term hibernation (e.g. *Cricetus cricetus*); (b) nonstandard short hibernation with irregular bouts of normothermia (*Allocricetulus* sp.); and (c) daily torpor (*Phodopus* sp.). It is the first attempt to compare humoral immunity of the animals with different overwintering strategies. We analyzed seasonal changes in humoral adaptive immune response to a T-cell dependent antigen (KLH) in hamsters with different types of hypothermia. The animals were housed individually under natural light and temperature conditions (outdoor enclosures). The group of ten males of each hamster species was immunized in each season with KLH. Blood samples were taken on day 10. To assess humoral immunity, serum anti-KLH IgG concentrations were assayed using an ELISA according to the method of Drazen et al. with our modifications. The humoral immunity declined during the autumn-winter season and rose in spring (termination of hibernation and onset of reproduction) in hibernating hamster species. Whereas species with daily torpor demonstrated the highest level of specific antibody in autumn, but it decreased in winter and spring. Thus we suggest that humoral immunity is compromised during hibernation in *C. cricetus* and *Allocricetulus curtatus*, but not in breeding season (as trade-off hypothesis predicted), while torpid species (*Phodopus sungorus*, *Phodopus roborovskii*) enhanced their immune function (in autumn) in order to counteract the immunosuppressive effects of stressors that occur in winter (low ambient temperatures and reduced food availability). Supported by a RFBR grant № 17-04-01061.

Form and Function

Penial and bacular morphology of mammals - what it can reveal about their owner?

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The reproductive organs exhibit an extraordinary morphological variability, both external (shape of phallus, lappets, papillas, surface ornamentation, spinosity, etc.) and also internal (os penis, os clitoridis). In general, a positive allometry and a high degree of phenotypic variability have been described for the characters associated with the reproduction apparatus, which is probably caused by the sexual selection. This topic was intensively studied during 1960s - 1970s, then the interest declined rapidly, but recently its popularity is rising again. New studies have revealed that morphological traits can fit well into phylogeny and they are also distinguishable in closely related species. The penis of some mammalian groups contains a penis bone (os penis) called baculum, that also displays an astonishing morphological diversity. And it's assumed that the baculum was lost and gained several times during the evolution of mammals. There is also increasing evidence of interdependence of the penial and bacular morphology with life history parameters (i.e. mating system, ovulation type, seasonality of reproduction, degree of sociality). For example, it was found that the increasing level of sociality is associated with a decreasing complexity of penile morphology or that the complexity of genital structure is generally higher in multi-male/multi-female groups as compared to monogamous species. Seasonality of reproduction, unpredictable mating opportunities, high degree of sperm competition, risk of multiple-mating or ovulation induction could be the driving force for the diverse and complex morphology of reproductive organs. Our research is focused on the description of genital morphology, the detection of correlations the penial-bacular morphology with life-history parameters and application of morphological traits to the phylogeny with the particular emphasis on several groups of rodents. And this contribution presents our first results.

Form and Function

Body weight regulation in small rodents a matter between predation risk and starvation?

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Genetic and environmental factors have been linked on several models that, in the recent years, have discussed the evolutionary background of body weight regulation. Small wild mammals are known to have a strong body weight regulation system. The risk of predation is among the factors suggested to explain the non-prevalence of overweight animals within natural populations, as the ability to escape predators, can be highly compromised if the animals are carrying large fat reserves. Such risk needs to be balanced with the risk of starvation due to the absence of fat stores, when food resources are scarce. We experimentally investigated the predications of the predation-starvation model using wood mice (*Apodemus sylvaticus*) and C57BL/6 mice by manipulating the risks of starvation and predation. We analysed the physiological and behavioural responses by simulating stochastic starvation events and manipulating the predation risk through broadcasting of owl calls. Results showed reductions in body weight, and body weight gain, induced by the increased risk of predation. Such variations were mostly explained by reduction of food intake, and increase in energy expenditure through alteration of physical activity and behaviour. Resting metabolic rate and thermogenic capacity were not affected. Starvation periods were compensated by overfeeding and reduction in activity during the recovery period, however fat storages did not increase over the limits of the pre-starvation period. These observations showed the influence of environmental components setting the body weight regulation limits and support the hypothesis of the predation risk being a factor modulating small rodents body weight.

Form and Function

Molecular evolutionary inferences of recent biological innovations in mice and rats

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The releases and analyses of the genome sequences of the house mouse and of the Norway rat provided new insights into the biological differences between *Mus* and *Rattus*. However, technically these differences could not be mapped specifically onto either the mouse or the rat lineage. We added map-based assemblies of the genomes of the Roof rat (*Rattus rattus* "S") and of the Algerian mouse (*Mus spretus*) and conducted comparative molecular evolutionary analyses of the protein coding portions of the two species of mouse and rat followed by bioinformatics inferences of the biology encoded by the emerged sets of genes. We were able to specifically map protein encoding differences and inferred biological differences onto the *Mus* and *Rattus* lineages. Thus, we were able to compare and contrast some of the most recent evolutionary innovations in the rat and mouse lineages.

Rodent Behaviour – Session 1

Individual movement: personality-dependent spatial ecology of free-ranging bank voles

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Personality-dependent space use and movement is an emerging topic in current ecological research, but mainly concerned with large-scale movements. Individual variation in movement and space use on local scales, within the confinements of a habitat, and its ecological consequences are so far studied only sparsely. The main aim of the present study was to test whether inter-individual differences in boldness and exploration influence space use, movement patterns and microhabitat choice in free-ranging bank voles (*Myodes glareolus*, n=21). Individuals were captured and marked from three different subpopulations in North-East-Germany and inter-individual differences in boldness and exploration were quantified directly in the field with repeated standardized tests. Subsequently, space use and movement patterns were monitored via automated VHF telemetry for a period of four days, yielding on average 384 locations per individual. We found evidence for personality-dependent space use and movement in free-ranging bank voles. Bolder bank voles occupied larger home ranges and core areas, estimated via kernel density analysis, moved longer distances and spatially overlapped less with conspecifics. Furthermore we found that bold and shy individuals occupied different microhabitats (based on vegetation cover), leading to a non-random distribution of behavioural types within the habitat. Exploration only had an effect on movement distance, individuals that were quantified as thorough explorers in the personality test did not cover as much distance in their natural habitat compared to those determined by the test as superficial explorers. Taken together our results indicate the segregation of behavioural types into individual ecological niches in bank voles. Thus, results strongly hint towards inter-individual differences having relevant ecological consequences which might be greatly important for ecological interactions within-and between species and the shaping of local biodiversity.

Rodent Behaviour – Session 1

The effect of animal personality on virus transmission in *Mastomys natalensis*

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Consistent differences in behaviour between individuals (i.e. animal personality) can affect fitness in a wide variety of species, including susceptibility to parasitism and pathogen infection. Indeed, individuals with a certain personality type could have a disproportional effect on the transmission dynamics. Studying the effects of animal personality on pathogen transmission is useful for epidemiological models and, in case of zoonotic diseases, for human health as well. Thus, good knowledge about the behavioural ecology of personality is required. Here, we used multimammate mice (*Mastomys natalensis*), a common pest species in sub-Saharan Africa and host for several zoonotic pathogens, such as *Lassa virus*, as a model system. Data were collected in Morogoro, Tanzania, between May and October 2017 in three 0.5 ha enclosures. During this period, we repeatedly recorded the behaviour of 207 individuals using the hole board test. We found that *Mastomys natalensis* expressed two personality traits: exploration of the holes in the arena ($R=0.22$, 95% CI: 0.15–0.27) and a jumping-grooming continuum ($R=0.41$, 95% CI: 0.36–0.44). These two personality traits were independent of each other and did not form a behavioural syndrome. However, both traits were significantly correlated with population density, where individuals became more explorative when density increased and spend less time grooming. There was no significant effect of individual differences in plasticity, suggesting that each individual reacts similar to these changes. Interestingly, home range size was not affected by these personality traits, but home range overlap was: individuals that consistently groomed more often had a larger overlap than those that did not. This may suggest these individuals may have a higher probability to come into contact with other individuals and infected excretions and hence become infected themselves. All together, these results may be important to understand changes in the transmission of infections when population size fluctuates.

Rodent Behaviour – Session 1

Movements and spatial overlapping of rodents in natural environment

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Abundance, distribution, movement patterns and habitat selection of reservoir species influence the dispersal of pathogens. The objective of this study is to determine the daily movements of small rodents inhabiting two natural protected areas of central-east Argentina. Movement estimators and qualitative characteristics of rodent paths were determined by means of a spool and line device (102 tracks) and radiotelemetry methods (10 tracks). Tracking was conducted from November 2011 to December 2012 in Otamendi Natural Reserve and from June to October 2017 in Pre Delta National Park. All captured species were tracked in Otamendi, while only *Oligoryzomys flavescens*, reservoir of the etiologic agent of Hantavirus Pulmonary Syndrome in the region, was tracked in Pre-Delta. Movement patterns varied according to species, sex, reproductive season, and body size. *Akodon azarae*, reservoir of a hantavirus genotype not associated to human disease, had an intermediate linearity index, moved randomly and shared paths with all the other species. *Oligoryzomys flavescens* made an intensive vertical use of the habitat, had the most linear paths and did not share paths with other species possibly due to its scansorial habits. The mean linear distance traveled by this species was 107 m and the mean area was 5,477 m². Individuals of this species overlapped 32% (range: 0-99.5%) of their home range with conspecifics. All species, with the exception of *Oligoryzomys flavescens*, overlapped their paths at an interspecific, intraspecific, intrasexual, and intersexual level. The tunnel-like paths below the vegetation cover had signs of frequent use by one or more species of rodents. The sharing of space among rodent species probably results in an increase in the frequency of encounters among individuals and it could favour the direct and indirect transmission of diseases.

Rodent Behaviour – Session 1

Personality drives interactions with wildlife detection devices, based on perceptions of risk and reward

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Effective wildlife surveys rely on the assumption that all individuals are equally detectable. However recent studies into trapping success have determined that trap misses and avoidances are surprisingly common. One reason for this bias is the presence of personality within wildlife populations. As individuals vary in their behavioural responses to environmental cues, they are expected to make similar trade-off decision in their willingness to interact with and enter novel devices. We investigated this phenomenon for wild populations of black rats (*Rattus rattus*) interacting with different, experimentally manipulated wildlife management devices. We hypothesised that bolder type individuals would interact sooner and with greater frequency compared to shyer individuals, who may actively avoid detection. Populations of black rats were trapped across 32 spatially independent peri-urban bushland sites in Sydney, Australia. We uniquely marked 129 individuals for later identification on cameras and ran rapid behavioural assays to test for personality traits relating to boldness and docility. We then measured the behavioural responses of our rats to novel devices with varied perceived risk and reward. Tracking tunnels left open-ended (low risk) or with one end sealed off (high risk) represented device-associated risks while a high reward attractant (100% peanut oil), low (100% vegetable oil) or medium attractant (50:50 peanut:vegetable oil) provided a gradient of rewards. We present how rats with different personality traits responded to devices with differing risk and reward. Understanding how a personality-driven bias affects detection rates will help strengthen the accuracy and reliability of wildlife surveys and effectiveness of control programs.

Rodent Behaviour – Session 1

Individual variation in cognitive styles affects foraging and anti-predatory strategies in a small mammal

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Balancing foraging gain and predation risk is one of the most fundamental trade-offs in the life of animals. Among-individual variation in cognition might affect how individuals balance these conflicting necessities, but the processes underlying individual differences are still unclear. Here we empirically assessed direct consequences of cognitive styles for fitness-determining behaviours, such as foraging and risk-taking behaviour, using a semi-natural setting. We exposed fast/inflexible (N = 21) and slow/flexible (N = 18) learners of bank voles (*Myodes glareolus*) to enclosed landscapes with different risk levels at two food patches. We quantified foraging behaviour, individual giving-up densities for food (a measure for perceived predation risk), and vigilance behaviour, which in a species with high predation pressure directly relate to fitness. Fast learners consumed up to 20% more food than slow learners in the high-risk area, increasingly exploited both food patches, and spent up to 75% of their visit foraging. Slow learners progressively avoided the high-risk area and spent approximately 50% of their visit exercising vigilance even in the low-risk area. Our results indicate that among-individual differences in cognitive styles are indeed reflected in different foraging and anti-predator strategies, providing insights into fitness consequences and differential selection pressures based on individual differences in cognition.

Rodent Behaviour – Session 1

Problem predators: can odour habituation reduce impacts of “rogue” rats on birds nests?

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Introduced rats are amongst the world’s worst invasive predators and cause the ongoing decline of endangered birds throughout the world. Not all individuals within a predator population are likely to consume rare prey species however, and some individuals are more likely to cause a disproportionate impact on prey populations than others. Decoupling the learnt association between a bird odour and a valuable food reward through olfactory pre-exposure has been demonstrated to reduce rat predation on birds’ nests by up to 62% (Price and Banks 2012 PNAS), however whether this technique targets those highly motivated, and most damaging individuals within a predator population remains unclear. Using individually marked wild black rats in bushland in northern Sydney, Australia, we explored behaviours, such as search image development, that allow some individuals to first find, and then target birds’ eggs (domestic quail) using avian olfactory cues (domestic quail feathers and faeces). We then tested whether a simple technique to induce habituation using unrewarded exposure to bird odours offers protection to rare prey. Our results provide a better understanding of the behavioural and learning mechanisms that underpin the predatory effectiveness of invasive rats, as well as insight into ways that olfactory learning in rodents can be exploited to protect vulnerable prey species or to meet other management aims.

Rodent Behaviour – Session 1

Domestic cats and dogs create a landscape of fear for pest rodents around rural homesteads

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Using domestic predators such as cats to control rodent pest problems around farms and homesteads is common across the world. However, practical scientific evidence on the impact of such biological control in agricultural settings is often lacking. We tested whether the presence of domestic cats and/or domestic dogs in rural homesteads would affect the foraging behaviour of pest rodents. We estimated giving up densities (GUDs) from established feeding patches and estimated relative rodent activity using tracking tiles at 40 homesteads across four agricultural communities. We found that the presence of cats and dogs at the same homestead significantly reduced activity and increased GUDs (i.e. increased perception of foraging cost) of pest rodent species. However, if only cats or dogs alone were present at the homestead there was no observed difference in rodent foraging activity in comparison to homesteads with no cats or dogs. Our results suggest that pest rodent activity can be discouraged through the presence of domestic predators. When different types of predator are present together they likely create a heightened landscape of fear for foraging rodents.

Rodent Behaviour – Session 1

Behavior of *Rattus rattus* (Linnaeus, 1758) around self-resetting traps

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Invasive ship rats (*Rattus rattus*) are the major threat to the native species and ecosystem of Goat Island (9.3 ha), New Zealand. In December 2015 a grid of 8 kill traps (DOC200s) was installed across the island to manage rat numbers. In June 2016 we extended the trapping grid with 10 self-resetting traps (GoodNature A24s), monitored with motion-activated cameras and trigger counters. All devices were checked approximately monthly until November 2017. Data on rat abundance from the kill trapping devices before, during and after the self-resetting trap study showed no significant difference among years, and were consistently low. In contrast, the videos reveal high rat activity on the island, which reduced over time, with the highest number of interactions happening in the first months after installing the self-resetting traps. The number of animals killed by the self-resetting traps varied among months and peaked in mid-summer. The rats showed interest in the self-resetting traps and interacted with them, resulting in deaths, but along with the kill traps (i.e. two devices per hectare) the number of rats killed was insufficient to offset intrinsic population growth and reinvasion from the adjacent coast, and hence achieve eradication on the island. Size selectivity is potentially an issue for both traps as young rats were not observed being killed. Self-resetting devices at one per hectare did reduce rat numbers in an area where kill trap maintenance was time and cost intensive, but maintaining very low rat numbers or achieving eradication requires additional refinement of the system (e.g. a combination of different tools or a higher density of devices).

Rodent Behaviour – Session 1

Influence of predator and plant chemical cues in the exploratory behaviour of the house mouse

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Foraging behaviour and avoidance of predators cover basic needs for self-maintenance and survival. These basic behaviours are triggered by internal and external sources of information like blood glucose levels and olfactory cues. Plant olfactory cues are valuable for rodents as the house mouse because they can inform about the ripening state of fruits and risks associated to unripe or rooted fruits. Our research found that ethanol as olfactory cue elicited avoidance and decreased locomotor activity in mice, these results highlighted the relevance of ethanol as a probable cue for fruit ripening, in the wild, this chemical cue could convey primordial information about the ripening state of fruits. Olfaction has also a main role in predator avoidance by mice, avoidance of physical encounters with the predator species, increases highly chances of survival. In another study, we found that mice avoided significantly olfactory cues from domestic ferrets (*Mustela furo*), which probable ancestor is the European polecat (*Mustela putorius*), natural predators of rodents. Future research should consider the interactions of predator and plant olfactory cues as they are part of the same olfactory dimension, and motivations for feeding and avoidance of predators are tightly linked.

Rodent Behaviour – Session 1

Communicating fear: the role of alarm pheromones in a bank vole

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Predation involves more than just predators consuming prey. Indirect effects, such as fear responses caused by predator presence, can have consequences for prey life history. Laboratory experiments have shown that some rodents can recognize fear in conspecifics via alarm pheromones. Individuals exposed to alarm pheromones can exhibit behavioural alterations that are similar to those displayed by predator-exposed individuals. Furthermore, mice alarm pheromone may be biochemically related to predator-produced scent cues and both contain similar sulfur-containing volatiles. Yet the ecological and evolutionary significance of alarm pheromones in wild mammals remains unclear. We investigated how alarm pheromones affect the behaviour and fitness of wild bank voles (*Myodes glareolus*) in several experiments conducted either in the lab or under semi-natural conditions in large outdoor enclosures. Specifically, we have compared the effects of exposure of voles to a second-hand fear cue, which in this case was transmitted via bedding material used by predator-exposed voles. Control animals were exposed to bedding used by voles with no predator experience. We have also compared alarm pheromone effects to real predator odor. Besides that we have studied the gross generational effects of predation risk emitted either via real predator odor or alarm pheromone. The first results show for instance a double increase in litter size in the group exposed to the alarm pheromone compared to control odor. Furthermore, female voles seems to be attracted to bedding that had been used by predator-exposed male voles. In a subsequent experiment female reproduction was also enhanced in the alarm pheromone treatment. In contrast males were repelled by conspecific male alarm pheromone. Our results suggest that predation risk can exert population-level effects through indirect alarm cue by prey individuals having experienced and escaped a predator attack.

Rodent Behaviour – Session 2

Cooperation among female house mice (*Mus musculus domesticus*) – a case study on social selection

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Social selection is a specific case of natural selection in that an individual's fitness is not only determined by its own phenotype but also by the phenotype of its social partner. Social selection thus refers to any selection resulting from social interactions. Communal nursing in the house mouse is an example of cooperation where females pool litters in the same nest and indiscriminately nurse own and other offspring despite potential exploitation. The direct fitness benefits associated with communal nursing shown in laboratory studies suggest it to be a selected component of female house mice reproductive behaviour, involving choice of a social partner. Here using data from a long-term study of free-living, wild house mice we investigated individual nursing decisions and determined what factors influenced a female's decision to nurse communally. Females chose to nurse solitarily more often than expected by chance, but the likelihood of nursing solitarily decreased when females had more partners available. While finding no influence of pairwise relatedness on partner choice, we observed that females shared their social environment with genetically similar individuals, suggesting a female's home area consisted of related females, possibly facilitating the evolution of cooperation. Within such a home area females were more likely to cooperate when the general relatedness of her available options was relatively high. Females formed communal nests with females that were familiar through previous associations and had young pups of usually less than 5 days old. Social partner choice proved to be an integrated part of cooperation among females, and might allow females to reduce the conflict over number of offspring in a communal nest and milk investment towards own and other offspring. We suggest that social partner choice may be a general mechanism to stabilize costly cooperation.

Rodent Behaviour – Session 2

Rats provide help based on their need of their partner

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When social partners exchange helpful acts reciprocally, increasing the benefit of the receiver can enhance its propensity to return a favour. Therefore, reciprocally cooperating animals should consider the relative benefit for the receiver when deciding to help a social partner. Norway rats (*Rattus norvegicus*) exchange food reciprocally during an experimental task. Here, we show that they thereby take both the cost of helping and the benefit for the receiver into account. Furthermore, they are able to determine the need of social partners solely by olfactory cues, providing stooges that smell hungry with more food than those that smell satiated. Using chemical analysis by GC-MS, we identified volatile organic compounds that differ in their abundance between hungry and satiated rats. Combined, this “smell of hunger” apparently serves as an honest signal of need in reciprocal cooperation, and thus facilitate the decision of an individual whom to help.

Rodent Behaviour – Session 2

Sex and reproductive state discrimination – are they innate or learned? Dwarf hamster species as a model

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It is obvious that sex and reproductive state discrimination (defined as a preference of an opposite sex conspecific and a receptive female, respectively) are the key events in reproduction and serve an appropriate choice of the sexual partner. The experimental data indicate that animals from different taxonomic groups discriminate sex and breeding condition of a potential partner via chemical signals and prefer odors from an opposite sex conspecifics and receptive females. However, it is still unclear whether such behavioral responses are innate. This study was conducted to clarify this question. Three species of the *Phodopus* genus – the Djungarian hamsters (*Phodopus sungorus*) (SH), the Campbell's hamsters (*Phodopus campbelli*) (CH) and the desert hamsters (*Phodopus roborovskii*) (DH) were used as a suitable model group. The taxonomic distance between the three species differs. SH and CH are closely related and produce the hybrids, as DH differs significantly from them and never breed successfully with any of them. All three species demonstrate sex and reproductive state discrimination via conspecific urine. SH and CH may discriminate sex but not the reproductive state of closely related species. Males of both species demonstrated discrimination of females reproductive state after sexual experience with the heterospecific female. Neither of these species discriminates sex and the reproductive state of DH. Crossfostering hamsters of all three species demonstrate the preference of the odors of opposite sex donors of the foster species and could discriminate breeding condition of a female. The data indicate that in dwarf hamsters the ability to discriminate sex and female reproductive state - dependent on a taxonomic distance between species - and that these behavioral patterns are not innate but learnt during an early postnatal ontogenesis.

Rodent Behaviour – Session 2

Habitat characteristics and species interference influence space use and nest-site occupancy: implications for social variation in two rodent sister species

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Nest-site selection is an important component of species socio-ecology, being a crucial factor in establishment of group living. Consequently, nest-site characteristics together with space-use proxies may reveal species social characteristics, a fact particularly interesting when direct observation of social interactions is hindered in nature. We used this approach to assess social variation between two sister species of a southern African rodent (*Rhabdomys bechuanae* and *Rhabdomys dilectus dilectus*) comparing patterns in allopatry and sympatry. Our results indicate that habitat preference and its impact on space-use and nest-site characteristics could act as an important driver of social divergence in our study models, and that interference between sister species could induce new ecological pressures that may influence their social evolution.

Rodent Behaviour – Session 2

Burrow system architecture and use by Thomas' pine vole, *Microtus thomasi* (Rodentia: Arvicolinae)

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Microtus thomasi is a fossorial vole, endemic to SW Balkans, which uses a variety of substrates from sea level to high altitudes. Even though the remarkable chromosomal variability of this species is well-studied, very little is known regarding the vole's underground behaviour. This was the goal of this study, starting with the scholastic uncovering of eight burrow systems in different localities of NW Peloponnese, Greece. In particular, several measurement and notes were taken, regarding those burrow systems (e.g. total tunnel length, average tunnel width and depth, number of nests, food caches, soil mounds etc.) and their complexity was calculated in terms of Fractal Dimension, based on the box-counting method (e.g. the Fractal Dimensions of the least and the most complex systems were estimated to 1.1795 and 1.4787, respectively). Moreover, several key coordinates from these systems were recorded with a differential GPS device, allowing their detailed mapping, using the QGIS software. Soil samples from each studied site were used for particle size analysis and estimations of CaCO₃, TC, TOC, TN, H and TP content. Also, the vegetation type of each site was described. Our results showed in overall that extension and complexity of the vole's burrow systems are rather more correlated with food availability and neighbouring burrow system density in the regions where they occurred than with altitude or soil composition i.e. in areas with many other already established systems and/or restricted food availability smaller total lengths and more food caches were comparatively observed than in systems of scarcely populated areas and/or with ample food resources. In comparison to older studies, interesting differences were also recorded, regarding the social behaviour of voles that lived together in a single burrow system. Finally, an effort was made to statistically distinguish those parameters that influence the measured burrow system features of *Microtus thomasi*.

Rodent Behaviour – Session 2

Formation of reproductive isolation in hamsters (*Cricetinae*) in allopatry

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According to the Dobzhansky-Muller model, in the absence of gene flow, conspecific populations can become reproductively isolated, and postzygotic isolation must increase in proportion to the square of the time elapsed since their divergence. On the example of pairs of allopatric species of subfamily *Cricetinae*, characterized by a different level of divergence, by behavioral and physiological methods we estimated the degree of formation of reproductive barriers. The potential prezygotic isolation was based on the results of behavioral tests with the exhibition of female olfactory stimuli to males. A crossbreeding was performed to detect postzygotic isolation. Divergence dates were estimated from molecular phylogenies. We found that complete reproductive isolation was formed in a pair of allopatric hamster species g. *Phodopus* - Roborovski and djungarian in about 5 million years. Sterility of F₁ males, conspecific preferences with minor differences in morphology of chromosomes was formed in djungarian hamsters and Campbell hamsters for 0.8 – 1 myr. In a pair of species, g. *Allocricetulus*, separated about 0.3-0.4 myr ago, postzygotic isolation mechanisms and conspecific preferences are already partly formed together with differences in the structure and number of chromosomes, although in laboratory we could obtain fertile hybrids. In species (chromosomal forms) of *Cricetulus barabensis* sensu lato diverged later than a pair of *Allocricetulus* species (0.16 – 0.2 myr ago), reproductive barriers are less expressed. Thus, the example of close related species of subfamily *Cricetinae* shows that 1) reproductive barriers developing in allopatry more pronounced in species that last longer in isolation; 2) prezygotic barriers in allopatry can develop as fast as postzygotic ones, which makes the mechanism of "reinforcement" suggested by F.G. Dobzhansky (in case of secondary contact zones occurrence) to be not so actual. This study was supported by the Russian Science Foundation № 16-14-10269.

Rodent Behaviour – Session 2

Oxytocin regulates aggressive behavior in nucleus accumbens in great long-tailed hamsters

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Human and animal aggressive behavior has been an important research topic in psychology and sociology. Mounting evidence suggests that oxytocin (OXT) and OXT receptor (OXTR) maybe crucial mediators of aggressive behavior. OXT modulates the social behavior within several brain regions including the amygdala, septum, nucleus accumbens (NAcc) hypothalamic paraventricular nucleus (PVN) and supraoptic nucleus (SON). Our study showed that OXT and OXTR are present in high level in NAcc of the great long-tailed hamsters, which maybe contribute to their aggressive behaviors. We proposed that OXT expression and the activation of the OXT receptor (OTR) in NAcc are associated with levels of aggression behaviors of the hamster. To test this hypothesis, we increased OXT level of great long-tailed hamsters in NAcc by infusing exogenous OXT chronically and examined whether hamsters would show a decreased level of aggressive behavior. We found that the hamster group with exogenous OXT infused into the NAcc showed elevated social explorative behaviors. Moreover, both the duration of active attack behavior and the active attacks frequency of the OXT infused hamster group decreased significantly. Immunohistochemistry results showed that the numbers of c-fos-positive cells were significantly decreased in neurons of the NAcc region in the hamster group infused with OXT compared with the hamster group infused with the vehicle only (Cerebro-Spinal Fluid, CSF). In summary, we proved that the elevated OXT level within a certain range in the NAcc region of the great long-tailed hamster could decrease their aggressive behaviors significantly.

Rodent Management – Session 1

Reducing rodent damage to rice in Cambodia through ecologically-based rodent management approaches tailored to local conditions

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Throughout Cambodia, rodents are an important pre-harvest pest of rice. The degree of rodent damage varies depending on the season and location, but in Takeo province, average rodent damage estimates of 16-22% per season were recently recorded across several villages. In such areas, rice farmers indiscriminately apply acute rodenticides and electric fencing despite their awareness of the hazardous risks to people and other animals. To help smallholder farmers minimize yield losses from rodent pests, adaptive research experiments were established in two villages in Takeo province. In each village, three replicate 5-hectare sites were selected for treatment and three for control. In each treatment site, groups of farmers implemented ecologically-based rodent management (EBRM) methods over two rice cropping seasons. The management methods were adapted based on the local conditions and preferred practices of farmers. These included maintaining weed-free field margins, synchronous planting, community rat hunts, no electric fencing and either a Linear Trap Barrier System (LTBS) with limited and targeted bromadiolone application (Kandaul village) or a Community Trap Barrier System (CTBS) with no rodenticides along with a LTBS near refuge habitats (Ro Vieng village). Over 100 rats were trapped at each treatment site per season and rodent damage levels were reduced from 20-35% on average per site and season in the non-treatment sites to less than 6% in the treatment sites. Rice yields were 20-32% higher in the treatment sites than in the non-treatment sites, giving at least a 50% increase in farmers' net income. These findings provide strong evidence of the benefits of EBRM for rice farmers in areas where rodent damage is high. These results are now being disseminated to farmers across Cambodia through a cross-learning platform and an integrated package of recommendations that can be specifically tailored to particular conditions is currently being developed.

Rodent Management – Session 1

Identification and potential uses of spatial patterns for predicting pest species outbreaks

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Rodent crop pests pose significant risks to food security not least because of complications regarding control actions, largely due to difficulties in predicting when an outbreak will occur. While it is possible, in some instances, to anticipate outbreaks given specific environmental conditions, warning signs may not appear sufficiently early to allow farmers to implement timely pre-emptive control actions given the constraints of agricultural practices. Spatial lags in the spread of outbreaks may allow the detection of the beginnings of an outbreak in a location, and provide an early warning before the rodent abundance pattern reaches a subsequent location. Research carried out on spatial patterns, such as travelling waves, is limited due to the need for extensive and exhaustive monitoring over a large area, and as a consequence the use of spatial patterns in applied ecology is limited. An extensive monitoring programme from 2011 to 2017 of *Microtus arvalis* (common vole) in northern Spain (100,000 km²) provides an ideal dataset, comprising 85,855 indices of abundance, for exploring both how a spatial pattern may inform control, but also advise on where monitoring efforts may be most effective. With this in mind, the aim of the research was (i) to determine the speed of the spatial pattern in common voles and how this varies with direction; (ii) to determine which environmental features are associated with the location of epicentres. Here we characterise the spatial pattern of common voles in a recently colonised part of their range, determine what landscape features lead to areas becoming sources of patterns, and suggest how this may provide valuable implications for the control of the pest species. In doing so we hope to be able to provide farmers with a predictive ability to prepare for an upcoming outbreak with the potential of reducing pest impacts.

Rodent Management – Session 1

Basic urban services as modifiers of rodent abundance in Brazilian urban slums

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There are more than one million *leptospirosis* cases reported annually worldwide, the majority of which are from tropical urban slums. In urban slums, inadequate infrastructure and lack of basic sanitation promote populations of synanthropic rats (*Rattus norvegicus* Berkenhout 1769), a major reservoir of *Leptospira* – the aetiological agent of *leptospirosis*. Slums are not homogeneous, and within slums there are socioeconomic and environmental gradients which influence access to basic urban services (BUS), which potentially affect rodent abundance and, ultimately, human infection risk. The aim of this study was to assess the effect of BUS, specifically rodent chemical control and urban refuse collection, on the abundance/activity of *Rattus norvegicus* populations in four urban slums in Salvador, Brazil, accounting for environmental and socioeconomic variation. Our main hypothesis is that rats will be less abundant/active in parts of the slums with rodent control and regular refuse collection. We have collected data to estimate rodent abundance and activity, by trapping-removal and track plates methods, in spatially randomized points within the four different slums. In addition to rodent sampling, we surveyed environmental variables and interviewed residents to evaluate their access to BUS within each area. Through mixed effects generalized linear models, we will assess whether rodent abundance/activity is lower where there is rodent control and urban refuse collection, after controlling for environmental and socioeconomic confounders. Further, this study will inform spatial models to identify rodent hotspots and relate those spots to human infection risk, both likely to be mediated by the access to BUS. Quantifying the effects of current offered BUS on the abundance/activity of urban *Rattus norvegicus* is key to evaluate current strategies for *leptospirosis* prevention, which will be the first step to the proposal of new, locally feasible and economic effective interventions.

Rodent Management – Session 1

Bait attraction may not be the same as bait consumption

Mattias Engman

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Foraging rodents cause extensive damage in agricultural and silviculture, therefore posing a threat to food security and forest restoration. Adaption to rodenticides and public ban of many pesticides in forestry requires new methods of control to be developed. One possible solution is to use synthetic odors mimicking food to manipulate rodents' behaviors as many of them rely to a big extent on their olfactory system to forage. The use of different foods to trap rodents is common knowledge, but little is known about which parts of the food and their volatile signals. Therefore we studied forest rodents attraction to two parts of acorns (*Quercus robur*) – the shell and the nut - and analyzed their volatile emissions. We assessed the odor attraction by baiting snap traps with visually masked shells and nuts. To identify the volatile emissions from the shell and nut, we sampled the acorn parts using solid-phase microextraction and dynamic headspace and then analyzed the samples with gas chromatography coupled to mass spectrometry (GC-MS). We trapped mainly yellow-necked mice (*Apodemus flavicollis*), wood mice (*Apodemus sylvaticus*) and bank voles (*Myodes glareolus*). Acorn shell and nut were equally attractive to them indicating that some volatile compounds were shared between the acorn parts. Analysis with GC-MS revealed that 16 volatile compounds were emitted both by the shell and the nut. The result from our study indicate that rodents may not only be attracted by odors from the edible parts of their food, but also by in-edible parts such as the acorn shell. This have implications when evaluating baits as bait consumption and bait attraction may not be correlated. Future work will test forest rodents' attraction to the 16 identified compounds in order to develop an odor analog of acorns which will be used to camouflage seeded trees.

Rodent Management – Session 1

Deter to protect: use of predator's odor smell to deter granivorous rodents from consuming acorns

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Seed consumption by granivorous rodents such as *Myodes glareolus* and *Apodemus sylvaticus* are one major drawback for the implementation of low-cost direct seeding in forest restoration programs around Europe. As a main prey for several mammal predators, rodents have evolved a complex olfactory system triggering anti-predation behaviors. Although fear-induced behavior in rodents has been studied intensively in recent years, its applicability has not yet been implemented successfully in the field of forest protection. Therefore, we aim to identify how rodents could be deterred by volatile odorant molecules from their predators and how these predator smell could be used as repellents to deter them from acorn consumption when direct seeding is applied. Our focus is on the identification of relevant odor volatiles from feces, urine, and fur of different mammal predators such as mink (*Neovision vision*), stoat (*Mustela erminea*), least weasel (*Mustela nivalis*), ferret (*Mustela putorius furo*) and the red fox (*Vulpes vulpes*). After identifying relevant odor volatiles, behavioral experiments with bank voles (*Myodes glareolus*) were implemented using synthetic generated predator volatiles in a y-maze set up. Finally, field experiments will be carried out optimizing our most relevant volatiles into the base matrix formulation SPLAT (Specialized Pheromone & Lure Application Technology) to investigate rodent deterrence by selected odor compounds during field conditions and possible side effects on seed germination. Our preliminary results show high rodent repellency of mink excrement, and no significant negative effects on acorn germination. Here we present our preliminary volatile compounds from fur and feces of the selected predators and their effects on rodent behavior. The present project could increase our understanding of prey-predator interaction dynamics and how its appliance could enhance seed-based forest restoration.

Rodent Management – Session 1

Rodents on pig farms: infestation levels related to environmental factors and management practices

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Domestic pig meat consumption is globally rising, increasing its production in development countries. Rodents produce economic and sanitary problems on pig farms. Characteristics of pig housing and management may affect rodent infestation. To analyze the relationship between wild small mammal infestation with pig farms' environmental characteristics and farmers' management practices, seasonal live-trapping in five habitats within 18 pig farms (seven under intensive and eleven under extensive management systems) were performed in central Argentina simultaneously with an environmental and management practices survey. The last was done interviewing the farmers with a semi-structured questionnaire. A total of 472 wild small mammal individuals were captured (with 2,360 cage live trap-nights and 2,463 Sherman trap-nights): the three introduced murids, *Rattus norvegicus*, *Rattus rattus* and *Mus musculus*, three native sigmodontines, *Akodon azarae*, *Oligoryzomys flavescens* and *Oxymycterus rufus* and also two native marsupials, *Didelphis albiventris* and *Lutreolina crassicaudata*. The information of the environmental characteristics and management practices registered were synthesized in eleven variables. Based on a Redundancy Analysis, 56% of the variance of small mammal abundances in the farms was associated with the type of management system, the frequency of rodent control activities, the type of disposal of domestic waste and the existence and location of waste deposits. Generalized Linear Mixer Models showed that *Rattus norvegicus*, *Mus musculus* and *Akodon azarae* abundances depended on season and habitat. Moreover, *Rattus norvegicus* was more abundant in farms where rodent control activities were absent or were not frequent, while *Mus musculus* where rodent control activities were frequent. For *Akodon azarae*, a relationship between the density of pigs and the habitat distribution was found. *Rattus rattus* abundances increased with the increase of dog abundances in farms. Management actions influenced infestation levels of rodents but little attention is lent to pest rodent control or prevention.

Rodent Management – Session 1

The occupancy of barn owl in artificial nest boxes to control rice field rats in Yogyakarta Indonesia

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To overcome rat problem in Indonesia, we implement an integrated pest management. One of the components implemented was a biological control using barn owls by constructing barn owl nest box in rice crop. The goal of the study was to evaluate occupancy of barn owl in an artificial nest box, rat population and rat damage. The research was conducted in three locations by allocating 10 nest boxes randomly in Yogyakarta in 2016. A separate location was selected as a control without barn owl nest boxes with 5 km distance. The assessment of their occupancy was monitored by the presence of the barn owl in their nest box (egg, chick and adult), used nest and their feces. An active burrow method was performed to monitor the rat population along 100 m of irrigation channel bank with three replicates. Rat damage intensity was estimated by sampling 150 tillers randomly (Aplin et al., 2003) then counting the total tiller number and cut tillers. The result indicated that 20% of nest boxes were occupied by the barn owl, 40% of them were ever occupied, and the rest 40% were never occupied. About 44% of active burrows was found with an average of one rat per 2 m length of the irrigation channel bank. The rat damage area was accounted for 44% with 6.5% for their intensity and was no significantly different to the control site. Constructing of barn owl nest boxes in rice fields did not affect the population of the rice field rat or their damage.

Rodent Management – Session 1

Biological control of urban rats in the World Heritage town of Luang Prabang, northern Laos

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Here we present results of a campaign of biological rodent control in the World Heritage town of Luang Prabang in Northern Laos that was implemented in 30 sub-districts ('villages') or 3,706 households, which constituted a large part protected under UNESCO (about 197 ha). Rat bait containing lethal quantities of the parasitic protist *Sarcocystis singaporensis* was applied by residents during the dry season (February to June) in the so-called 'wetlands' and 'heritage zone', both of which are part of peninsular Luang Prabang (at the confluence of the Mekong and Khan rivers). Levels of rodent infestation before and after treatment were monitored by the percentage of footprint-positive tracking patches, live-trapping, and interviews with residents. The only rodent species observed in the town were the Asian house rat (*Rattus rattus*; *Rattus tanezumi*) and the Pacific rat (*Rattus exulans*). The campaign significantly reduced rodent activity in the protected area: By 44.5% - 91.3% in the heritage zone (average reduction: 69.8%), and 27.3% - 95.5% in the wetlands (average: 67.1%) according to the post-campaign data in June/July (wet season). Rodents activity increased or remained at pre-campaign level in three untreated villages. Interviews with residents revealed similar results: They observed significantly fewer rodents on their properties after the campaign. We detected significant correlation between villagers' observations and rodent activity, lending credibility to the former. Almost all villages, except two, observed dead rats after application of rat bait. Interestingly, we trapped higher proportions of Pacific rats and juvenile House rats after the campaign, suggesting that a considerable part of the adult House rat population had been removed. Based on the spatial distribution of the Pacific rat in the town, we speculate about the possible origin of this species in Northern Laos. Results are discussed in view of the development of a sustainable, urban rodent management concept for Luang Prabang.

Rodent Management – Session 1

The impact of rodent management on rice yield in lowland irrigated areas in Indonesia

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Rodent damage in rice crops leads to reduced yields and poor food security for farmers throughout Indonesia. The goal of this study, conducted between 2014 and 2016, was to assess the impact of rodent management methods on rice yields in 4 different regions. The study sites, all in lowland irrigated areas, were in Aceh Province, Cirebon and Indramayu Regency in northern west Java, and Purbalingga Regency in southwestern central Java. Different rat management methods ranging from full protection using plastic fences and bubu traps, fumigation, sanitation and synchronization of planting date were implemented depending on the severity of rat damage in the previous cropping season. In all regions farmers enclosed their crops using plastic fences equipped with bubu traps along the fence within a crop season. The number of rat captured during the crop cycle (planting to harvest) varied among locations: 1,331 rats from 44 traps for Aceh; 7,000 rats from 80 traps for Cirebon; 4,916 rats from 70 traps for Indramayu and 130 rats from 70 traps for Purbalingga. The rice yields before and after implementing the rodent management were different, with all regions showing increased yields: from 1.03 to 5.89 ton/ha in Aceh; 3.32 to 7.56 ton/ha in Cirebon; 4.76 to 8.93 ton/ha in Indramayu and 7.32 to 10.86 ton/ha in Purbalingga. In summary rat management, particularly surrounding the crop with the plastic fence plus bubu traps increased rice yield by 1.5-5 times compared to the previous season where these methods were not implemented. Farmers have indicated they will continue to use plastic fence and bubu traps.

Rodent Management – Session 1

Reducing impacts of rodents on the post-harvest value chain in rice-based cropping system in Myanmar

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Pre-harvest losses of rodents in Myanmar range from 8-25%, however, post-harvest loss (during harvesting and in storage) has not been well documented. Quantity and quality losses of rice grain and seed were monitored for two years in the lower Ayeyarwady delta. We measured (i) the amount of grain stored in burrows under non-threshed rice piles 4 weeks after harvest, (ii) losses of grain and effects on grain quality in grain stores, and (iii) seed quantity and quality losses from different storage bags (IRRI hermetic bags, local hermetic bags and polyethylene bags) were compared. The rice grain is stored for family consumption and for sale to markets. The rice seed is stored for the next crop. In year three of our study, a community village-level rodent management system was conducted in three villages. Actions included trapping, sanitation around storage houses, and promotion of rodent-proofing of grain stores. There were four species of rodents causing losses. The most common species in the field was *Bandicota bengalensis* and in grain stores was *Rattus rattus*. The mean amount of grain collected from rat burrows under a pile was 8.67 ± 5.69 kg and the total grain loss was equivalent to 3% of total rice yield. Stored grain loss was $10.63 \pm 1.16\%$ in 2013 and $1.22 \pm 0.42\%$ in 2014. The mean seed loss was $4.49 \pm 2.07\%$ and germination loss was 43.07%. Rodent damage to seeds was highest in bags that were not hermetic. Community level management of rodents reduced losses from 1 to 4%; farmers benefited by about USD 81/family. Storage structures need to be improved, and better sanitation is required in and around storage houses. Hermetic storage of seed is recommended to reduce losses and for maintaining seed quality. Regular trapping should be conducted as a community activity at the village level.

Rodent Management – Session 1

Adoption pathways of ecologically-based rodent management in Myanmar

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Rodents are one of the top three pests in both lowland and upland agro-ecosystem in Myanmar. A total of 25 rodent outbreak events were recorded from 2007 to 2017. Ecologically-based rodent management (EBRM) in lowland rice system has been introduced in Myanmar since 2005, yet it has not been adopted at a large scale. Developing and implementing EBRM in different agriculture systems is a complex issue that is affected by multiple factors. Household surveys and focus group discussions (FGD) were conducted in areas where chronic rodent problems occurred annually and where recent rodent outbreaks have occurred to identify the key challenges of farmers for EBRM adoption. In recent years, rodents have caused mean annual losses of 8.50 +1.31% in monsoon rice (n=76), 6.65 +1.3043 % (n=61) in summer rice, 13.32 +2.19% in green gram (n=14), 20.35 +4.11% in black gram (n=24) and 18 +7.80 % (n=17) in perennial crops including rubber, oil palm and betel nut. Mean losses caused during rodent outbreaks in upland rice was 76.67 +8.82%. Ninety percent of farmers only implemented control when rodents damaged plants and there were many rodent burrows visible. No proactive management actions were reported from either the household or FGDs. A subset of farmers used rodenticides (36%), and/or trapping (25%), whereas the rest did no control (killing of animals is not acceptable in their religion). In rodent outbreak areas, farmers control rodents by using rodenticides and kill-trapping. Neither approach discriminates between pest and non-pest rodent species. Farmers said control methods used are not efficient but are feasible and applicable. Our survey findings suggested that developing and implementing EBRM should be done through a farmer community participatory approach. Including policy makers early in development of EBRM is crucial for its promotion as a national policy.

Rodent Management – Session 1

Ecologically-based rodent management 20 years on - progress, challenges and where next

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Ecologically-based rodent management (EBRM) was first formulated in 1997, and has been a key approach to tackle important rodent impacts globally. Food security is a major concern in developing countries, where a 5% reduction of rodent losses on cereal staples could prevent 280 million people from being undernourished. In developed countries and oceanic islands, rodents are an important conservation issue. Alas, the conservation issue is not on the radar screen for most developing countries. Another major rodent issue in both developing and developed countries is that rodents are an important avenue for zoonoses in urban and rural environments. This paper will focus on progress and challenges in agricultural systems. Ecologically-based rodent management (EBRM) was developed based on adaptive research conducted to manage eruptions of mouse populations in Australian wheat fields, and chronic and acute annual losses by rats in Southeast Asian rice fields and in mixed cropping systems in eastern Africa where maize is the dominant crop. We will review progress of EBRM over the past 20 years with brief case studies from Africa, Asia, Australia and Europe and provide examples how EBRM helps to minimize rodent abundance, losses and the use of rodenticides. Although there has been strong progress, there is still much to be done. Further intensification of agriculture coupled with an increase in occurrence of extreme climatic events are likely to lead to more rodent outbreaks globally. Also minimum tillage agriculture and the re-designing of agricultural lands to include more corridors and increased heterogeneity at a landscape scale may lead to resurgence in chronic rodent problems both pre- and post-harvest. We also need to pay more attention to the extent and economic impacts of rodent borne diseases on smallholder communities.

Rodent Management – Session 1

Integration of the landscape of fear of rodents in EBRM methodologies

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Present pest management methods are mostly reactive and have huge disadvantages such as emerging genetic rodenticide resistance with serious threat for relay toxicity. Rodent control should be based on pest-species ecology and ethology to facilitate development of ecologically-based rodent management (EBRM). A main aspect of EBRM is the advanced knowledge of both the ecology and behaviour of the targeted rodent pest species. A tool to assist knowledge on the spatiotemporal behaviour of rodents, is the landscape of fear. The landscape of fear (LOF) indicates levels of anxiety that a prey species perceives at several sites within its territory and embodies the areal variation in scavenging cost as result of predation risk. In practice, the LOF enables to predict where traps or bait are most expected to come across and used by rodents by mapping habitat use as a result of perceived fear. A major opportunity for rodent control strategies would be to incorporate the LOF of pest species in EBRM methodologies. By focussing on those areas where rodents regard the smallest amount of predation risk, rodent pest management could become more effective.

Rodent Management – Session 1

Rodent trapping grids are sustainable for long-term landscape suppression of invasive rat (*Rattus rattus*), but not mouse (*Mus musculus*), populations in Hawaii

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Invasive rodents (rats, *Rattus* spp., and house mice, *Mus musculus*) are among the most damaging animals to agriculture and native species on many island ecosystems including those in Hawaii. Traps and toxic baits are widely used tools for rodent pest control or eradication. Rats and mice cause widespread environmental harm in Hawaii, including by feeding on insect pollinators and many native plants, and land managers require sustainable ways to control rodents across the landscape without using toxic baits. We experimentally tested whether snap-traps, placed in plastic boxes to limit non-target interference, were effective at suppressing invasive rodents in woodland and grassland sites on Hawaii Island where 20 threatened or endangered plant species reside; many of these species are harmed by rodents. Our design had a total of 12 plots, each 2.25 ha, that included three treatments (n = 4 per treatment): rodent removal (RR), rodents+ants+yellowjackets removal (AR), and control or reference plots (CO). In each RR and AR plot, a grid of 169 mouse traps (each 12.5 m apart) and 49 rat traps (each 25 m apart) was installed and armed continuously for 1.5 years, with bait refreshed each 1-2 weeks. We monitored rodent populations in all 12 plots using tracking tunnels, which are baited ink cards placed in tunnels so that foot prints of animal visitors can be identified. We determined that both rats and mice could be effectively suppressed (<20% detection in tracking tunnels) for ~4 months after trapping initiated; yet only rat, and not mouse, suppression was sustainable thereafter. Trail camera evidence revealed that mice became habituated to traps in some cases, leading to trap avoidance, and that some non-target animals interfered with mouse traps. In areas with high mouse populations, grids of snap-traps may not be a sustainable management technique for long-term house mouse control.

Rodent Management – Session 1

Ecology of rodent pests in lowland irrigated rice fields under alternate wetting and drying conditions

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With the introduction of the water-saving technology, Alternate Wetting and Drying (AWD), farmers are hesitant to adopt this measure for fear the practice will lead to increases in rodent pest activity, consequently exacerbating yield loss. Rodents are one of the most important pests in rice, causing both pre- and postharvest damage. It is, therefore, understandable that farmers will be hesitant to adopt a measure when they think this will lead to more rat damage to their rice. We investigated the effects of AWD on the population dynamics, habitat use and damage levels inflicted on growing rice crop by two most important vertebrate pests of rice in Indonesia and the Philippines, respectively: *Rattus argentiventer*, and *Rattus tanezumi*. The knowledge, attitudes and practices (KAP) of Indonesian and Philippine farmers were also surveyed. Analyses indicate that AWD has no effect on rodent pest population dynamics, habitat use and damage levels on rice. Indonesian and Philippine farmers employed similar rodent control methods: use of poisons and cleaning the rice fields. Philippine farmers prefer acute rodenticides whilst Indonesian farmers prefer anticoagulants. Farmers in both countries prefer to work alone when managing rodent pests. Damage levels in Indonesia and the Philippines seem to reflect that the interventions by farmers are inadequate and call for community-based action.

Rodent Management – Session 1

Status of rodent pests in rice eco-systems in Sri Lanka

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Sri Lankan farmers report rodents as an emerging problem in rice cultivations across the country. This is in addition to the incidences of leptospirosis among the farming communities since 1990s. Hence, both the agriculture and health sectors initiated programs to minimize pre-harvest crop losses and rodent-borne diseases. This study aims to develop ecologically-based rodent management system (EBRM) against this pest. The study areas covered three agro-ecological zones (wet, intermediate and dry with annual rainfall >2,500, 2,500 - 1,750 and <1,750 mm respectively) where farmer reported high rat populations and incidence of leptospirosis cases (7,099 recorded cases in the year 2008). Live capture traps were set up for two consecutive nights at three different crop stages in the field and during off season in and around houses. The percentage tiller damage was assessed in the sampling sites. Disease incidences of *Leptospirosis* were collected from the Ministry of Health. We observed *Rattus rattus* and *Bandicoo indica* as the dominant species present in the rice fields and *Rattus rattus* was the most common species found in and around houses. The peak populations of *Rattus rattus* was recorded during the booting stage of rice in all sampling sites and in the intermediate zone we recorded the highest rodent population. Highest rodent damage was observed in the intermediate zone during booting (18.4%) and at the booting stage in the wet zone (10.2%) and the dry zone (6.8%). The prevalence of leptospirosis was high in the wet zone compared to the other areas. Efforts will be made to study the breeding ecology of *Rattus rattus* and to determine the prevalence of leptospirosis through a serological test. Based on the results, a disease forecasting model and EBRM will be developed.

Rodent Management – Session 2

Enabling effective rodent pest research in African smallholder farming systems

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A meta-analysis of published research between the years 1910 to 2015 on rodent pest damage and management was carried out for the Afro-Malagasy region. Using a defined set of criteria, 162 publications were identified with a focus on rodent pest research in agricultural contexts. Although this showed relevant research activities have taken place in 32 African countries, more than half of the research has been focussed in four countries only: Tanzania [25%], Nigeria [9%], Ethiopia [9%] and Kenya [8%]. Data extracted from these publications strongly suggest pest rodents have a significant negative effect on Afro-Malagasy smallholder farming communities. Crop losses varied between cropping stages, storage and crops and the highest losses occurred during early cropping stages (46% median loss during seedling stage) and the mature stage (15% median loss). There was a scarcity of studies investigating the effectiveness of various management actions on rodent pest damage and population abundance. We argue that there has been inadequate empirical research focused on developing sustainable control methods for rodent pests, with the situation further exacerbated by a lack of communication pathways for appropriate knowledge extension. We carried out stakeholder analyses in six countries which indicated rodent pests were considered to be a serious problem among smallholder farming communities. However, these views were not shared by government authorities and rodent control businesses who were generally not aware of the importance smallholder communities attributed to rodent pests. Our analysis suggests blockages in information flow from communities to government and industry are preventing the recognition and resolution of rodent pest problems affecting smallholder farmers across the Afro-Malagasy region. A new research project funded by the African Union involving researchers from seven countries aims to increase empirical research on sustainable rodent control methods as well as unblock communication pathways between service providers and smallholder communities.

Rodent Management – Session 2

Effect of synthetic hormones on reproduction in *Mastomys natalensis*

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Rodent pest management traditionally relies on some form of lethal control. Developing effective fertility control for pest rodent species could be a major breakthrough particularly in the context of managing rodent population outbreaks. This laboratory-based study is the first to report on the effects of using fertility compounds on an out breaking rodent pest species found throughout sub-Saharan Africa. *Mastomys natalensis* were fed bait containing the synthetic steroid hormones quinestrol and levonorgestrel, both singly and in combination, at three concentrations (10, 50, 100 ppm) for 7 days. Consumption of the bait and animal body mass was mostly the same between treatments when analysed by sex, day and treatment. However, a repeated measures ANOVA indicated that quinestrol and quinestrol/levonorgestrel treatments reduced consumption by up to 45%, particularly at the higher concentrations of 50 and 100 ppm. Although there was no clear concentration effect on animal body mass, quinestrol and quinestrol/levonorgestrel lowered body mass by up to 20% compared to the untreated and levo-norgestrel treatments. Quinestrol and quinestrol/levonorgestrel reduced the weight of male rat testes, epididymis and seminal vesicles by 60–80%, and sperm concentration and motility were reduced by more than 95%. No weight changes were observed to uterine and ovarian tissue. However, high uterine oedema was observed among all female rats consuming treated bait at 8 and 40 days from trial start. Trials with mate pairing showed there were significant differences in the pregnancy rate with all treatments when compared to the untreated control group of rodents.

Rodent Management – Session 2

An Africa Centre of Excellence for Innovative Rodent Pest Management and Biosensor Technology Development (ACE IRPM&BTD) in sub-Saharan Africa

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Rodents are some of the most serious mammalian pests in sub-Saharan Africa. The economic, health and social impact of rodents is not adequately quantified, species identity is not well known and the ecology and dynamism of populations are understudied in sub-Saharan Africa. An Africa Centre of Excellence for Innovative Rodent Pest Management and Biosensor Technology Development (ACE IRPM&BTD) was established in 2016/2017, based in Tanzania. The ACEIRPM&BTD shall enhance scientific knowledge (taxonomy, ecology, zoonotic diseases, pest management, biosensor using rats), technology and innovations (STI) on rodent pest management in Africa. ACEIRPM&BTD is currently focusing on two major activities (i) Postgraduate training (16 registered PhD candidates undertaking studies in Tanzania, Uganda and Ethiopia). Ten MSc. candidates will embark on research activities in 2018/2019 (ii) Curriculum development for MSc. programmes to train potential candidates for PhD studies on rodents. About 35 PhD and 80 MSc candidates will enrol in the next five years. Studies already being undertaken include: (i) Landscape ecology and population dynamics of rodents in Afro-alpine ecosystems, Ethiopia (ii) Diversity and population dynamics of rodents and associated ectoparasites in Mt. Elgon ecosystem, Uganda. (iii) Prevalence and diversity of haemoflagelates and filarial worms in rodents and shrews in Uganda (iv) Habitat disturbance, population dynamics and community structure of rodents in forest reserves, Uganda. (v) Ectoparasites and gastrointestinal helminthes diversity in rodents and shrews in Siemens Mountains, Ethiopia. (vi) Prevalence of *Leptospira* in rodents, shrews and humans in Uganda (vii) Community ecology of rodents in the Selous ecosystem, Tanzania (viii) Ecology of rodents and flea ectoparasites in plague endemic foci in the Rift Valley, Tanzania. (ix) Biosensor technology development using the African giant pouched rats, *Cricetomys gambianus* (5 studies in pipeline). The ACEIRPM&BTD will support high impact research on rodents in Africa and welcomes collaboration with scientists from all over the world.

Rodent Management – Session 2

Population dynamics and breeding patterns of *Mastomys natalensis* (Smith 1834) in three different agricultural practices

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The multimammate mouse, *Mastomys natalensis* (Smith, 1834), is an important agricultural pest in sub-Saharan Africa where it can cause severe crop losses. The eruptive nature of this rodent species has been linked before to abundant rainfall leading to population outbreaks. The aim of this study was to examine and describe the population dynamics and breeding patterns of *Mastomys natalensis* in three locations in Tanzania with different cropping system, crop calendars and water availability: rainfed maize/single crop, rainfed maize/double crop, and irrigated rice/double crop. In these locations *Mastomys natalensis* was the dominant rodent pest species, contributing more than 95% of animals captured in the study sites. Rodent population densities were higher in an irrigated rice/double crop fields than in either the rainfed maize/single crop or rainfed maize/double crop fields. *Mastomys natalensis* showed almost continuous breeding in irrigated rice/double crop fields, and extended breeding was observed in rainfed maize/double crop fields. The nearly constant supply of water in the irrigated rice/double crop fields allows for an almost continuous availability of young green vegetation with germinating crop and weed seeds. This provides good conditions for the maturation of *Mastomys natalensis* and hence allows continuous breeding. Forecasting models based on rainfall should take into account differences in rainfall pattern or alternative provision of water from irrigation.

Rodent Management – Session 2

A large-scale experiment to evaluate the effects of trapping on muskrat (*Ondatra zibethicus*) population development in The Netherlands

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Muskrats are considered a pest species in The Netherlands and are being harvested in a year-round control-program. Supported by the man-power and registration system in this control-program, a unique large scale management experiment took place from 2013 till 2015 (3 years) to study the effect of manipulating Muskrat harvest intensity (time invested in trapping) on catch rate. The experiment took place in 117 atlas squares of 5*5 km, selected in a stratified random way. The experimental results were analysed with mixed-effects models, with appropriate spatio-temporal covariance structures to avoid biases or inflation of significance. There was a strongly positive relation between time spent trapping and number of animals caught, substantiating that catch is determined by effort. Catch rates did furthermore vary substantially between seasons, being higher in autumn than in spring, were correlated across years, and did exhibit a marked spatial auto-correlation up to distances of 10 to 15 km on average. The development of catch rate over time differed between experimental atlas squares, but could not be related to experimental treatments or any other known environmental variable of relevance. This experiment thus did not provide evidence for the role of quantity of effort on Muskrat population dynamics. We identified several mechanisms that may have attenuated differences in trapping effort on local Muskrat populations studied. We suggest that the spatial context and spatial scale, as well as the effectiveness of time spent trapping, are more important than previously thought. The experimentally assigned change in effort was presumably not sufficient to provide an experimental evidence for the hypothesised effects, given the spatial scale of the plots. New research efforts should therefore focus on disentangling the role of quality of effort invested versus its quantity, and also find ways to accurately document aspects of quality in the trap recording system.

Rodent Management – Session 2

Aspects of good practice rodent control that affect exposure of non-target vertebrates to anticoagulant rodenticides

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Norway rats are frequently controlled with anticoagulant rodenticides in European livestock farming. Products are highly efficient but can pose environmental risks like primary exposure of non-target vertebrates and secondary exposure of predators and scavengers. Several features of good practice rodent control aim to reduce risk but often effects are not well known. On farms around Muenster, Northrhein-Westfalia, 1) We investigated the potential difference between using bait boxes only inside buildings in contrast to traditional bait box application in and around buildings regarding anticoagulant residues in liver tissue of non-target small mammals. First results suggested a lower exposure for some species if rodenticides are applied only inside buildings. 2) We also tested a new bait box design and observed small mammal behavior with camera traps. Non-toxic bait paste or bait blocks placed "above head", 200 mm up on the inner box wall, excluded all shrews and voles from the bait but not mice and the targeted rats. 3) We localized the places where Norway rats succumb to rodenticides by treating 53 live-trapped and radio tagged individuals with a lethal dose of the anticoagulant brodifacoum. Most rats died in hidden places inaccessible to avian or large mammalian predators. Some rats died in dense vegetation with limited access to predators or in open areas where they were exposed to predators. The latter can be easily removed and disposed to prevent consumption of poisoned rodents by predators or scavengers. The study showed that several aspects of good practice rodent control may reduce exposure of non-target species to anticoagulant rodenticides to further minimize non-target exposure.

Rodent Management – Session 2

Dynamic of the invasive rodent ranges in Russia: facts and forecast

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A list of 100 invasive species of animals, plants and microorganisms (TOP-100 worst), which are the most dangerous for ecosystems, native species and humans in the territory of Russia, is compiled. It contains 10 species of mammals, 6 of them are rodent species: *Castor canadensis* Kuhl, 1820; *Ondatra zibethicus* Linnaeus, 1766; *Apodemus agrarius* (Pallas, 1771), *Mus musculus* Linnaeus, 1758; *Rattus rattus* Linnaeus, 1758; *Rattus norvegicus* Berkenhout, 1769. The distribution of these rodents in the territory of Russia and in neighboring countries was analyzed on the basis of all available presence data from museums, monitoring and literature sources. We created geographical maps of the dynamics of the distribution range of invasive rodents using GIS-technologies and environmental niche modeling. We used the maximum entropy method (MaxEnt) for modeling the species' potential geographic distributions (Phillips et al., 2006 and other). An extensive literature review was conducted to select the important variables which are involved in determining the distribution of the rodent species. The selected environmental variables were: land cover/land use characteristics, climatic, topographic and location of anthropogenic objects. The native range and in time dynamics of rodent species range were identified. It is shown that regions of recent invasions of rodents are mainly located in the east part of Russia. The reduction of the *Rattus rattus* range was established in the last decades. A forecast of the changes in the rodent ranges under different scenarios of climate change is presented. According to preliminary data, climate change has only a small effect on the regions of rodent invasions. The anthropogenic transformation of landscapes, transport traffic intensity and land use changes have more significant impact for the range dynamics.

Rodent Management – Session 2

The black rat (*Rattus rattus*) in Madagascar: threat to health and livelihoods

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Malagasy farmers face numerous risks to their agriculture, including frequent pest outbreaks. The black rat (*Rattus rattus*) is the primary rodent pest, and a key reservoir for a number of transmissible diseases including bubonic plague. Control using ecologically-based rodent management (EBRM) approaches has been shown to significantly reduce crop losses where it has been implemented in parts of Southeast Asia. EBRM is not presently practiced in Madagascar and there is an opportunity to develop strategies that improve both food security and human health. A good understanding of the breeding ecology and habitat use of the pest species is fundamental to the successful design and implementation of EBRM, as well as consideration of the specific agricultural production system. Experience in Southeast Asia has demonstrated the importance of integrating local knowledge and socio-cultural factors. Here, we present data on the size and breeding condition of *Rattus rattus* populations across Madagascar and discuss the implications of capture probability for the design of control programmes. As part of a wider study on the occurrence of rodent-borne illnesses, rodent trapping was conducted at paired rural and urban sites at twenty-eight locations across Madagascar between 2011 and 2013. Household questionnaire surveys were also conducted at the each site, and provide information on agricultural practices, local perceptions of the rodent problem, and control methods currently practiced.

Rodent Management – Session 2

What the uninvited guests eat: dietary analysis of rodent pests present in the rural human dwellings of Pothwar, Pakistan

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Knowledge of what pest species are eating is very important to determine their impact on stored food products and it can help to develop more effective management strategies, such as targeted baits and lures. In this study, we investigated the food habits of two rodent species, *Rattus rattus* f. "S" (ship rat) and *Mus musculus* (house mouse) present in rural human dwellings of Pothwar, Pakistan. The trapping was conducted seasonally in village households, shops and farm houses from March 2012 through February 2014. We studied the dietary composition and seasonal variation in the food habits of the two rodent species. Overall, thirteen prey items were identified in gut contents of both *Rattus rattus* and *Mus musculus*. Among these items, cereal grains were the chief staple in the diet of both species. *Triticum aestivum* was the major cereal grain occurring in the gut content of both species across all the seasons. Among oil seeds, *Arachis hypogaea* consumption varied and it was best consumed in the autumn season. Arthropods (mainly insects) were consumed both the species and the intensity of consumption of arthropods was second to that of *Triticum aestivum*. No variation was detected in the food consumption across different trapping sites, seasons and trapping structures. Overall, the stomach content analysis showed that *Rattus rattus* and *Mus musculus* are omnivore, and mainly feeds on seeds, especially cereal grains and oilseeds. Our results indicated that the two rodent species were consistent pests of stored grains. This shows the potential negative impact of these pest species on people's health and the economy through consumption and contamination of their food products.

Rodent Management – Session 2

Low frequency of warfarin resistance in Norway rats in China after 30 years usage of anticoagulant rodenticides

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The first generation anticoagulant rodenticides (FGARs), such as warfarin and diphacinone, have been widely used in rodent control in China for over 30 years and resistant Norway rats have been reported. The genetic basis of warfarin resistance has been studied in Norway rats in many European countries, but is an untouched area for Norway rats in China. Mutations in the vitamin K epoxide reductase complex subunit 1 (*Vkorc1*) gene confer anticoagulant resistance in rodents. In this study, we analyzed the *Vkorc1* polymorphisms of 681 Norway rats collected in Zhanjiang and Harbin City in China from 2008 to 2015 and evaluated the warfarin resistance frequency. Analysis results revealed 4 mutations including 3 not previously reported. Two new synonymous mutations His68His and Leu105Leu are not associated with warfarin resistance. One new nonsynonymous mutation Ala140Thr was found in Zhanjiang rat samples collected in 3 different years with low frequencies (3.3%-4.0%) and is likely associated with warfarin resistance. No *Vkorc1* mutation related to warfarin resistance was detected in rats in Harbin. Laboratory resistance tests suggested low warfarin resistance frequencies in rats from Zhanjiang (4.9%-17.1%) and Harbin City (0-2.5%). Therefore, both genetic analysis and laboratory resistance tests suggested low warfarin resistance frequencies in rats from Zhanjiang and Harbin City, which is likely owing to the absence of *Vkorc1* mutations resistant to second generation anticoagulant rodenticides (SGARs), as well as different strategy of anticoagulant usage from Europe. The alternative usage of FGARs and SGARs might represent an effective strategy against the development of warfarin resistance in Norway rats in China.

Rodent Management – Session 2

Comparative biological properties of the four stereoisomers of difethialone – a way to reduce the tissue persistence of difethialone

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Difethialone, a second generation anticoagulant rodenticide (SGAR) is highly potent to control rodent populations. However, its long persistence is responsible for secondary exposure or poisoning of predators and scavengers. A major pathway for improving difethialone has recently been proposed based on their stereoisomerism. In fact, the SGAR molecules, which all contain 2 asymmetric carbons, coexist in the form of 4 stereoisomers of configuration, the 1R/3R, 1S/3S, 1R/3S and 1S/3R stereoisomers. Stereoisomers 1R/3R and 1S/3S are enantiomers and have thus identical physicochemical properties in a symmetric environment, as stereoisomers 1R/3S and 1S/3R. The commercial forms contain the 4 stereoisomers in variable proportions and persistence and efficiency of the commercial form is the result of the persistence and efficiency of each stereoisomer. This study aims to evaluate the biological properties of each stereoisomer of difethialone as rodenticide. Separation of stereoisomers has been performed on chiral column. Pharmacokinetic properties of each stereoisomer has been determined by in vivo study in rats and efficiency has been evaluated in vitro by the determination of the efficiency to inhibit VKOR activity and in vivo by a no choice feeding test. Pharmacokinetic properties of the four stereoisomers are different with two stereoisomers systematically more persistent than the two other ones. The four stereoisomers are able to inhibit VKOR activity in warfarin-susceptible rats with the same efficiency. All the baits containing either 1R/3R or 1S/3S or 1R/3S or 1S/3R are able to induce more than 90% of mortality of rats in a no-choice feeding test. However, difethialone residues at the death of animals were comprised between 4 and 16% of the active substance ingested according to the stereoisomer. Modifying the proportion of stereoisomers of difethialone is thus a way to reduce ecotoxicity. This improvement may be major if pharmacokinetic properties observed in rats are similar in non-target species.

Rodent Management – Session 2

Management of rodent pests in pig farming in North Rhine-Westphalia in Germany

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There is limited research focused on rodent control practices, usage of anticoagulant rodenticides and the acceptance of Pest Control Operators (PCOs) in domestic pig farming in Germany. In the present study, operation managers were offered the possibility to outsource rodent control to PCOs supported by a financial contribution of the North Rhine-Westphalian Animal Disease Fund (TSK) for two years. Data were collected from monitoring records of PCOs and personal interviews with farmers and PCOs. Of 47 farmers who were offered to participate, 33 joined the project. Despite the widespread opinion that the professional would not be worth it – we found that farmers financially profit from the work of the PCO, as calculated costs of pest control measures per operation on average did not greatly differ between costs incurred by employment of PCOs and costs that arise by farmers themselves. All PCOs used difenacoum and brodifacoum against pest infestations in each farm and the two anticoagulants, cumulatively accounted for 98 % of amounts of active ingredients of SGARs used within this study. By this, the infestation with rodents was reduced and most of the participating farmers assessed the project as success and employ the PCOs permanently. However, mapping the farm locations to resistance areas of the Rodenticide Resistance Action Committee (RRAC) shows that brodifacoum was frequently used in areas that are marked as areas that have no risk or rather are at low risk for resistance. If PCOs working in areas where resistances might occur, administer the highest potent anticoagulant available at present per se to avoid failure of pest control or if there are more today unknown resistance areas present in Germany, cannot be distinguished by the present data. Due to the alarmingly high quantities of brodifacoum used in the present study and the resulting risk for the environment, we highly recommend to further analyze the implementation practices of farmers and PCOs in livestock farming in Germany.

Rodent Management – Session 2

Experimental evidence for the effects of muskrat control (*Ondatra zibethicus*) on abundance in The Netherlands.

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Unambiguous evidence for the effectiveness of Muskrat control in well-established populations in mainland Europe is still lacking. This is important given ongoing public debate on the need for Muskrat control and the political desire at the level of the European Union to eradicate Invasive Alien Species (IAS), amongst which the Muskrat. In this study, indices of Muskrat abundance have been collected using Capture Mark Recapture for multiple years in two study sites that were experimentally managed without Muskrat control for three years. The data were compared to those from six reference areas under permanent control by kill-trapping and one site in which control had been abandoned more than eight years ago. In the No-trapping area, the index of Muskrat abundance was variable, but consistently high. Meanwhile, the index was consistently low in the reference areas. In the temporary absence of kill-trapping in the experimental areas, the index of Muskrat abundance increased significantly. The results are interpreted as compelling experimental proof for an effect of Muskrat control on Muskrat numbers, a basic premise of the Muskrat control programme.

Phylogeography – Session 1

Colonization and speedy speciation of an island invasive

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Chromosomal rearrangements may play an important role during the process of speciation. Rearrangements may promote hybrid unfitness leading to reduced gene flow as well as recombination suppression, processes which could lead to differentiation and ultimately reproductive isolation. The western house mouse (*Mus musculus domesticus*) inhabiting the Madeira island is an excellent model to study the potential role of chromosomes in speciation. From an ancestral karyotype consisting of 40 telocentric chromosomes, six distinct chromosomal races have arisen, characterized by different combinations of centromeric (Robertsonian) fusions of the telocentrics, sometimes further modified by whole-arm reciprocal translocations (WARTs). This astonishing level of chromosomal variation seems to have been attained in only ~1,000 years, the estimated time of colonization of the island by the house mouse. The combination of both molecular and paleontological data (radiocarbon dating of bone structures) supports the presence of mice in Madeira one millennium ago, most likely accidentally transported by Viking navigators.

Phylogeography – Session 1

The chromosomal variability of lesser blind mole-rat populations (*Nannospalax*, *Spalacinae*, *Rodentia*) in Greece

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Extreme chromosomal variability is a common trait in several rodent taxa and lesser blind mole-rats (*Nannospalax*, *Spalacinae*) constitute an excellent example, with dozens of chromosomal races described so far. The genus has been extensively studied cytogenetically in its Asian range, but comparatively less in Europe, with virtually no data from differentially stained chromosomes! Regarding Greece, only two karyological studies – more than thirty years old – exist. However, each of the four localities studied in the past revealed a different chromosomal race with $2n=52, 56, 58$ (continental Greece) and $2n=38$ (Lesvos island), respectively, implying a rather remarkable chromosomal diversity for *Nannospalax* in Greece, which this study aspired to unravel. Thus, mole-rats were collected from several continental and one island locality of Greece and the karyological study was conducted on G- and C- banded metaphase spreads. All individuals from continental Greece were verified to belong to the super-species *Nannospalax leucodon*. Interestingly, despite the large distance between most collected populations (ranging from Peloponnese to E. Macedonia), all were characterized by $2n=56/NF=84$ and had an identical autosomal morphology, with the exception of one specimen. In fact, this chromosomal form constitutes a new, rather widespread, chromosomal race for the species, whereas at the same time the existence of the race, previously described as 'Hellenicus', with $2n=58/NF=88$ was not confirmed! Remarkably, the single specimen from Viotia, E. Sterea Ellada with a slightly different karyotype, due to pericentric inversions in two autosomal pairs, resembled the "Epiroticus" race, which, however, lies ca. 250 km to the NW! On the other hand, the population from Limnos island with $2n=38/NF=74$ is formally placed in the super-species *Nannospalax xanthodon* ('Anatolicus' race). Based on the overall study results, the phylogenetic relationships among the Greek chromosomal races of *Nannospalax* and those of neighbouring countries are discussed and the next research steps are proposed.

Phylogeography – Session 1

Adaptive phylogeography of bank voles in Europe – what can the genome tell us?

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Bank vole (*Myodes glareolus*) represents our key model species for studies of adaptive phylogeography in which we examine the possible role of interpopulation variability and selection in postglacial colonization of continental Europe. In Great Britain, the bank vole populations underwent a replacement event in which the first colonizing population was partially replaced by later coming population bearing different haemoglobin (Hb) variant. This variant contains amino acid cysteine (Cys) on the position 52 of beta globin instead of serine (Ser) and as previous studies showed, it gives its bearer's red blood cells significantly higher antioxidative capacity. Since higher levels of oxidative stress may arise under multitude of ecological conditions and the colonizing populations originated in different glacial refugia, we assume that this difference in capacity to resist oxidative stress could represent an adaptation to particular environmental conditions encountered in refugium. Moreover, it could have given the second colonising population selective advantage over the first during the period of significant climatic changes after last glacial maximum. The glacial refugia of both colonists were located in continental Europe, where the discontinuous distribution of some mtDNA clades also points to possible population replacement events. To determine whether the pattern present in mtDNA will be reflected also in the genome, we sequenced more than 800 individuals from over 90 localities throughout Europe by massively parallel genotyping-by-sequencing (GBS). In this talk we will present our newest results of population structure analyses from these data. Both Admixture and Bayesian Analysis of Population Structure programs confirm that particular continental populations underwent a true population replacement event on the level of their genome, not only mtDNA. The Cys Hb distribution in continental Europe and its correlation with environmental variables also points to a possibility that this Hb variant could have played an important role in those events.

Phylogeography – Session 1

Ecological divergence and species response to climate change: niche modelling in the bank vole

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The bank vole (*Myodes glareolus*) is a widespread rodent inhabiting the temperate zone of Eurasia. Its range extends from Ireland and the north of Spain on its westernmost limits to central Siberia in the east. This broad distribution is explained by a postglacial colonization from multiple last glacial maximum (LGM) refugia located primarily in the Carpathian Mountains and on the Mediterranean peninsulas. Previous phylogeographic studies defined at least six distinct genetic lineages for the bank vole across Eurasia, each of which likely originated in a different LGM refugium. Generally, ecological divergence plays an important role driving the origin and maintaining distinct genetic lineages within species and therefore is considered as one of the main mechanism of intraspecific variation. Ecological Niche Modelling (ENM) approaches have been used to assess current and past distribution ranges of species based on the environmental characteristics of locality records, and their integration with phylogenetic information can help us understanding the influence of environmental heterogeneity on the origin and maintenance of intraspecific variation. In this work we apply ENM to assess the environmental variables influencing the current and past distribution of the distinct lineages of the bank vole across Eurasia. We expect the variation in hydroclimatic variables (i.e. temperature and precipitation) to reveal differences in ecological niches among the lineages, and explain their persistence in different glacial refugia during the LGM as well as their relative success during postglacial colonization.

Phylogeography – Session 1

More insights in the evolution of edible dormouse from the old growth Hyrcanian forests

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The edible dormouse (*Glis glis*), a species from a monotypic genus of family *Gliridae*, which has been frequently used as a model to promote the understanding of patterns of arboreal species regarding glacial oscillations. Ancient Hyrcanian forests, one of the old-growth relicts of the temperate deciduous forests worldwide has been recently documented as an important refugium during the Last Glacial Maximum (LGM). More investigation based on sequencing mitochondrial *Cytb* belonging to the different local populations distributed along the Hyrcanian forests as well as skull and mandible morphological assessments indicated considerable intraspecific evolutionary divergence of the species. The integration of phylogeny, geometric morphometric and environmental niche modeling approaches in this study confirms the presence of multiple cryptic refugia for fat dormice as small forest-dwelling species during paleontological oscillations.

Phylogeography – Session 2

Ethiopian rodents - extremely diverse, endemic and endangered

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Ethiopia is an African country with very diverse geomorphology, which is reflected in its amazing biodiversity. For example Ethiopian highlands, harbouring the largest areas of Afromontane ecosystems in Africa and one of the most striking elevational ecological gradients on the Earth, are known as one of the most important centres of endemism in the world. Other ecosystems, e.g. Somali-Maasai and Sudanian savannahs, rain forests or semi-deserts, have been less studied, however, available data suggest they also often host endemic evolutionary lineages of otherwise widespread taxa. In this presentation we summarize both published and unpublished genetic data about Ethiopian rodents, collected in two last decades. Using huge genetic datasets of rodents from Ethiopia as well as other regions of sub-Saharan Africa, we will describe their major evolutionary patterns and biogeographical relations. Not surprisingly, the Ethiopian highlands served as a cradle of diversity for numerous mountain taxa - many of them remained endemic in Ethiopia (and often diversified at elevational gradient or in "local" allopatry), but some others dispersed and speciated in southern parts of Eastern Afromontane biodiversity hot-spot. More surprisingly, we found that even taxa living now in the wide belt of Sudanian savanna started their Plio-Pleistocene diversification in Ethiopia, i.e. in the easternmost part of this ecosystem. Last, but not least, unique and geographically restricted Ethiopian rainforests harbour the so-called "palaeoendemics", i.e. the evolutionary lineages that survived here several millions years, but are now highly endangered because of intense exploitation by humans. The research was funded by the Czech Science Foundation project No. 18-17398S and the Russian Foundation for Basic Research project No. 18-04-00563.

Phylogeography – Session 2

Biogeography of small mammals in south-western Angola: the first genetic evidence

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Angola represents one of the most understudied African countries with respect to biodiversity at all levels. Furthermore, Angola represents an area which holds particular interest for biogeographers owing to its immense habitat diversity and the confluence of three very different biomes: northern Congo basin lowland forests, eastern Zambezi miombo woodlands and southern Namib Desert. Although recent activities of various research groups brought some interesting results about the diversity and biogeographic affinities of Angolan birds, virtually nothing is known about mammals. Especially small mammals are a very useful model for testing the uniqueness/endemicity/biodiversity value since humans have had a strong impact on mammalian distributions in Angola, particularly on those of large carnivores and ungulates during the civil war (1975-2002), when widespread poaching affected strongly a range of species. A field expedition with the main purpose of collecting small mammals was conducted in July 2017. Altogether, we sampled 318 individuals at 11 different localities in south-western Angola. According to external identification, sampled specimens belong to 18 different genera. This high diversity reflects the habitat diversity of sampled localities as we were trapping in dry, semi-desert and desert habitats (typical for some *Elephantulus*, *Petromyscus* and *Gerbilliscus*) up to moist forest (here we found *Lophuromys*, *Aethomys* and *Mus*). Phylogenetic analyses based on DNA barcoding in the context of our collection of samples from mostly eastern and central Africa have revealed an interesting biogeographic pattern in four genera or species lineages (*Mus minutoides*, *Mus triton*, *Mastomys* and *Dendromus*). All of them were represented by two different species or lineages in south-western Angola, the first one has its relatives in the north (southern Democratic Republic of Congo) whilst the second easterly in Zambia.

Phylogeography – Session 2

Comparative phylogeography of the Mongolian region based on its mammals

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The periodic oscillations of glacials and interglacials have had an enormous impact on formation and changes of global mammal communities. Particularly, refugia play a significant role in species diversification and modification of their genetic diversity. Refugia were crucial for the survival of some taxa and their subsequent recolonization of particular regions or whole continents during inhospitable conditions (glacial elements during interglacial periods and vice versa). The recognition of refuge from a geographical point of view and fauna compositions in certain (macro)regions helps us to understand earlier conditions and biological processes which have influenced the recent diversity and distribution of particular species. Refugia have been well studied, especially in North America and Europe. In the context of the entire Palaearctic Realm, however, it is worthwhile to focus also on refugia in Asia. There are several proposed refuge areas such as: Beringia, South Ural, Caucasus or southern part of Asia. In the recent studies, the area including Altai, (Western) Sayan and the adjacent areas of Mongolia and China is emerging as a significant refugium, especially for glacial species or so-called mammoth-steppe fauna. The current results indicate the peculiarity of local populations and the refugee character of this region and also the key position of the entire Altay-Sayan-western Mongolian region characterized by the continuous presence of grasslands and deserts until at the present since the Late Pleistocene. Within our research, we analyze basic phylogenetic and population-genetic parameters in selected species in order to find out the degree of diversification for sub-populations and corresponding time spans, links to other populations, and current and past biogeographical influences. This is the first introduction of our results realised for several selected species (e.g. *Apodemus peninsulae*, *Microtus gregalis*, *Allactaga sibirica*, *Eolagurus luteus*, *Dipus sagitta*, *Dryomys nitedula*).

Phylogeography – Session 2

Genetic structure and origin of remnant red squirrel (*Sciurus vulgaris* L.) populations in the south of England

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The Eurasian red squirrel (*Sciurus vulgaris*) is an emblematic species for conservation and represents a good example of the negative effect the impact of alien introductions. Indeed, red squirrel (*Sciurus vulgaris*) populations in the UK have experienced a dramatic decline over the last 60 years due to habitat loss and the spread of the “red squirrel parapox” virus following the introduction of the grey squirrel (*Sciurus carolinensis*). Currently, red squirrel populations in the UK are highly fragmented and need to be closely monitored in order to assess their viability and the success of conservation efforts. The situation is even more dramatic in the south of England, where it survives only on islands where the grey squirrel is absent, and the Isle of Wight is its main stronghold. Using the D-loop, we investigate the genetic diversity and the putative ancestry of the squirrels on three islands from the South of England (Brownsea Island, Furzey Island and the Isle of Wight) in order to infer their conservation status.

Phylogeography – Session 2

Collagen fingerprinting of Late Pleistocene rodents

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Microfaunal remains are often used as palaeoenvironmental proxies and underpin studies of phylogeography and climate. They provide physical evidence for the presence of species at particular locations and times, and are used to define faunas related to climate stages or events. Consequently, they provide a context in which to examine genetic data and may be used to validate phylogeographic studies. Rodent remains are abundant in numerous sites of archaeozoological interest, potentially forming an important part of the fauna represented there, but are often difficult to identify. For example, postcranial elements from different species are frequently incomplete and indistinguishable, as are many isolated teeth of arvicoline rodents, and this has led to significant mis-identifications in the past. We demonstrate the application of a relatively recent method, collagen fingerprinting (or Zooarchaeology using Mass Spectroscopy: ZooMS), to rodent remains from a Late Pleistocene cave site in England. The method distinguished the arvicoline rodent genera that were present and a range of extant and extinct *Microtus* vole species. ZooMS is much less time-consuming and expensive to apply than modern morphometric or DNA-based techniques, allowing bulk sampling of thousands of specimens. It can be used on a wider variety of material than the former and is not subject to the chronological limits of DNA preservation. It is also less destructive than sampling for ancient DNA, so material is still available for subsequent studies of morphological variation, preservation and taphonomy. The data provide an accurate and comprehensive record of the species present at the site, Pin Hole Cave in Derbyshire, which has previously been designated as the British type location for the Marine Isotope Stage 3 fauna (ca. 60-30 Kya). It is important that definitive faunal data are available from such sites, to provide the essential background for studies of phylogeography and climate change.

Population Dynamics – Session 1

Long-term dynamics of voles and lemmings in Finnish Lapland: importance of community approach

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Dynamics of voles and lemmings in northern Finnish Lapland have been monitored at Kilpisjärvi since late 1940s and at Pallasjärvi since 1970. A drastic change in the population dynamics took place in mid and late 1980s. Earlier "beautiful" cycles turned to primarily seasonal dynamics. This also included changes in the species composition of rodent communities. However, recently the cycle has returned! In the cyclic times, vole dynamics were characterized by synchronous cycles, particularly the deepest crash phase was synchronous in all sympatric species, though in the increase and peak phases some moderate inverse density changes were observed among competing species. The two main hypothesis put forward to explain the change are based on the role of intensive forestry in the taiga zone (decline in arboreal lichens as winter food for *Myodes glareolus*, and consequences for *Microtus agrestis* through shared predation), and climate change affecting the snow structure and subnivean space. During noncyclic times starting in mid 1980s, smaller and more agile *Myodes glareolus* and *Myodes rutilus* turned seasonal but maintained their earlier abundances. Larger and more clumsy species *Myodes rufocanus*, *Microtus agrestis*, *Microtus oeconomus* and *Lemmus lemmus* drastically declined in abundance. At more northern and altitudinally higher Kilpisjärvi the dynamic change took place a bit later, around 1990. Also here, the species with a larger body size became more uncommon. Also some demographic features have changed. The decline in clumsy species with large body size refers to predation effects. This decline has taken place both in *Myodes rufocanus* and *Microtus agrestis* and *Microtus oeconomus*. It has taken place in all habitats, also in protected taiga regions, and also far (more than 100 km) from any forest management, possibly suggesting for the role of mobile predators and /or climate change.

Population Dynamics – Session 1

Rainfall and changing population dynamics during a long-term CMR study of *Mastomys natalensis* in Tanzania

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The multimammate mouse, *Mastomys natalensis*, is a common and widely distributed rodent in agriculture and peridomestic environments in most of Africa. It is a serious pest in cereal fields and causes devastating damage during outbreak years. Earlier work in Tanzania could link these outbreaks to unusually abundant early rainfall (in October-December) leading to aseasonal breeding resulting in an additional generation within a single year, causing a tenfold increase newly recruited individuals. After this initial work in the 1980s, we have carried out capture recapture studies in a permanent 3 ha study grid in Morogoro, Tanzania, since 1994. Every fourth week (sometimes more frequent), animals have been live trapped during three consecutive days, marked individually and released. So far, this has resulted in 321 trap sessions, and with in total 64,913 captures of 28,226 individual *Mastomys natalensis*. Over these almost 25 years, population dynamics continued to show a very regular seasonal pattern with interannual variation. However, outbreaks have become very rare, the amplitude of the fluctuations has become lower and the average abundance shows a decreasing trend. Breeding remained seasonal but the breeding season is shortened. The relation between October-December rainfall and outbreaks has become less clear. The changes seems to be linked to changes in rainfall. There has indeed been a decrease in annual precipitation over the whole period although the average amount of rainfall in October-December has remained similar. Apart from the decreasing total amount of rainfall, the temporal distribution of rainfall during the wet season seems to have changed. These changes did not happen gradually but started about 15 years ago with a second non-linear change around 2012. We investigate the relation between the changes in rainfall patterns and population dynamics and what the possible consequences could be.

Population Dynamics – Session 1

Transient and seasonal drivers of population demography and virus transmission in rodents

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Continuous wavelet transforms provide a means to identify common periodicities in noisy, non-stationary time series. This is particularly useful when modelling complex, non-linear relationships over a range of time scales, such as those commonly seen in population demography, disease and climate time series. Wavelet analysis can also be used to identify both consistent and transient relationships in noisy time series. Here, we use continuous wavelet transforms and coherency analysis to investigate population demography and arenavirus infection in rodents in relation to both global and local weather patterns. We show that while seroprevalence is related to rodent density, changes in both the intensity and variability of rainfall in our study region have differing consequences for density and seroprevalence. Finally, we detect phase shifts driven by changing weather patterns at higher resolutions than conventional methods of analysis would normally allow. These patterns are analysed within a Bayesian framework to identify relationships between transient climate drivers and rodent abundance and arenavirus infection while accounting for temporal correlation. Wavelet analysis can be used to detect high resolution, non-linear relationships between demography, transmission and changing climatic conditions in a strongly fluctuating rodent population.

Population Dynamics – Session 1

Population cycles in a hibernating rodent

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The common hamster (*Cricetus cricetus*) in Europe has become of high conservation concern since the 1960s when the western European populations began to decline. As a result, its distribution range was substantially reduced and become highly fragmented. Yet long-term studies of its demography are lacking so the pattern of its population dynamics is poorly understood. Hamsters are known to be among highly prolific rodents which can outbreak in some years. Unlike small annual voles, hamsters are much bigger (200–600 g) and biannual. Most individuals mature following the first hibernation when they are about one year of age. Adults can produce one to three litters of 4–6 offspring each. They rarely survive to breed following the second hibernation. We analyse the 16-year data on population density of hamsters in a natural population situated on the periphery of Olomouc, Czech Republic, collected from 2002 to 2017 using a capture-recapture approach. Besides the declining temporal trend, we observed large fluctuations around the trend indicating the presence of some periodicity in data. By applying autocorrelation function, we obtained weak evidence of 4-yr population cycles. However, partial autocorrelation function and autoregressive linear models confirmed that the dynamics is of order 2, suggesting that the hamsters do exhibit cyclic dynamics resulting from the delayed density-dependence in population growth rates. We also observed important characteristics proposed to define cyclic fluctuations biologically, such as the Chitty effect, summer decline or density-dependent productivity. We are confident that studying population dynamics in other rodents than voles may bring new perspective to population cycle research.

Population Dynamics – Session 1

Towards a metastability approach: outbreaks of mice in Australia

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Populations of mice in Australia keep low densities most of the time, but sudden population outbreaks cause important economic damages in cereal crops. The outbreaks of mice have irregular dynamics and so far no one has been able to find a satisfactory explanatory mechanism. The aim of this study was to identify which are the basic principles and mechanisms responsible for epidemic outbreaks in Walpeup, Victoria, using a time series from 1983 to 2004. We fitted two types of models, single species logistic growth including exogenous factors, focused on house mouse populations (*Mus musculus*), and predator-prey models with functional response focused on population of mice and generalist predators (*Elanus axillaris*). For the first approximation we used single species models with humidity, precipitation, evaporation, temperature and productivity of wheat crop as exogenous factors (alone and mixed), but none of the models accurately predicted the outbreaks. On the other hand, we evaluated the existence of alternative equilibrium points related with metastability, through phase portraits and stochastic simulations. The predator-prey approach explained transitional states between lower and high densities, allowing us to identify the mechanisms that generate the outbreaks and establish management measures in the future to reduce their economic impact.

Population Dynamics – Session 2

Multi-scale density-dependent dispersal in spatially structured populations

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In spatially structured populations, dispersal is context-dependent and related both to local conditions (within patches) and to the metapopulation as a whole. Density-dependence experienced at different scales likely plays a role in initiating dispersal and determining dispersal success. This multi-scale density-dependence has hitherto received little attention despite its potential to produce spatiotemporally heterogeneous dispersal rates and fundamentally alter predictions about metapopulation dynamics and persistence. We developed a spatially explicit metapopulation model to quantify dual-scale density-dependence using data from a metapopulation of water voles *Arvicola amphibius* in Assynt North West Scotland where those rodents grow up to 300 g, live in small colonies and occupy 8% of the 860 km waterway network with slow flowing water and vegetated banks. Average dispersal was large scale with a colonization halving distance of 4.14 km. The per capita probability that a dispersal event resulted in successful establishment, or prevented extinction via the rescue effect, was higher for juveniles living in source patches with larger population sizes, i.e., consistent with positive local density-dependent emigration, and higher in years when the number of occupied sites in the metapopulation was lowest, i.e., consistent with negative regional density-dependence. In model simulations, multi-scale density-dependent dispersal induced increased variability in metapopulation dynamics and hence increased extinction risk. This was offset by increased dispersal success in low occupancy years. Thus, negative density dependent dispersal at the metapopulation scale partly counters the heavily destabilising impact of positive density dependence at the local scale. We suggest that metapopulations can only persist where those influences counter each other.

Population Dynamics – Session 2

Coupling agent-based with equation-based models to study spatially explicit megapopulation dynamics

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Taking the spatial heterogeneity of real landscapes into account in population dynamics remains extremely difficult. We propose combining equation based modeling (EBM) and agent-based modeling (ABM) to overcome the difficulties classically raised. ABM allows describing entities that act according to specific rules evolving on various scales. However, a large number of entities may lead to computational difficulties (e.g. for populations of small mammals such as voles, that can exceed millions of individuals). Here, EBM handle aged-structured population growth and ABM represents the spreading of voles on large scales. Simulations applied to the spreading of a montane water vole population showed that our hybrid model is quite efficient in representing the reality observed and might help to highlight some key parameters during population expansion. This paves the way for further developments, including the introduction of density-dependent parameters (predation, diseases, etc.) capable of triggering population declines in an explicitly spatial context.

Population Dynamics – Session 2

The Bruce effect revisited: is pregnancy termination in female rodents an adaptation to ensure breeding success after male turnover in low densities?

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Pregnancy termination after encountering a strange male, the Bruce effect, is regarded as a counterstrategy of female mammals towards anticipated infanticide. While confirmed in caged rodent pairs, no verification for the Bruce effect existed from experimental field populations of small rodents. We suggest that the effect may be adaptive for breeding rodent females only under specific conditions related to populations with cyclically fluctuating densities. We investigated the occurrence of delay in birth date after experimental turnover of the breeding male under different population composition in bank voles (*Myodes glareolus*) in large outdoor enclosures: one-male-multiple-females (n=6 populations/18 females), multiple-male-multiple-females (n=15/45), and single-male-single-female (MF treatment, n=74/74). Most delays were observed in the MF treatment after turnover. Parallel we showed in a laboratory experiment (n=205 females), that overwintered and primiparous females, the most abundant cohort during population lows in the increase phase of cyclic rodent populations, were more likely to delay births after turnover of the male than yearborn and multiparous females. Taken together, our results suggest that the Bruce effect may be an adaptive breeding strategy for rodent females in cyclic populations specifically at low densities in the increase phase. Then isolated, overwintered animals associate in MF pairs. During population lows infanticide risk and inbreeding risk may then be higher than during population highs, while also the fitness value of a litter in an increasing population is higher. Therefore, the Bruce effect may be adaptive for females during annual population lows in the increase phases, even at the costs of delaying reproduction.

Population Dynamics – Session 2

The long-haired rat (*Rattus villosissimus*): an ecosystem disrupter in arid Australia

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Species in the genus *Rattus* are well-known as pests in agricultural systems. In natural ecosystems they can have strong top-down effects on vegetation through seed predation and seedling herbivory. However, the broad ecosystem impacts of population outbreaks of *Rattus* species are not well understood. We examined this issue for the long-haired rat (*Rattus villosissimus*) in a region of arid Australia with highly unpredictable rainfall. The species is the largest extant rodent in arid Australia (body mass: 150 g). The long-haired rat is not resident in the study area in the western Simpson Desert, rather population outbreaks occur every 25-30 years. We sought to describe and assess the full range of ecological interactions that occurred during a population outbreak that ran from June 2010 to December 2012. The long-haired rat outbreak resulted in a series of novel ecological interactions; these interactions had not been observed during the periods when the rat was not present. The interactions that were observed included; 1) long-haired rat predation on smaller mammals (body mass <100 g) especially other rodents; 2) invasion by the rats in to refuge habitat of the nationally vulnerable plains mouse (*Pseudomys australis*), and 3) feeding and associated damage to the nationally vulnerable keystone tree species *Acacia peuce*. In addition, long-haired rat burrow construction resulted in large volumes of soil redistribution and the presence of rats produced a spike in rodent biomass that was over twice that during irruptions where the rat was absent. The sporadic occurrence of the long-haired rat and the intensity and spatial scale of the novel interactions indicate that it can be considered a disruptive factor in the functioning of the Simpson Desert ecosystem.

Population Dynamics – Session 2

The role of food availability in life history traits and population dynamics of the edible dormouse (*Glis glis*) in pine dominated forest

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The distribution and the predictability of food resources are important ecological factors influencing reproduction and life history tactics of many animal species. It is especially important for specialized seed predators like the edible dormouse, which can skip reproduction in years with low seed availability. Whereas the majority of studies were conducted in beech or oak dominated forests the present study was conducted in pine forest, with Scots pine (*Pinus sylvestris*) as the dominant tree species (above 90%). In a field experiment we tested the hypothesis that the presence of high caloric food from spring to autumn affects life history tactics and population dynamics of dormouse. Therefore, in years 2014 – 2016 on two experimental plots, we provided hazelnuts as a supplementary food from spring to autumn, whereas two other study plots remained without any additional food as control plots. Supplemental feeding did not affect reproduction, body condition nor population dynamics of dormice. Moreover, we did not observe differences in number of offspring or their sex ratio. However, in one year (2015) additional food elevated body mass of adult females but in next year (2016) it caused the weight loss of females. This illustrates that high-calorie food in itself may not be the only factor responsible for the condition of individuals, their reproduction and population dynamics in this rodent species, contrary to other studies. Additionally, during the autumn time, we discovered that additional food decreased relatedness between dormice which shared the same nestbox, which indicates that increased food availability reduced the competition among individuals during the autumn period.

Population Dynamics – Session 2

Does anticipatory reproduction exist?

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Anticipatory reproduction is the controversial mechanism of population regulation by which the animal reproduces before the actual ripening of its main forage and the juveniles begin independent feeding during the period of maximal food abundance. The primary object in studies of such mechanisms is the edible dormouse (*Glis glis* L., 1766). The intensity of its reproduction is regulated according to two different principles: in the species' optimum range the changes in reproductive activity of males play the main role, and in the peripheral population of the Zhiguli Mountains, reproductive regulation occurs through mass embryonic resorption in females. In 2016–2017, studies of the species' reproduction were conducted in the Zhiguli population. For comparison, in 2017 a study of reproduction of the yellow-necked mouse (*Apodemus flavicollis*, Melchior, 1834) was realized. It was found that mating of the dormouse begins long before the growth of acorns. At the beginning of their maturation, the vast majority of dormice females are already pregnant. The resorption or birth of juveniles depends on the proportion of green acorns in female nutrition during the period of gestation. In the yellow-necked mouse at the very beginning of acorn growth oestrus occurs, and during the ripening of acorns the entire reproduction cycle from the mating to the reaching of puberty by the young is observed. In both species, by the time the acorns are completely ripe and fall, the juveniles become independent. Thus, at least in two species anticipatory reproduction in oak communities consists of rodents feeding on immature seeds during pregnancy and lactation, eliminating a delay between forage yield and rodent reproduction. Mechanisms similar to anticipatory reproduction can most likely be found in animals under two conditions: a long life cycle and reproduction that depends on the limited period of availability of the main forage.

Population Dynamics – Session 2

Small mammals in montane forests: not where, but when?

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Community dynamics is a well documented topic concerning the ecology of small mammals, but very few studies have focused simultaneously on its temporal and elevational patterns. Here we report the multiannual dynamics of small mammal communities along an elevational gradient in relation to the habitat characteristics. During a five-year faunistic inventory in Retezat National Park, Romania we live-trapped small mammals in different forested and shrubby habitats at elevations between 770 m and 2,080 m. Because small mammal communities in mountains face more severe climatical and habitat-related limiting factors, we hypothesized that: 1. these communities undergo significant year-to-year changes; 2. elevation interferes with the patterns of community dynamics; 3. the effect of habitat selection is eclipsed by the temporal changes. We used ANOVA and partial constrained multivariate analysis with habitat factors, year, elevation, and their interaction as predictors and trapping site as covariate. All community metrics differed significantly among years. Species composition was predicted not only by year but also by its interaction with elevation, but not by elevation itself. The elevational pattern of the community dynamics shifted direction each year. The dominant rodent species, *Myodes glareolus* and *Apodemus flavicollis* showed opposite patterns, possibly as a strategy to avoid competition. Overall, their abundances were negatively correlated. Moisture, human disturbance and proportion of the conifers in the canopy were best predictors of species composition, but the variation explained was lower than that caused by the yearly changes. Human impact on montane habitats is currently increasing because of forest exploitation and the global warming will lead to decreased moisture and cover of conifers. Thus, the further study of the interaction of these habitat changes with the time is important in order to understand and predict their synergistic effects on small mammal communities, their mechanisms and consequences.

Population Dynamics – Session 2

Breeding versus survival: proximal causes of abrupt population decline under environmental change in a desert rodent

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The population dynamics of a desert-dwelling psammophilous rodent (the midday gerbil, *Meriones meridianus*) was shown to exhibit delayed step transition from the high-(1994-2002) to low-abundance (2003-2017) regime in response to gradual landscape change from desert to steppe caused by the drastic reduction of livestock in the rangelands of southern Russia after the collapse of the USSR in the early 1990s. We tested whether breeding and demographic parameters were correlated with the observed abrupt downward population shift. We found that reproductive activity (the percentage of breeding females, the number of litters per female, fecundity) did not vary with time or population regime. The number of young recruited per female also showed no trend, did not differ between periods of high and low population abundance, and did not depend on reproductive activity, suggesting that recruitment rate is determined by survival rather than reproduction. The only parameter that significantly varied with time and differed between periods was the sex ratio among mature individuals (SR=males:females) – it decreased with time and was as much as twice more female-biased during the period of low population abundance. However, SR was not related to any reproductive parameter, including the percentage of breeding females. We conclude that proximate reasons for abrupt population decline are not associated with the changes in breeding patterns or mate limitation caused by the Allee effect as was suggested (Tchabovsky et al. 2016), but relate to the increased mortality in the desert landscape fragmented by steppeization, which is expected to be higher for males as the mobile and the dispersing sex. (RFBR 16-04-00739)

Population Dynamics – Session 2

Habitat preferences and spatial distribution of lemmings in western Taimyr

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The lemmings in the Arctic tundra north of 73 °N have received little attention, because this region is remote and difficult to access. Habitat use and spatial distribution of two species of lemmings – Siberian lemming (*Lemmus sibiricus*) and collared lemming (*Dicrostonyx torquatus*), were studied during nine summer field seasons (June-August) in 1993-1995, 2002 and 2004-2008 at the west coast of Taimyr peninsula in the delta of the river Pyasina (74°10' N, 86°45' E). Lemmings were captured by three different methods: by snap-traps along permanent lines and in plots in the main types of habitats and by live-traps on a permanent plot in the dominant habitat types. We caught 492 Siberian and 73 collared lemmings. Snap-trap line surveys showed that each of the two species had its own preferred habitat. For Siberian lemming, it was the grass-sedge marshy tundra and rocks or stony fields with lichen-moss vegetation, for collared lemming it was the rubble polygonal dwarf-willow tundra. On the other hand, the plant community preferences partly coincided in the two species: both lemmings had a high abundance in the dominant plant community - polygonal-hummocky tundra. Habitat distribution of Siberian lemmings was considerably wider than that of collared lemmings. *Lemmus sibiricus* had a significantly wider spatial-ecological niche, measured as Simpson's index of habitat diversity. When both species coexisted on the same plot, Siberian lemmings were ousted into the moister habitats with a moss-sedge type plant cover. The spatial distribution of lemmings was patchier when the habitat diversity increased. The home range size decreased when the population density increased.

Population Dynamics – Session 2

The linkage between *Melocanna* bamboo flowering and rodent outbreaks: an empirical study from Chittagong Hill Tracts of Bangladesh

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In 2006 to 2010 rodent population outbreaks resultant from the 50-year cycle of bamboo flowering were reported in Mizoram, India, the Chittagong Hill Tracts, Bangladesh, and Chin State, Myanmar. The ecological dynamics between rodent population outbreaks and bamboo flowering were studied in Ruma Upazila of Bandarban district. Small mammal trapping (March 2009 to December 2011) in the villages of Basatlang, Munlai, Mualpi and Neweden was carried out to understand the dynamics of rodent populations in different habitats. The highest percentage of rodent species was captured at community households, followed by bamboo forests, crop fields and outside around villages. Ecological survey of bamboo flowering and bamboo seed fall in 2009 found that there were differences in partially rodent eaten seeds per square meter by month ($p=0.0001$) and a positive correlation between seed fall and partially eaten seeds ($r=0.611$). In 2010 there was a positive correlation ($r=0.417$) between seed fall and the number of rodent damaged seeds in response to cut, burned and normal bamboo forest. The study confirms that massive bamboo seed fall increases food availability for rodents, rodents do indeed eat bamboo seeds and the extended availability of seed leads to population outbreaks. Particularly *Rattus rattus* was able to breed for 4-5 months in the forest with animals migrating out in to farmers' fields as the bamboo seed germinated, causing crop losses of 80-100%. Shortening the time of rodent breeding was possible by cutting and/or burning the bamboo forest at the time of flower initiation as this led to a significant delay in seed production. Implementing large scale bamboo clearance could help prevent the development of population outbreaks or reduce their severity. Although farmers did not feel competent or knowledgeable about rodent management, their main coping strategy of planting earlier ripening rice crops in order to harvest before rodent outbreaks develop, is a sound strategy that should be encouraged during outbreak years. Research on increasing the yield of earlier ripening crops could help manage food insecurity during rodent outbreaks.

Population Dynamics – Session 2

Population dynamics and breeding patterns of multimammate rat (*Mastomys natalensi*, Smith 1832) in semi-arid areas in Tanzania

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The population dynamics and breeding patterns of Multimammate rat (*Mastomys natalensis* Smith 1834) in maize agro-ecosystems in semi-arid areas in Tanzania was investigated from March 2016 to February 2018 in the maize fields and fallow land. A capture mark release study was carried out with four 70 x 70 m grids and set at farmers' fields using live-trapping at a distance of 10 x 10 m apart for three consecutive nights. Rodent species captured were: *Mastomys natalensis*, *Lemniscomys rosalia*, *Lemniscomys zebra*, *Gerbilliscus vicinus*, *Pelomys fallax*, *Arvicanthis neumani*, *Thallomys paedulus* and *Acomys wilsoni*. *Mastomys natalensis* was the most abundant (>93%) of all species captured while other were in low number in both habitats. The highest population was observed from June to October indicating that was probably due to the influx of juveniles into the population. It was observed that the study area experiences a short rainfall season with extended breeding patterns for *Mastomys natalensis*. However, the highest percentage of reproductively active animals was found during April and the lowest level in September and October. We concluded that most females *Mastomys natalensis* are reproductively active when there is enough food and rainfall. It is recommended that there will be necessary to reduce breeding activity by preventing access to fresh vegetative food such as young sprouting grass.

Population Dynamics – Session 2

Effects of stream proximity on trails of *Cuniculus paca*: a 20 year survey

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The Paca (*Cuniculus paca*), found from Mexico to Brazil and Paraguay, is one of the largest rodents in the world (5-14 kg). The species is hunted for its valued meat throughout its distribution area. Pacas use burrows that have multiple entrances and exits, with at least one leading to a water source. The latter is used both to escape from predators as well as in reproductive behavior. Given the foregoing, the density of pacas and their trails should therefore theoretically be higher nearer sources of water. We walked a trail leading away from a stream and recorded the number of paca trails at 50 m intervals for 600 m, and every 10 m along an elevation gradient. This count was conducted over the span of 20 years (1997–2017), at the Alberto Manuel Brenes Biological Reserve, San Ramón, Costa Rica, specifically along the Palmito trail (10° 13.14 N, 84° 35.79 W). The number of paca trails decreased with distance from water in 2017 ($y = -0.024x + 7$, $R^2 = 0.82$). We found seven trails at 50 m from water, five at 100 m and three at 150 m. Besides that we found only one additional trail, 250 m from water. The relationship between trail number and elevation was also significant, but not as strong ($y = -0.018x + 17.67$, $R^2 = 0.44$). There is therefore a clear relationship between distance from water and elevation at the site. The highest distances from water were found in 2007 and the largest number of trails in 2010 (10 trails at 50 m). The smallest number of trails was found in 2005, all within 200 m of water. The pattern has been consistent throughout the years: the number of paca trails always is greatest nearer the stream, although numbers and distances varied, perhaps due to climatic factors.

Population Dynamics – Session 2

It's a trap: effective methods for monitoring mouse populations in Australia

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Feral house mice cause substantial economic damage to grain crops in Australia, particularly during house mouse plagues. Populations are monitored to detect changes in abundance and to use in models to forecast likely mouse outbreaks. However, it is not possible to use live-trapping (the "gold standard") for assessing mouse abundance at a large number of monitoring sites spread across southern and eastern Australia. A range of alternative methods was tried to assist the grains industry with strategic decisions to reduce crop damage. The aim of this work is to determine which survey methods could provide useful, affordable information across a large area. Monitoring of mouse populations was conducted at representative grain farms using (1) live trapping at long-term ("benchmark" sites (n=3), (2) mouse chew cards and active burrow counts (n=110 farms), and (3) qualitative information networks with growers, grower groups and advisors (n=12 regions). Monitoring was conducted over 5 years through low, medium and high abundance conditions. Live trapping provided the most useful, but most expensive, information. There was wide variability in chew card and active burrow counts much of which was unlikely to be due to differences in mouse abundance. When alternative food was abundant, mice did not use chew cards. When crop biomass was high, it was difficult to detect active burrows. Live trapping supplemented with data from chew cards and active burrows remains the best approach to monitor a wide range of sites. We are now exploring development of automated recording systems to signal changes in mouse activity in fields. These systems will need to be compared against data from live trapping sites over a range of conditions. It is likely that live-trapping will need to be used for the foreseeable future to provide useful information such as breeding condition and population abundance, required for the forecast models.

Population Dynamics – Session 2

Study on the evolutionary ecology of small herbivorous mammals: life history strategy of plateau pika (*Ochotona curzoniae*)

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Life history research lies at the heart of evolutionary ecology. It studies the complex relationships in the living process, which can help us understand the evolution theory and analyze and predict population dynamics. After studying life history of plateau pika, an endemic herbivorous small mammal habituating in the Qinghai-Tibet Plateau, the following results are reported: 1. General life history features of plateau pika. 2. The similarities and differences of life history features between plateau pika and boreal pika. 3. Survival features of plateau pika in life history 4. Reproductive features of plateau pika 5. The body growth rule of plateau pika and its growth model. The growth model of juveniles is: $dm/dt=6.5266 \cdot m^{0.75} - 12.1787 \cdot m$. 6. Trade-off between life history features. 7. The fitness level of plateau pika in Mammalia. A life history feature table and a life history strategy analysis table of 65 mammal species belonging to 9 Order have been compiled according to their life table data, among which the fitness indexes of 46 species have been calculated. The fitness index of plateau pika is ranked 43rd, only higher than those of bank vole (*Myodes glareolus*), chimpanzee (*Pan troglodytes*) and African elephant (*Loxodonta africana*). The fitness index of plateau pika ($r=0.1125$) was lower than that of boreal pika (*Ochotona princeps*) ($r=2.172$). The survival rate is the main factor influencing fitness. 8. The dynamics of plateau pika population. The density of plateau pika population in three years was calculated with a computer program compiled in Turbo C language, according to Jolly-Seber method. The dynamics of plateau pika population was coincident with the low intrinsic population growth rate ($r=0.1125$), i.e. plateau pika population was stable.

Rodent-Borne Diseases

Review of hosts of Lassa virus in west Africa

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Lassa virus (LASV) causes a deadly haemorrhagic fever in humans, killing several thousand people in West Africa annually. For more than 40 years, the Natal multimammate mouse, *Mastomys natalensis*, has been assumed to be the sole host of LASV. But three other species have been found LASV positive recently: the African wood mouse, *Hylomyscus pamfi*, the Guinean multimammate mouse, *Mastomys erythroleucus* and the pygmy mouse *Mus baoulei*. This presentation is a review gathering these recent findings in Nigeria, Guinea, Benin and Ghana. There is no specific *Mastomys* host per lineage since *Mastomys natalensis* is host to lineages II and IV, and *Mastomys erythroleucus* is host to lineages III and IV. Only *Hylomyscus pamfi* and *Mus baoulei* seem specific to new LASV lineages. A time-calibrated phylogeny of the partial glycoprotein sequences suggests a recent host-switching (40-60 years) between *Mastomys natalensis* and humans in Sierra Leone and Nigeria, but an older one (150-200 years) in Guinea and Mali. Analyse suggests a very old host-switching (500-600 years) between *Hylomyscus pamfi*, or *Mus baoulei* and humans, or may be between *Hylomyscus pamfi* or *Mus baoulei* and commensal rodents such as *Mastomys natalensis* and *Mastomys erythroleucus*. A general model of transmission between rodents and humans is proposed as part of the eco-pathosystem.

Rodent-Borne Diseases

Phylogenetic analysis and prevalence of Lassa virus in multimammate mice within the highly endemic Edo-Ondo hotspot for Lassa fever, Nigeria

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Lassa fever is a rodent-borne viral hemorrhagic fever that kills thousands of humans yearly in Nigeria and certain other west African countries. Recently, multiple host species of the Lassa virus (LASV) were recorded in preliminary surveys of small mammal populations around Nigeria. LASV lineage II was detected in the multimammate mouse *Mastomys natalensis* in southwestern Nigeria while lineage III was discovered in *Mastomys erythroleucus* to the east. This calls for more site-specific investigations to further understand the virus-rodent distribution and prevalence of LASV per endemic area. In this study we focus on 6 localities spanning the Lassa fever hotspot that runs through Edo and Ondo States within southwestern Nigeria, where LASV lineage II was previously discovered in *Mastomys natalensis*. During 2014-2016 1,038 small mammal specimens, representing at least 13 species, were captured. Whole blood from these specimens was screened for LASV by RT-PCRs targeted on S and L segments. Out of these *Mastomys natalensis* was LASV-positive in 5 localities while *Mastomys erythroleucus* also tested positive in one of the 5 localities. Phylogenetic analysis of virus sequences obtained from PCR-positive rodents show they all belong to LASV lineage II, the first time this lineage has been found in *Mastomys erythroleucus*. This demonstrates it is probably easier than previously thought for LASV to jump between *Mastomys* hosts. LASV phylogenetic clades clustered according to geographical location only to a certain extent. Our findings also show that LASV prevalence in rodents, even within this heavily endemic zone, is quite varied; ranging from 0% to 78% for *Mastomys natalensis*, for example. Our results provide increased insight concerning the risk of rodent-to-human transmission of LASV in the Edo-Ondo area, especially as concerns the identity and distribution of natural rodent reservoirs. In addition, our findings point out high-prevalence localities where disease-control efforts can be focused.

Rodent-Borne Diseases

Manifold implications of host species diversity on parasite occurrence: a community perspective

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Host species diversity is expected to have dramatic effects on parasite occurrence via multiple, sometimes contrasting, mechanisms. We employed a natural gradient of rodent species diversity and explored the bacterial community in the wild rodents' blood. In exploring the entire bacterial community, we have shown that it becomes more diverse with greater host diversity. However, the two dominant bacterial species responded differently to the diversity gradient; *Mycoplasma* bacterium was diluted with increased host diversity, whereas the *Bartonella* bacterium reached its peak of occurrence at medium host diversity levels. Laboratory experiments suggest that this difference in bacterial response is the result of their distinct transmission mechanisms and the level of specificity to the rodent species. Taken together, our results highlight the contribution of a community approach for understanding host diversity-parasite occurrence relationships and suggest that although these relationships may be complex in nature, they are somewhat predictable.

Rodent-Borne Diseases

Bacterial parasite communities of the fossorial water vole *Arvicola terrestris* during a period of high abundance: richness and similarity in a dynamic world

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The fossorial water vole *Arvicola terrestris* is a grassland rodent and significant agricultural pest in the eastern French region of Franche-Comté. This species exhibits population outbreaks with a mean period of 6 years and a high abundance phase of 1-3 years. Little is known about the bacterial parasites found in this species or how bacterial parasite communities may change during the peak phase. We used high-throughput sequencing to sequence the V4 region of the 16s rRNA gene of bacterial DNA extracted from spleens, livers, lungs, hearts, and kidneys of *Arvicola terrestris* individuals collected during autumn 2014, spring and autumn 2015 and spring 2016 from 5 sites in Franche-Comté to determine if bacterial parasite communities in this host vary spatially and temporally during the host high abundance phase. 32 bacterial operational taxonomic units (OTUs) corresponding to 12 parasitic bacterial genera were detected, including *Bartonella* sp., *Mycoplasma* sp., *Leptospira* sp., *Mycobacterium* sp., and *Bordetella* sp. Generalized linear modelling was used to identify significant predictors of OTU richness at the host individual (infracommunity) and host population (component community) scale; infracommunity richness ranged from 0 to 9 OTUs/animal and was best predicted by sampling site and date, with spring richness significantly lower than autumn richness. Bootstrapped component community richness ranged from 6.9 to 17.7 OTUs/population and was best predicted by local host abundance, with high-abundance populations hosting richer communities than low-abundance populations. Communities from autumn 2014 were significantly richer than spring communities despite low local host abundance at one site. Mantel tests using Jaccard and geographic distance indicate that infracommunity similarity, but not component community similarity, decay (weakly) with geographic distance. Characterization of infra- and component community richness and similarity at high abundance provides us with a foundation from which changes in bacterial parasite communities during the decline and low-abundance phase can be explored.

Rodent-Borne Diseases

Parasites of urban rodents representing sanitary risk in La Plata city, Argentina: an example of the Latin American situation

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Argentina, as the rest of Latin America, is characterized by an important social fragmentation. There are numerous areas, mostly around big cities, where people live in conditions that represent a constant risk for their health. These conditions are represented mostly by environmental and structural factors (as accumulated garbage, polluted water bodies, absence of sewage networks, etc.). This context generates a suitable scenario for the presence of urban rodents, which are represented by the Norway rat (*Rattus norvegicus*), the black rat (*Rattus rattus*) and the house mouse (*Mus musculus*). These synanthropic species are related to a high number of pathogens that directly affect to human health. The aim of this study was to register parasites of urban rodents that represent sanitary risk in different areas of La Plata city and to analyze factors that could be favouring their presence. Seasonal samplings were carried out in seven areas of Gran La Plata, Buenos Aires province, Argentina: six shantytowns and peripheral neighbourhoods and one area of the inner city of La Plata. A total of thirteen species of parasites were found: *Acantocephala* spp., *Capillaria hepatica*, *Eimeria* spp., *Heterakis spumosa*, *Hymenolepis diminuta*, *Neospora caninum*, *Nippostrongylus brasiliensis*, *Rodentolepis nana*, *Strobilocercus fasciolaris*, *Strongyloides ratti*, *Syphacia muris*, *Toxoplasma gondii* and *Trichuris muris*; and one genus bacteria: *Leptospira* spp. Six of these taxa represent a potential sanitary risk for human and domestic animals: *Strobilocercus fasciolaris*, *Hymenolepis diminuta*, *Hymenolepis nana*, *Capillaria hepatica* (helminths); *Toxoplasma gondii* (Protozoa) and *Leptospira* spp. (bacteria). The highest number of zoonotic species was observed in the areas with water bodies passing through and accumulation of garbage. This study shows urban rodents as sentinels of zoonotic diseases, alerting about the necessity of implementing actions tending to decrease their presence, with the final aim of avoiding risks to human and animal health.

Rodent-Borne Diseases

Helminth communities in synanthropic rodents of Buenos Aires (Argentina)

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The murine rodents *Mus musculus*, *Rattus rattus* and *Rattus norvegicus* are considered among the best urban adapted mammal species around the world and are host of different human pathogens, including zoonotic helminth species. As their presence in cities is related to poor hygienic and environmental conditions, rodents represent good biological models for pathogen transmission studies in urban environments. In this study, rodents were captured in the City of Buenos Aires (Argentina) for parasitological screening in 3 representative environments: residential neighborhoods (where the dominant species *Rattus rattus* is); shantytowns (the dominant species are *Rattus norvegicus* and *Mus musculus*) and parks (*Rattus norvegicus* and *Mus musculus* are the dominant species, accompanied by the native *Oligoryzomys flavescens*). Seventy-five percent of the rodents were parasitized with at least one of the 12 identified helminth species (1 acanthocephala, 3 cestodes and 8 nematodes), including species like *Hymenolepis nana* and *Hymenolepi diminuta*, recognized worldwide from a zoonotic aspect. Our results showed that helminth communities of urban rodents could be grouped according to composition and relative abundances and responded to the structure of host community. Each rodent species presented its own characteristics in terms of richness, diversity and helminth composition, keeping these characteristics still occupying more than one landscape unit. Several mechanisms contribute to complexity of the structure of parasite communities, where parasites itself, definitive and intermediate hosts and environmental and anthropogenic factors all play a role in the dynamics of parasitological communities. Inhabitants of shantytowns would be the most exposed to zoonotic diseases transmitted by rodents. As shantytowns they are not included in urban planning programs, it is essential to focus efforts on individual and community actions in improve environmental quality to reduce exposure to rodent-borne diseases.

Rodent-Borne Diseases

Towards understanding the role of small mammals in the transmission of Lyme disease in Virginia, USA

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Larvae and nymphs of many species of ticks select small mammals, reptiles, and birds as hosts. Since 2011, we have examined more than 1,000 small mammals of 10 species and collected a small tissue sample as well as all visible ticks; rates of infestation range from 18% in harvest mice to 53% in meadow voles. Identification of immature ticks is challenging and requires molecular or genetic methods beyond classification as being from the genus *Ixodes* or another genus. *Ixodes* ticks include *Ixodes scapularis*, the species that transmits the Lyme disease-causing bacterium *Borrelia burgdorferi* to humans. Of the approximately 2,300 ticks collected from small mammals, 491 were identified as *Ixodes* spp. ticks.

Rodent-Borne Diseases

Connecting the dots: linking *Yersinia pestis* seroprevalence in rodents and shepherd dogs to flea abundance in western China

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The People's Republic of China still suffers from many outbreaks of plague (caused by *Yersinia pestis*), since plague was firstly recorded around 1353 in the northeastern Hebei province. In order to understand its epidemiological dynamics for controlling reasons, in this study, the distribution and prevalence dynamics of *Yersinia pestis* in Sichuan Province (China) was investigated during the period 1997-2013. Rodents and fleas from captured rodents' fur and their burrows were collected from 2001-2012. Moreover, this information was analyzed combining with the seroprevalence in shepherd dogs screened from 1997 to 2013. 6,101 (43%) of the 14,202 investigated rodents carried infected fleas. However, the % of rodents carrying infected fleas and the flea index varied over the different years. Temperature, air humidity and precipitation can predict the incidence *Yersinia pestis* in Qinghai voles. The average number of fleas in the burrows varied over the years and between the different months of the year. Generally, flea numbers are still low in the period May-June, but peak in August and September. The average number of fleas per burrow and the % of infected dogs were strongly correlated, $r(7) = 0.89$, $p < 0.01$. The seroprevalence in shepherd dogs was 9.7% (78/801). The results indicated that the risk for pathogen transmission is likely to be most eminent in the time of year that the average number of fleas per burrow is the largest. The shepherd dogs are the most possible vectors that transfer the pathogen among its owners and rodents.

Workshop Rodent-Borne Diseases

Ecology of Puumala hantavirus in Europe

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Understanding the dynamics of zoonotic hosts and zoonotic pathogens in their reservoir host populations is a prerequisite for predicting and preventing disease epidemics. The infection risk of humans by Puumala hantavirus (PUUV) is high in northern Europe, where like in Finland bank voles (*Myodes glareolus*) undergo cyclic fluctuations. During 1995 - 2017 about 35,000 human cases of NE (nephropathia epidemica) were diagnosed in Finland. We analysed the annual NE incidence in various parts of Finland, from coastal areas to inland and from south to north, reflecting declining proportion of agricultural land and forest fragmentation. There was a trend for one year NE peaks in coastal and southern regions while two year peaks occurred inland, possibly indicating more restricted dispersal of host and virus in the increase phase in former ones. We review a detailed 7-year longitudinal capture-mark-recapture study, mostly at monthly intervals, on seasonal and multiannual patterns of the PUUV infection in the highly endemic area in Central Finland. Infected bank voles were most abundant in mid-winter months during years of increasing or peak host density. Seroprevalence of PUUV in bank voles exhibited a regular, seasonal pattern reflecting the annual population turnover and accumulation of infections within each cohort. In autumn, the PUUV transmission rate tracked increasing host abundance, suggesting a density-dependent transmission. However, prevalence of PUUV infection was similar during cyclic increase and peak years despite a twofold difference in maximum host density. This may result from the high proportion of young individuals carrying maternal antibodies in summer of the peak year delaying transmission during the cycle peak years. This increase/peak dilemma is reflected in the human NE incidence: even though the bank vole density is clearly higher in the peak year, the number of NE cases can often be similar or even higher in the increase year.

Workshop Rodent-Borne Diseases

Review of leptospirosis carriage in rodents worldwide and identification of key host species and knowledge gaps in the Asian-Pacific region

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Some rodent species are well known to live in close proximity to human houses and storage facilities and can both consume and contaminate stored produce. Rodent borne diseases can also be transmitted to human and livestock through contaminated food and exposure to rodents feces and urine. Here we report on the epidemiological aspect of a joint research project; RAT-ADAPT (Rodent damage and transmission of rodent-borne zoonotic disease in households in Asian-Pacific territories). The project focuses on rodent-borne diseases and food security. In a first stage the SCOPUS database was screened with the keyword string "rodent* OR rat* AND leptospir*" to identify the current state-of-the art knowledge on leptospirosis rodent reservoir hosts. Over 1,700 relevant English records over the past 20 years were found. These records were allocated to geographic regions using a text-mining approach and this information was combined with recent WHO maps on mortality and morbidity of leptospirosis worldwide to identify key knowledge gaps in the Asian-Pacific region. Grey literature reports and personal communication with health authorities in the region were used to complete the review. The primary rodent hosts were identified. Additionally, household surveys were conducted to gather farmers' knowledge on leptospirosis disease local rodent hosts. In a second stage and to fill some apparent knowledge gaps, rodent trapping and leptospira screening by PCR was carried out in selected countries of the Asian-Pacific region (Myanmar, Sri Lanka and Indonesia). These data will be used to identify the disease focal areas and implications of flooding on rodent host and disease epidemiology. Moreover, a better understanding of rodent dynamics will also assist in crop protection and conservation in the Asian-Pacific region.

Workshop Rodent-Borne Diseases

Leptospirosis in Madagascar: the epidemiology of multiple *Leptospira* species in diverse host communities

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Leptospirosis can be caused by a range of *Leptospira* species and is one of the most common, but neglected, zoonotic diseases in the world. Understanding the relative importance of different reservoir species and the distribution of infection across heterogeneous tropical landscapes is crucial for developing effective public health strategies. In a study of invasive and endemic small mammals inhabiting a forest-agricultural landscape in Madagascar, three of the four pathogenic *Leptospira* species found infected the invasive *Rattus rattus*, including species more commonly found in other sympatric hosts. Mixed infections were frequent, with strong evidence of facilitation between *Leptospira* species. Thus, due to their abundance and wide distribution, *Rattus rattus* could act as epidemiological bridges between forests and agricultural areas, as well as potentially enabling the evolution of new strains through recombination in coinfecting hosts. *Leptospira* infections were more common *Rattus rattus* from sites with more irrigated rice-fields. This pattern was largely driven by *Leptospira borgpetersenii* rather than *Leptospira interrogans*. Increased transmission of *Leptospira borgpetersenii* in rice-field dominated areas could be related to improved environmental persistence of leptospires, but could also be affected by the higher abundance of *Mus musculus* in these areas, a species with a high prevalence of intense *Leptospira borgpetersenii* infections. Thus, although *Rattus rattus* is a key reservoir host, other mammal species may play important roles in the complex epidemiology of leptospirosis.

Workshop Rodent-Borne Diseases

Bornaviruses as “novel” zoonotic pathogen

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Bornaviruses are known for a very long time in Germany and are named after the city of Borna in Saxony due to an outbreak of the “Borna disease” in horses. The causative agent is the classical Borna disease virus 1 (BoDV-1) which is most likely transmitted by shrews (*Crocidura leucodon*). Since 2015, four deaths of human encephalitis patients from infection by a novel squirrel bornavirus (variegated squirrel bornavirus 1; VSBV 1) were recorded in Germany. This unexpected incidence raised serious concerns about the zoonotic and pathogenic potential of VSBV 1 and related bornaviruses. The number of squirrels or humans currently infected with or exposed to potentially harmful bornaviruses is not known, and it is also unclear whether only squirrels can transmit such viruses or whether a reservoir in other hosts exists that needs to be identified. In addition, very recent findings also confirmed that the classical bornavirus BoDV-1 can induce lethal infections of humans. Therefore, more research data are urgently needed, and the BMBF-funded Zoonotic Bornavirus Consortium “ZooBoCo” started mid 2017 to provide data for a better understanding of the zoonotic potential of these mammalian bornaviruses, their distinctive features as well as their putative reservoir host species and the way of transmission. The consortium consists of members working in veterinary or human medicine, at universities, clinical research institutes and governmental institutions. Collaborations with international partners will also allow performing risk assessment studies in non-human primates. The main goal of this „one health“- approach is to provide a solid basis for improved public health measures and guidelines helping to identify and handle pathogenic bornaviruses and their reservoir species. This will be also a blueprint for effective measures and instruments concerning zoonotic infections originating from animal reservoirs like zoo and (exotic) pet animals, wild rodents or insectivores.

Workshop Rodent-Borne Diseases

The role of rodents in tick-borne viral diseases with special emphasis on tick-borne encephalitis

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Tick-borne viruses are principally transmitted by ticks. However, beside ticks vertebrates play an important role for most tick-borne pathogens as reservoir hosts or as amplifying hosts. Tick-borne encephalitis (TBE) is the most important viral tick-borne disease in Eurasia. The tick-borne encephalitis virus circulates between ticks and several rodent species seem to play an important role as amplifying hosts. Rodents, mainly the bank vole (*Myodes glareolus*) and field mice (*Apodemus* spp.) play an important role for the amplification and sustaining of the natural transmission cycle. There is increasing evidence that TBE virus can be found in the brains of small rodents during winter time which let us hypothesize that the viral neurotropism of TBE virus in humans might be an erroneous ecological hibernating mechanism of TBE virus in a wrong host. The effect and impact of the amplifying host species on the pathogenicity of TBE virus remains to be clarified. Besides this, there is increasing evidence for a major role of rodents for the genetic stability of TBE virus. Multiple passages of TBE virus exclusively in ticks seem to degenerate the viral genome and cause extinction of the virus transmission cycle. These examples show that rodents beside a specific role as amplifying and reservoir hosts may play a more complex role in the viral natural maintenance cycle of tick-borne viruses.

Workshop Rodent-Borne Diseases

Network “Rodent-borne pathogens”: looking into the rodent reservoirs

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Rodents are important as pests in agriculture and forestry, as model organisms for biomedical studies and as pathogen reservoirs. These pathogens might be zoonotic and cause disease in domestic animals and humans. Alternatively, they might be rodent-specific and have no or still unknown zoonotic potential. The network “Rodent-borne pathogens” was established as a platform for an interdisciplinary collaboration of scientists working in mammalogy, ecology, genetics, immunology, toxicology, epidemiology, virology, microbiology, parasitology and human and veterinary medicine. The network was involved in the discovery of novel DNA and RNA viruses, some of them with potential to serve as models of human pathogens, such as bank vole hepacivirus, closely related to human hepatitis C virus or rat hepatitis E virus (HEV). Currently ongoing studies on the zoonotic variegated squirrel bornavirus 1 (VSBV-1) are dedicated to the identification of the geographic and host origin of this virus. Further studies of the network are focussed to pathogens in Norway rats from different habitats, including pest rats in zoos and from agricultural areas, and from breeding colonies. These studies detected high frequencies of infections with *Leptospira*, rat hepatitis E virus and *Rattus norvegicus* polyomavirus 1. Currently a workflow will be established including various pathogen-specific RT-PCR/PCR and serological assays, multiplex serology and open-view methods, including isolation approaches. A current interdisciplinary study within the RoBoPub consortium deals with the reservoir association and geographic distribution of Puumala orthohantavirus (PUUV) and *Leptospira* spp. in Germany and consequences of population bottlenecks on their molecular evolution. In conclusion, the network provides an important infrastructure for ongoing collaboration that is highly beneficial for interdisciplinary scientific work with high relevance in several fields of research. Additional targeted and non-targeted investigations within the network will help to increase our still very limited knowledge about the “virosphere” in rodents.

Workshop Rodent-Borne Diseases

Who is the reservoir of Monkeypox? Work in progress

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Human Monkeypox is a disease that is known from central and west Africa and that is caused by the Monkeypox virus, an Orthopoxvirus. It is a zoonosis with symptoms similar to smallpox and increasing frequency of human-to-human transmission in central Africa. Two separate clades of the virus exist: the Congo basin clade with a mortality of about 15% and the west African clade that causes a milder disease. Human cases were frequently seen during localized outbreaks in DR Congo but in the last 12 months epidemics have been reported from Nigeria (where Monkeypox had not been reported since 1978), Central African Republic and Liberia. In none of these cases, the source of the virus or what caused the (re-)emergence of the disease was known. The natural reservoir is still unknown (despite the name, it is not primates) but an introduction of Monkeypox to the USA in 2003 was linked to the import of *Cricetomys gambianus* and *Graphiurus* sp. from Ghana. Also squirrels are often mentioned as potential hosts. Intensive field work in DRC, in areas where Monkeypox is endemic in humans but also in areas where it has not been reported, has yielded a number of sequences from different species of small mammals (rodents, shrews, bats, carnivores, ...) that showed traces of Orthopoxvirus DNA. Overall prevalence was between 10 and 20 percent. Yet no species stood out as one in which the infection is more common and the genetic distances between the observed viral material were not related to the phylogeny of the host. Similarly, a wide array of mammals have proven seropositive without pointing to a particular host species. Our screening work is currently continuing and by the time of the conference we hope to present more detailed results and to suggest working hypotheses for further research.

Workshop Rodent-Borne Diseases

Optimal control model for rodent-borne leptospirosis in Salvador, Brazil

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Within the next three decades, two million people worldwide will live in urban slums, making up around 70% of the urban population in poor countries. Slum communities face a myriad of political, economic, and health challenges, yet often lack sufficient resources or central (governmental) planning to address them. In low to medium income countries, infectious diseases of poverty are common, including globally distributed zoonoses such as leptospirosis, which impart their greatest burden on the urban poor. In Brazil alone, 12,000 people annually are infected with *Leptospira*, a zoonotic bacteria carried and shed in urban settings mainly by brown rats (*Rattus norvegicus*). Few studies have evaluated the effectiveness of interventions, such as application of rodenticide or habitat modification. Rodenticides temporarily reduce rodent abundance while habitat modification such as closing of sewers reduces both carrying capacity of rat populations and survival of *Leptospira* in the environment. Given the scarcity of resources and need for intervention, it is important to evaluate the cost-effectiveness of different combinations of time-dependent intervention scenarios. We here present a mathematical model based on optimal control theory, using age-structured model for leptospire infection in a rat populations and parameters inferred from empirical studies in five slum communities in the city of Salvador, Brazil. An optimal control models optimizes time-dependent interventions through incorporating both the cost of an intervention and the cost of an infection. Our results suggest that habitat modification, despite being relatively more expensive; can reduce infection prevalence in rat populations. Continuous application of rodenticide reduces rat populations sufficiently to diminish human risk. The models presented here, using leptospirosis as a case study, can guide the optimal allocation of resources to reduce zoonotic risk.

Workshop Rodent-Borne Diseases

Identification of potential endemic rodent hosts for zoonotic pathogens in South Africa using network analyses

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The loss of biodiversity has been suggested to increase the risk of zoonotic spillovers of pathogens and parasites from wildlife posing a challenge to human and animal health. At the same time, predicting and identifying potential wildlife sources of zoonotic pathogens and/or parasites is difficult, particularly for poorly studied wildlife communities such as those of endemic rodents in many regions of Africa. Using field collections of ecological and parasitological data from eleven sympatric small mammal species (nine rodents, two insectivores) and their ectoparasitic arthropods (ten tick species, 14 mite species, 5 flea species and 4 louse species) we analysed network metrics including modularity and node centrality to evaluate the relative epidemiological importance of the rodent species captured in Telperion /Ezemvelo Nature Reserve, Gauteng Province, South Africa. Networks showed an intermediate level of nestedness but in both bipartite and unipartite networks two closely related murid rodents, *Micaelamys namaquensis* and *Aethomys ineptus*, emerged as sharing a large number of arthropod vectors with other rodents that also affect livestock and humans. These include ticks and fleas that may act as vectors for pathogens of medical (*Rickettsia conorii*, *Yersinia pestis*) and veterinary importance in the region (*Theileria parva*, *Anaplasma marginale*, *Babesia bigema* and *Ehrlichia bovi*). The two murids appear to be habitat generalists compared to other sympatric rodents and have been recorded as human commensals in parts of South Africa. As the geographic range of *Micaelamys namaquensis* includes most of sub-Saharan Africa and they are host to several *Bartonella* spp., including those of zoonotic concern, our findings suggest that this species may act as a source of zoonotic spillovers in the future. Thus, more detailed studies of its biology and pathogen/parasite community are need to prevent the emergence of zoonotic diseases from this host.

Workshop Rodent-Borne Diseases

An interdisciplinary approach to reduce leptospirosis in two slum communities in Salvador, Brazil

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One billion people worldwide reside in informal, slum communities, characterized by overcrowding, lack of infrastructure and basic sanitation, and inadequate access to potable water. Slum residents suffer disproportionately from infectious diseases including zoonosis. Leptospirosis, transmitted mainly by rats, is exacerbated by complex structural and tropical climate conditions that affect vulnerable populations. In low-and-middle-income countries, the majority of the slums lack support and action from the local and federal government agencies, in which community organizations fill the gap to address disparities within the current system. Our study aims to develop collaborative maps on a fine geographical scale using objective measures of *Leptospira* transmission risk, such as serological surveys and rodent trapping, which we combine with youths' assessment of the built and social environment. Perceived risk will be measured using participatory methods, such as Photovoice, to visualize and discuss communities' perceptions through the use of photography. To improve our spatial distribution of risk, we will integrate objective and perceived risk for human infection and infer relevant factors that were not originally considered. This collaborative effort can improve our assessment of risk through active engagement and dialogue with community members, who will also participate in the decision-making process to inform future local interventions.

Workshop Rodent-Borne Diseases

Assessing the effect of native forest replacement by exotic plantations on Andes hantavirus infection in wild rodents from central Chile

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Land conversion for forestry/agricultural activities may increase hantavirus transmission in wild rodent hosts, sometimes creating conditions for outbreaks of hantavirus pulmonary syndrome (HPS) in humans. In Chile, a hantavirus strain named Andes virus (ANDV) causes HPS with mortality rate of 40%. One of the most important land-use change in central Chile is the replacement of native forests by exotic Monterey pine (*Pinus radiata*) plantations, which modifies the structure and species composition of rodent assemblages. Therefore, our aim was to study ANDV seroprevalence in wild rodents inhabiting native forest and pine plantations, and assess possible population and community parameters of small mammals that may influence ANDV infection. Rodents were sampled seasonally during 2016 and 2017 in a landscape that contains extensive stands of Monterey pine and interspersed remnants of Maulino forest, a native temperate forest from central Chile. Three types of habitats were sampled: native forest, adult pine plantation and young pine plantation. Blood samples were tested for antibodies against ANDV using a strip immunoblot assay. 1,630 blood samples from seven species were analyzed. Four species had seropositive samples and seropositive individuals were present across all sampling sites. ANDV seroprevalence in *Oligoryzomys longicaudatus* (the principal reservoir of ANDV) was significantly higher in native forest with an overall seroprevalence of 7.5%, compared to the other habitats in which the overall seroprevalence range from 0% to 2.8%. The abundance of the principal reservoir was the main predictor of ANDV infection. Our findings suggest that land conversion to Monterey pine plantations, including adult and young plantations would not increase ANDV risk exposure to humans.

Workshop Rodent-Borne Diseases

High disease transmission risk from occasionally synanthropic rodent reservoirs

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The risk of transmitting pathogens from rodents to humans is determined by amongst others the contact zone in time and space. Transmission modes (indirect, direct) explain how pathogens are transferred to humans, but do not explain the conditions leading to the transfer of pathogens from rodents to humans. Here, we present the concept of "contact modes" between rodents and humans. We identified occasional synanthropy, viz. rodents occasionally entering human dwellings, as a major contact mode represented in 114 out of 216 reservoir rodent species and being a contact mode in 50 out of 67 zoonotic diseases spread by rodents. We revealed occasional synanthropy to be common in northern latitudes in North America, large parts of Europe, Russia and East Asia, while true synanthropy (species more or less exclusively found in and near human dwellings) to be more common in southern latitudes in South America, Africa and South-East Asia. Occasionally synanthropic rodents spend the majority of their life in other environments (e.g. forests, fields and wetlands). We analyzed intrinsic (e.g. population density) and extrinsic (e.g. weather conditions and food availability) factors potentially triggering occasional synanthropy. We discuss to which extent the timing of occasional synanthropy is predictable and how this knowledge can be used for alerting the public about transmission risk and for disease prevention and control.

Workshop Rodent-Borne Diseases

Dynamics of *Leptospira* and Tula orthohantavirus in small mammals: impact of landscape and biodiversity

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Rodents are important reservoirs for zoonotic pathogens that cause severe diseases in humans. Recent investigations revealed that factors like land-use and small mammal biodiversity have the potential to mitigate the underlying transmission processes on various levels. Biodiversity is hypothesized to be more closely related to pathogen prevalence on the population level, through direct mitigation of transmission rates while certain landscape features might also promote or hinder transmission. Although these factors are crucial to estimate potential future changes in human infection risk, they remain poorly understood. Here we present the first results of an ongoing large-scale field experiment. In Central Germany small mammals were trapped in 2017 and analysed for *Leptospira*, an ubiquitous bacterium, and *Tula orthohantavirus* prevalence in spring, summer and autumn. Trapping was conducted on woodlands and adjacent grasslands that differed in the intensity of land use. Prevalences ranged between 0-58% for *Tula orthohantavirus* and *Leptospira* prevalences reached 41% in *Microtus* species in autumn. First analysis revealed a strong impact of small mammal biodiversity on the growth rates of the common vole (*Microtus arvalis*) population. This study will generate a better understanding of natural pathogen-host dynamics, allowing public health recommendations and policy advice according to predicted future biodiversity scenarios.

Workshop Rodent-Borne Diseases

Temporal changes in rodent density and climatic factors as ecological drivers of tick-borne encephalitis (TBE) within a natural endemic foci

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Tick-borne encephalitis (TBE) is a severe neurological disease caused by the TBE virus (TBEV), a flavivirus transmitted mainly by the tick *Ixodes ricinus*. TBE has a patchy distribution in natural endemic hotspots. TBEV circulation in the natural environment occurs via three different modes of transmission: vertical transmission (from the infected female to the succeeding offspring), viraemic transmission (infectious animals are the source of the virus when ticks feed on them and vice versa) and non-viraemic transmission or co-feeding (NVT or COF, when ticks get infected while simultaneously feeding on susceptible or not susceptible/immune animals). NVT has been recognized as the most efficient so far. The rodent *Apodemus flavicollis* is the most important host in terms of supporting transmission of TBEV between feeding ticks. The co-occurrence of larvae and nymphs on rodent hosts is therefore essential for the NVT and is favoured by the seasonal synchronicity of their activity. We used a long term dataset from 2000 to 2014 on yellow-necked mouse (*Apodemus flavicollis*) population, feeding *Ixodes ricinus*, rodent TBE seroprevalence and climatic data to investigate the principal drivers of co-feeding ticks on rodents. In particular, climatic conditions (i.e. autumnal cooling) during the previous year of sampling affected COF occurrence in terms of ticks synchronicity. Larvae intensity, but not nymphs, was associated with rodent density only until a certain threshold, above which ticks bites on rodent hosts are wasted. Also individual features of rodents affected COF occurrence, i.e. heaviest males carried more COF groups and the overall number of COF groups positively affected TBEV infection prevalence in rodents the following year. In conclusion, climatic variables and rodent density could be used as early warning tools to determine the persistence of a TBE foci.

Taxonomy-Genetics

New rodent species described since 2000; an age of discovery, comments and prospects

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In this contribution I present a review on the new living rodent species described since 2000. The most relevant issue to emphasize is that we are in an age of discovery. An average of ca. 14 new rodent species were described each year. Since 2000, over 250 new species have been described on the basis of specimens collected in South America, Asia, Africa, Oceania, North America, and Europe. The new rodent species belong to 21 families; most of them are allocated to the families *Muridae* and *Cricetidae*, but also to less diverse families as *Platacanthomyidae* and *Sminthidae*, as well as to the until then considered extinct *Diatomyidae*. Most discoveries were prompted by the analysis of genetic variation, although several new species have been hypothesized exclusively on the basis of morphological variation. Even when most taxonomic studies are based on one locus or few loci, we are starting a transition to an era where (sub)genomic data is analyzed with a coalescent approach. After commenting on distinct particularities of the new species, it is concluded that field collection of specimens and collections-based research needs to be intensified to characterize rodent diversity. Financial support: FONDECYT 1141055 and 1180366.

Taxonomy Genetics

Molecular phylogeny and distribution of the most widespread African rodents, the multimammate mice genus *Mastomys*: a review

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Murid rodents of the genus *Mastomys* ("multimammate mice or rats") represent one of the most successful groups of indigenous African mammals. This genus inhabits almost the whole sub-Saharan Africa and a small population of one species lives also in Morocco. They are very important from human point of view (important agricultural pests and reservoirs of diseases), but they serve also as model taxa for fundamental biological research (speciation, phylogeography, host-parasite co-evolution, etc.). For proper use of *Mastomys* as biological models, the information about their evolutionary history is necessary. Unfortunately, most available genetic data on this genus are based on mitochondrial DNA, which provides only partial information. Further, detailed genetic data from large areas in Africa have been completely lacking. Currently, eight morphologically very similar species are recognized especially on the basis of their karyotypes and mitochondrial sequences. Some of them have large area of distribution, e.g. the most widespread species, *Mastomys natalensis*, or Sudanian savanna specialist *Mastomys erythroleucus*, while the distribution of other species is geographically very restricted (e.g. *Mastomys awashensis* in Ethiopia or *Mastomys shortridgei* in humid habitats of southwestern Africa). Here, we combine all newly produced and already published mitochondrial sequences of *Mastomys* and describe the most complete distribution of their mitochondrial variability across whole continent. For the first time we use nuclear data to reconstruct the multi-locus phylogeny of the genus. The results show that the genus is not monophyletic (*Mastomys pernanus* should not be *Mastomys*), the highest species diversity is found in Ethiopia. In addition, we also clarify other questions in species delimitations and taxonomy. The research was funded by the Czech Science Foundation project No. 18-17398S and by the Russian Foundation for Basic Research No. 18-04-00563-a.

Taxonomy Genetics

Molecular evolution, hybridization and introgression affect molecular systematics of old world mice

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Despite the post-zygotic reproductive isolation between the house mouse (*Mus musculus domesticus*) and the Algerian mouse (*Mus spretus*) hybridization between the two species locally has resulted in introgression. We show how heterogeneity in molecular divergence, geographic variation in introgression, and incomplete lineage sorting result in a highly variable mosaic of the genome wide systematic relationships between mice. We infer how these variable patterns of molecular divergence and of introgression at protein coding genes may affect the biology of the species, and conceivably, variability in some of their unique phenotypic characteristics.

Taxonomy Genetics

Genetic structure and morphological evolution of the house mouse on the Orkney Archipelago

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The house mouse has colonized numerous islands following human travelers. This has exposed it to a high variety of environments, prone to trigger adaptive evolution. The colonization itself, processing by successive founder events and bottlenecks, may promote evolution. Hence, both adaptive and stochastic processes could contribute to an accelerated evolution on islands. We developed an approach coupling genetic and morphometric approaches on a set of more than 250 mice from eight of the Orkney Islands. A first genetic analysis using mitochondrial D-loop sequences allowed us to determine the relationships between Orkney and western European mice. A second analysis based on 21 microsatellites provided insights into genetic structure within the archipelago, revealing a strong geographic structure at a small spatial scale. Morphometric analyses were performed on the first upper molar. Despite their phylogenetic relatedness, Orkney mice displayed a morphological diversity as high as among Western European populations. This diversification erased the phylogenetic signal in the tooth morphology, and is ascribed to an accelerated morphological evolution on Orkneys. In contrast, within Orkneys, morphological and genetic divergences are largely in agreement. This holds true at the scale of the archipelago, of the main island, and even at the scale of local genetic clusters (<5 km). This suggests that on Orkneys tooth morphology evolved in a rather neutral way in isolated populations, and does not correspond to an adaptive divergence. It further suggests that the strong genetic structure at a small spatial scale was a fuel for the important morphological diversification.

Taxonomy Genetics

Genetic differentiation and phylogeographic structure of the house mouse *Mus musculus* s.str. in the northern Palearctic

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The systematics of the parapatric commensal taxa of house mice *Mus musculus* remains now rather controversial. We consider *Mus musculus* as a polytypic species, including subspecies *Mus musculus*, *Mus musculus wagneri*, *Mus musculus gansuensis*, *Mus musculus molossinus*. These subspecies are diagnosed by morphological, ecological, behavioral and cytogenetic features. We realized taxonomic estimation and analysis of genetic variability using nuclear (exon BRCA1) and mitochondrial (D-loop, cytb) markers. The material for genetic analysis was provided by 170 mtDNA and 46 nuclear sequences of house mice from Russia and the nearest countries of eastern Europe and central Asia. According to mtDNA variability, the phylogeographic structure turned out to be extremely heterogeneous. It was allocated 7 treasures: in Europe - 2, in Asia - 3 and 2 mixed. Two European branches divided the lines of house mice belonging to the subspecies *Mus musculus musculus* and *Mus musculus wagneri*. Basal monophyletic clade as well as control region and cytochrome b gene was lineage from Transcaucasia. Asian branches were characterized by 3 lines of subspecies of *Mus musculus* (*Mus musculus*, *Mus musculus wagneri*, *Mus musculus molossinus*). Of these, it should be noted a phylogroup from Siberia. It is assumed that mice in modern human history could be settled along major trade and transport routes. By the variability of the BRCA1 gene, *Mus musculus* was divided into two phylogroups by eight substitutions (6 transitions 2 transversions). The first group included individuals of the subspecies *Mus musculus*, in the second *Mus musculus wagneri*. Individuals of a hybrid origin formed a separate subcluster, apparently included hybrids of *Mus musculus* and *Mus domesticus*. Our data of mitochondrial and nuclear DNA analysis support the point of view that the subspecies *Mus musculus wagneri* should be considered as a separate species.

Taxonomy Genetics

Taxonomic structure and evolutionary history of mountain voles (*Alticola*, subgenus *Aschizomys*) in north-eastern Asia

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Two species of Asian mountain voles assigned to subgenus *Aschizomys*, of the genus *Alticola*, namely, *Alticola macrotis* and *Alticola lemminus* inhabit mountain areas from Altay range at the south to Korytski Range and Chukotka peninsula in northeast Siberia. The distribution of both species is highly fragmented. The certain borders of their distribution, taxonomic status of isolated populations and phylogenetic interrelationships are obscure. We examine patterns of lineage diversification, phylogenetic and population genetic history analyzing mitochondrial *cytb* and three nuclear markers: partial *BRCA*, *GHR* and *LCAT* from specimens covering a large portion of species' ranges. We tested the hypothesis of hybridization between two species with JML software. The obtained results support the hypothesis of ancestral polymorphism and incomplete lineage sorting rather than interspecies hybridization. Genetic differentiation within both species as inferred from the *cytb* tree including museum type specimens is consistent with current species delimitations. The current intraspecies taxonomy correctly reflects evolutionary relationships. The nuclear genes species tree supports monophyly of the subgenus and included species. Further, we combine results of the phylogeographic analysis with species niche and distribution modelling with MAXENT software and use these combined results to reconstruct possible ancestral area and species distribution history from LGM to present. This study was conducted under research theme № AAAA-17-1170 424 10 167-2 and RFBR grant № 15-04-04602 and Program of Presidium RAS "Dynamics of gene pools in natural populations" and "Development of vital and biosphere processes".

Taxonomy Genetics

Multiple mitochondrial pseudogenes in the nuclear genome in two species of mole voles (*Ellobius*, *Cricetidae*)

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Within the last decades, mitochondrial molecular markers have been widely used for phylogeographic and phylogenetic studies. They are most suitable markers when estimating genetic divergence between natural fragmented populations. However, the presence of numerous nuclear mitochondrial copies (numts) may severely complicate such studies. The mole voles, genus *Ellobius*, are specialized subterranean rodents with highly fragmented range. In our earlier study of the Northern mole vole population, *Ellobius talpinus*, we uncovered high nucleotide diversity of the mitochondrial control region fragment (Kuprina et al., 2016). Here we suggest that one of two predominating haplotypes which have been assigned to the mitochondrial control region actually represents a nuclear pseudogene (numt) of the control region. Moreover, the subsequent cloning of control region and cytochrome b fragments of the Northern mole vole and the Zaisan mole vole (*Ellobius tancrei*) showed the presence of different variants of these putative numts within the genome of each individual. To reveal an approximate time of various mitochondrial-nuclear translocations we conducted a phylogenetic analysis using the control region fragment of different taxa of subfamily *Arvicolinae* including pseudogenes of *Ellobius talpinus* and *Ellobius tancrei* obtained in this study. Our results emphasize the importance of testing for numts in every phylogenetic and phylogeographic study using mt markers. Technical and financial support: Chromas and MCT RRCs of SPbSU, RFBR (projects 16-04-00479, 18-04-00730) research theme № AAAA-17-1170 424 10 167-2 and Program of Presidium RAS "Dynamics of gene pools in natural populations" and "Development of vital and biosphere processes".

Taxonomy Genetics

Comparative study of striped field mouse *Apodemus agrarius* from continental and insular populations: the result of five microsatellite loci analysis

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The striped field mouse inhabits a wide geographical area from central Europe to the Pacific coast of Asia including adjacent islands. The species range is subdivided into two isolated fragments (European-Kazakh-Siberian versus Russian Far East-Chinese-Korean) with disjunction in Transbaikalia. We compared the level of genetic variability and differentiation within and between these isolates using 4 regional group samples (30 animals in each group). The fragment analysis of GTTDS8, GATAE10A, CAA2A, GTTF9A and GSADT7 (selected from Makova et al 1998) was carried out. It was shown that allelic diversity in the western isolate was lower than in the eastern one. High affinity of regional groups within each of the isolates and a bit greater genetic differentiation between these isolates were found. The second aim of our investigation was to compare population structure and differentiation of mainland and island local populations of the eastern lineage. 263 mice from 6 continental localities of Russian Far East as well as 3 islands of the Peter the Great Bay (Sea of Japan) were analyzed. The allele numbers in the continental populations were higher than in the island ones. Tests for HWE indicated significant heterozygote deficiency in both types of populations. Island populations were more significantly different both from each other and in comparison with continental populations. This suggests the importance of genetic drift in the formation of their genetic structure, especially on the islands. The work was supported by grant № 18-4-031 of "Far East" Program of RAS.

Taxonomy Genetics

Phylogeography, taxonomy and diversity of montane populations of laminate-toothed rats (Muridae: Otomys) in the southern Great Escarpment, South Africa, with the description of a new species

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Mitochondrial DNA sequences of the cytochrome b gene (cyt b, 1137 bp) were used to investigate evolutionary relationships of five putative taxa of *Otomys* (family *Muridae*, subfamily *Murinae*, tribe *Otomyini*) occurring in the Western Cape and Eastern Cape provinces of South Africa. A total of 22 specimens of three putative species (*Otomys auratus*, *Otomys sloggetti* and *Otomys cf. karoensis*) were added to data obtained from GenBank and the amalgamated data set was analysed phylogenetically. Outgroups were selected from other genera of the tribe *Arvicanthini*. To incorporate a further 28 sequences from a shorter segment of 407 bp of cyt b obtained from a recently published study we created a second dataset in which we trimmed the sequences to 407 bp and this was analysed separately. We analysed craniodental and craniometric characters of 94 adult skulls from localities from which individuals had been sequenced or karyotyped herein or previously. Phylogenetic analysis revealed the existence of a well-supported unique mitochondrial lineage of *Otomys cf. karoensis* (named herein *Otomys willani* sp. nov.) from the southern Drakensberg Range. Craniometric analysis distinguished *Otomys karoensis* from *Otomys willani* sp. nov., and added a further four localities to the range of the latter species.

Taxonomy Genetics

Computational species delimitation provides evidence for distinct evolutionary lineages of *Trinomys iheringi* (Rodentia: Echomyidae)

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The endemic Brazilian spiny rat genus *Trinomys* comprises 13 taxa occurring in Atlantic forest, Cerrado and Caatinga biomes. This genus has a controversial systematics, and until recently six subspecies were recognized for *Trinomys iheringi* (*Trinomys iheringi iheringi*, *Trinomys iheringi graciosus*, *Trinomys iheringi bonafidei*, *Trinomys iheringi eliasi*, *Trinomys iheringi paratus*, *Trinomys iheringi panema* and *Trinomys iheringi denigratus*), all present in southeastern Brazil. Ilha Grande island populations, in Rio de Janeiro state, were considered as *Trinomys dimidiatus*, the species with geographical distribution spanning the mainland adjacent to this island. However, studies based on cytochrome b suggested that individuals from the Ilha Grande island actually belong to *Trinomys iheringi*. As a consequence, *Trinomys iheringi* now consists of a monotypic species with a disjunct distribution: in the Ilha Grande island, and in the São Paulo state, both in the São Sebastião island and in the mainland. Given this disjunct geographic distribution, we were prompted to investigate the phylogenetic relationships between populations from different localities. We sequenced the mitochondrial gene cytochrome b for 170 individuals of *Trinomys*, comprising all currently recognized species and added sequences available in GenBank to estimate within-genus divergence times. Moreover, we applied computational species delimitation methods to investigate whether *Trinomys iheringi* populations from the Ilha Grande island and São Paulo state were independent evolutionary units. Our results indicate that the Ilha Grande island and São Paulo populations separated around 0.798 Mya (0.35-1.33 Mya). Geological data poses that Ilha Grande island was completely separated from the mainland around 0.0051 Mya, which is far more recent than the estimated age of split between these two lineages. Therefore, we are suggesting that this divergence did not result from a vicariant event. Computational species delimitation methods always recovered both populations from the São Sebastião island and mainland São Paulo as unique entities. Our analysis indicates that *Trinomys iheringi* is not monotypic and possibly consists of several subspecies.

Taxonomy Genetics

Genetic analysis of type material brings logical order in geographic distribution and taxonomy. Case study of Central Asian vole genera *Neodon*, *Blanfordimus*, *Lasiopodomys*

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The systematics and nomenclature of central Asian vole species from genera *Neodon*, *Blanfordimus* and *Lasiopodomys* raised many questions. The dramatic discordance may be discovered in comparison of species distribution and taxonomy. Thus, the range of *Lasiopodomys fuscus* is very narrow and is in the very center of distribution ranges of voles from the genus *Neodon*. It is on the other hand very isolated from two other congeneric species. The range of *Neodon juldaschi* in turn lays in the center of distribution of voles from the genus *Blanfordimus* and is strongly isolated from the distribution of congeneric voles. It should be kept in mind that the proper use of species names depends entirely on the process of verifying whether additional specimens are conspecific with the specimen with which the species name is associated. Related to this the genetic studies of type material are of paramount importance in elucidating taxonomic issues. We successfully extracted DNA and obtained fragments of mitochondrial cytb from lectotype and paralectotypes of *Lasiopodomys fuscus* (collected by Przhevalskii) and the holotype of *Neodon juldaschi* (collected by Severtzov) from the collection of the Zoological Institute RAS. The results of phylogenetic analysis bring back the logic correspondence between zoogeography and systematics. Thus, *Lasiopodomys fuscus* should be without any doubt assigned to the genus *Neodon* and *Neodon juldaschi* to the genus *Blanfordimus*. Both species with a high support find their places within corresponding monophyletic clusters at the phylogenetic tree. Funding: research theme № AAAA-17-1170 424 10 167-2, RFBR grant № 15-04-04602, Program of Presidium RAS "Dynamics of gene pools in natural populations" and "Development of vital and biosphere processes".

Taxonomy Genetics

The genus *Sciurus* in Turkey: data on their distribution, morphometry, karyology and mtDNA sequence variation

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The genus *Sciurus* is represented by two species: *Sciurus anomalus* and *Sciurus vulgaris*. The latter species is naturally distributed in European part of Turkey. *Sciurus anomalus* has a predominant distribution in Anatolia but allopatrically found with *Sciurus vulgaris* on the Northeast of Turkey. In this study, *Sciurus anomalus* and *Sciurus vulgaris* samples were collected from their natural habitats in Turkey. Morphometric characteristics of both species were studied based on standard and geometric morphometric approaches. Karyotyping was also conducted to find out the chromosomal properties of both species. Partial DNA sequences of two mitochondrial genes (Cytb and dLoop) were sequenced for genetical comparisons and phylogenetical assessment. Morphological measurements showed significant differences between two species ($P < 0.05$) based on 26 cranial characters. Mandibles and the skull used in geometric morphometric analysis resulted in significant differences ($P = 0.013$) in terms of shape based on mandibles but did not yield any significant differences ($P = 0.069$) based on skull. Both species have the same chromosome number $2n = 40$ but differ in the NF (*Sciurus vulgaris* 76 and *Sciurus anomalus* 80) and NFa (*Sciurus vulgaris* 72 and *Sciurus anomalus* 76) values obtained from karyological analysis. The two species were distinguishable based on both mtDNA gene regions utilized and the sequences were approved by the sequences obtained from the Genbank. Two separated *Sciurus vulgaris* populations were found in Turkey. Based on the mtDNA sequences Edirne samples (from Thrace, European part of Turkey) were clustered with the northeast squirrel population. The genetic distance between two species is found to be 0.182 ± 0.020 based on mtDNA dLoop sequences. The results obtained from both mitochondrial gene regions supported each other.

Taxonomy Genetics

A new vole record from Anatolia may change the evolutionary story of voles in Anatolia

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Microtus species are distributed in open meadows and agriculture areas in the Holarctic region. It is one of the most specious taxa in *Arvicolinae* by having 58 species. The speciation processes is still on going and recent studies have discovered new species for the genera. This makes the taxa a good model for the studies on sympatric issues and ecological speciation. In Turkey there are 13 vole species, and three of them are endemic to Turkey (*Microtus anatolicus*, *Microtus dogramacii*, and recently described *Microtus elbeyli*). In this study, we collected more than 400 samples from inner and eastern Anatolia and evaluate them on the basis of morphology and molecular characters. Our preliminary results showed *Microtus qazvinensis* is distributed in Elazığ Province of Turkey. This species was described from Iran and this is the first record of this species from eastern Turkey. The karyotype and morphological results support our findings. On the other hand, up to now, *Microtus socialis* was thought to be widely distribute in the east of Turkey. However, our results could not verify the presence of this species in Turkey. Additionally, our results showed that

has possibly a wider distribution in Turkey than former publication states. These results will possibly change the discussion about species distribution and evolution of voles in Anatolia. Also our preliminary results showed that *Microtus irani* and *Microtus guentheri* were separately placed in the bottom position in the phylogenetic tree of Turkish voles.

Conservation and Ecosystem Services

Small mammal responses to farming practices in central Argentinian agroecosystems: the use of hierarchical occupancy models

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Organic farming is more environmentally friendly than conventional agriculture, promoting greater levels of habitat heterogeneity. Field borders could be more suitable for biodiversity in agricultural anthromes. Small mammals are crucial in these anthromes due to their contribution to food webs and seed consumption. We used hierarchical multi-season occupancy models to assess the effect of organic versus conventional farming on multiple small mammal species in agricultural anthromes of central Argentina. We modelled detectability and increased precision of estimates, overcoming deficiencies of previous studies. Small mammals were seasonally surveyed in 70 field borders (conventional) and 63 (organic) during two years. We were able to include less frequent specialist species, detecting a positive relationship with organic management possibly because of higher habitat quality of borders. Vegetation volume was the most important explanatory variable in both managements. Species' richness was greater under organic management mainly in spring when the habitat quality differences with conventional management were the greatest. Spring is key for the rodent assemblage because of the beginning of reproductive period, when resource demand is important. We suggest that maintaining high quality border habitats, as those supported by organic management, could allow farmers to obtain economic profit while also contributing to biodiversity conservation. Considering the positive role that native rodents may have in some agricultural anthromes, the maintenance of high population numbers may be important for biodiversity conservation. The approach used in this study shows the importance of modelling imperfect detection, reducing bias in parameter estimates, and it should be implemented in similar studies.

Conservation and Ecosystem Services

Native rodents are the main seed predators in areas representing distinct phases along an active restoration process in a neotropical savanna

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Land use conversion to agriculture and pasturelands may alter not only the abundance of seed-eating animals but also their role as seed predators and dispersers. We investigated the effect of landscape changes, including areas under restoration process, on seed predation by native rodents in the Brazilian Cerrado, the most diverse savanna of the world. We evaluated seed predation of two tree species (*Tachigali vulgaris* and *Copaifera langsdorffii*; *Fabaceae*) in five habitats: typical savanna (cerrado sensu stricto), abandoned pasture dominated by African grass *Urochloa decumbens*, and three environments representing distinct phases along an active restoration process (two, three, and four years after direct seeding of native species). We also evaluated rodent abundance in these areas. In captivity, we offered seeds of both species and of *Urochloa decumbens* to *Necromys lasiurus* (*Sigmodontinae*), the most abundant rodent in the study. Field tests with semipermeable exclosures indicated that small rodents were the main seed predators in all habitats. Only for *Copaifera langsdorffii* seed-predation rates differed among habitats, being higher during the rainy season in the native Cerrado and pasture. We captured 180 rodents belonging to five species, with a high dominance of *Necromys lasiurus* (ca. 95% of all individuals). Areas in more advanced regeneration process and native environments tended to show greater rodent richness, following plant community patterns. In captivity, *Necromys lasiurus* preyed upon all species offered. Our results suggest that the transformation of native areas in planted pastures and subsequent regeneration processes modify the abundance of small mammals in the Brazilian savanna but not their role as main seed predators. The abundance of this group is relevant for crucial ecological processes, such as seed predation and potential for reducing the establishment of introduced species. Season of seeding and rodent abundance must be considered in restoration projects in open-vegetation habitats such as savannas and grasslands.

Conservation and Ecosystem Services

Research progresses on seed-rodent interactions in China

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Seed-rodent interaction has been recognized as one of the important components of the forest ecosystems. Seeds provide food to rodents which provide service of seed dispersal and regeneration. It is obvious that seed-rodent relation is composed of both predation and mutualism. Seeds tend to manipulate hoarding behavior of rodents to maximize the seed dispersal fitness by adopting a series of conflicting but well-balanced strategies of attraction and defense. Rodents tend to select seeds to maximize their fitness by adopting various hoarding behavior and seed management strategies. This reciprocal interaction would finally determine their ecological relationship shifting between predation to mutualism, and then the role of rodents in forest regeneration. Deforestation and forest fragmentation would greatly affect the seed-rodent interactions and then forest regeneration and health. There is a need to take actions of managing the seed-rodent interaction so as to facilitate recovery of degenerated forest ecosystems. Since middle 1990s, the seed-rodent interaction in six locations representing the tropical, sub-tropical, warm-temperate, temperate and cold-temperate climate zones have been carried out in China. This paper will present a review of research progresses on seed-rodent interactions in China.

Conservation and Ecosystem Services

Effects of insect-infestation on rodent-mediated dispersal of *Quercus aliena*: results from field and enclosure experiments

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Rodents influence plant establishment and regeneration by functioning as both seed predators and dispersers. However, these rodent-plant interactions can vary significantly due to various environmental conditions and the activity of other insect seed-predators. Here, we use a combination of both field and enclosure (i.e. individual cage and semi-natural enclosure) experiments, to determine whether rodents can distinguish sound seeds from those infested with insects. We also demonstrate how such responses to insects are influenced by food abundance and other environmental factors. We presented rodents with two kinds of *Quercus aliena* seeds (sound and insect-infested seeds) in a subtropical forest in Qinling Mountains, central China, from September to November of 2011 to 2013. The result showed that rodents prefer to hoarded and ate sound seeds than infested seeds in the field and semi-natural enclosure, while they prefer to ate infested seeds than sound seeds in the individual cages. In addition, both hoarding and eating decisions were influenced by relative food abundance. Rodents hoarded more sound seeds in years of high food abundance while they ate more both sound and insect-infested seeds when food was less abundant. Compared with field results, rodents reduced scatter hoarding behavior in semi-natural enclosures and ate more insect-infested seeds in smaller individual cages. These results further confirm that rodents distinguish infested seeds from non-infested seeds but demonstrate that this behavior varies with conditions (environment and food abundance). We suggest that such interactions will influence the dispersal and natural regeneration of seeds as well as predation rates on insect larvae.

Conservation and Ecosystem Services

Estimation of benefits and losses of seed scatter hoarding behaviour by rodents in a subtropical forest: implications for the evolution of mutualism in seed-rodent systems

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Seed hoarding behaviour of rodents plays an important role in seed dispersal and seedling regeneration of trees, as well as for the evolution of mutualism between trees and rodents in forest ecosystems. There are two opposite views on why rodents adopt a scatter-hoarding strategy: the pilferage avoidance hypothesis predicts that the cache pilferage rate should be very low to ensure benefits of cache owners, while the reciprocal pilferage hypothesis has an opposite prediction. Because it is difficult to identify seed hoarders and pilferers under field conditions by using traditional methods, the full costs incurred and benefits accrued by scatter-hoarding have not been fully evaluated in most seed-rodent systems. Our study aimed to test the two hypotheses at individual level under field conditions. By using infrared camera tracking and seed tagging methods, we investigated the comprehensive benefits and losses of scatter-hoarded *Camellia oleifera* seeds for three sympatric rodent species (*Apodemus draco*, *Niviventer confucianus* and *Leopoldamys edwardsi*) in a subtropical forest of Southwest China 2013-2015. We established the relationships between the rodents and the seeds at the individual level. For each rodent species, we calculated the cache recovery rate of cache owners, as well as conspecific and interspecific pilferage rates. We found all three sympatric rodent species had a cache recovery advantage (recovery rates > 50%) with rates that far exceeded average pilferage rates (<10%) over a 30-day tracking period. The smallest species (*Apodemus draco*) showed the highest rate of scatter-hoarding and the highest recovery advantage compared to the other two larger species. Across species, rates of scatter-hoarding and benefits were positively correlated with each other. Hence species having higher scatter-hoarding preference had higher competitive ability for seeds. Our results suggest that scatter-hoarding benefits the cache owners more in food competition, not the cache pilfers, supporting the pilferage avoidance hypothesis.

Conservation and Ecosystem Services

Seed size effects on seed dispersal and predation by rodents at tree individual level

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Seed predation and dispersal by scatter-hoarding rodents play an important role not only on the seedling regeneration of trees, but also on the spatial distribution and structure composition of the whole forest communities. Both seed size and seed density have been found significantly affect the foraging preferences of rodents, which in turn influence the seed fates themselves. Current studies focusing on how seed size and seed density affect foraging behaviour of scatter-hoarding rodents mainly target one of two scales of comparison: the species scale, with comparisons of dispersal and predation of seeds from multiple species; or the individual seed scale, with comparisons among individual seeds from the same species. Even though individual variation in reproductive success within populations is a key component of evolutionary fitness, variation in seed dispersal and predation at the scale of individual trees is poorly understood. Our study asks how variation in seed mass and number among tree individuals affects the behaviour of animal dispersers and in turn the fitness of the trees. We first surveyed intraspecific variation in seed production of two *Fagaceae* tree species in a natural subtropical forest in south-western China. We then investigated how this variation affects seed predation and dispersal by scatter-hoarding rodents, which were the primary seed dispersers/predators. We weighed and then followed the fate of 11,618 seeds from 54 tree individuals to determine their survival and, if they survived, the distance they were dispersed. Our results showed a large variation of seed production among individuals in both tree species, including number of seeds, mean seed mass, the coefficient of variation (CV) of seed mass. The total number of seeds, the CV of seed mass and the crown size significantly affect the seed fates among tree individuals, but their effects differed between tree species.

Conservation and Ecosystem Services

Forest fragmentation alters seed-rodent interaction networks: implications for rodent management

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Forest fragmentation has caused remarkable changes in species diversity and composition. However, it is still unclear how forest fragmentation affects the structure of interaction networks between rodents and plant seeds. In forest ecosystems, the interaction network between rodents and tree seeds is an important ecological network, and it plays an important role in the maintenance of biodiversity and service and function of ecosystem. In this study, we investigated how the interaction network between rodents and tree seeds was altered under forest fragmentation in a subtropical region in the Dujiangyan region, Sichuan Province, China. We studied the seed-rodent interactions in 14 secondary forest patches that ranged in area from 2 to 58 ha, and in succession stage from 10 to at least 100 years old. We measured the visit frequency (interaction strength) of rodents eating or hoarding seeds in each patch during 3 successive years, using seed tagging and infrared camera trapping, and calculated the metrics of the seed-rodent networks. We found that the seed-rodent interactions and population abundances of seeds and rodents mainly changed with stand age, not patch size: older patches had lower connectance and interaction strength, but higher nestedness. Connectance and interaction strength decreased with increase of metabolic per capita seed availability, while nestedness increased with increase of seed richness, but decreased with increase of rodent abundance. Seed coat thickness and starch contents had significant association with network metrics. Our results indicated that higher abundance of rodents and lower abundance of plant seeds contributed to higher interaction strength but lower nestedness of the seed-rodent interaction networks at early succession stage. Therefore, in order to facilitate the restoration of degenerated forests, it is necessary to take some intervention measures to protect the scatter-hoarding rodent species and reduce the invasion of farmland or commensal rodent species into the forest patches.

Conservation and Ecosystem Services

Lead (Pb) bioconcentration in cestode parasites (*Hymenolepis* spp.) of rats (*Rattus* spp.) and their potential as indicator of heavy metal contamination in terrestrial environments

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There is a dearth of information about the use of parasites as indicators of lead (Pb) contamination in various terrestrial environments. In this study, *Hymenolepis* spp. from *Rattus* spp. samples collected in Los Baños, Laguna were subjected to lead concentration analysis. Rat samples were infected with intestinal cestodes, *Hymenolepis diminuta* (35.6%), and *Hymenolepis nana* (34.4%), and the liver parasite, *Taenia taeniaformis* (48.9%). Cestode prevalence was highest in *Rattus norvegicus* at 68.4%. Lead concentration (ppm) was observed to be highest in rats from agricultural sites, followed by residential rats, and lastly by forest rats. A higher lead bioconcentration factor (BF) was revealed in *Hymenolepis* spp. than in the rat host's intestine, kidney, and liver; however host muscle tissue had higher lead BF. No significant difference ($p=0.612$) in Pb concentration was observed between infected and uninfected rats. Lastly, a weak correlation between parasite burden and Pb concentration in rat tissues was observed ($r=0.140$). This study reveals that *Hymenolepis* spp. could bioaccumulate lead in rat hosts. However, it may not be as sensitive as other parasites observed in other host-parasite relationships. It is recommended to conduct laboratory experiments to establish the potential of intestinal parasites of rats to influence accumulation of heavy metals in the animal host's tissues.

Conservation and Ecosystem Services

Changes in rodent burrow abundance and distribution in grazing ecosystems of southern Russia under human-induced landscape transformation from the desert to steppe

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Rodents play an important role in rangelands through the engineering of extensive burrow systems, which provide key habitats for many animal and plant species. We have analyzed the long-term pattern of variation in the abundance and distribution of rodent burrows in grazing ecosystems of southern Russia under the landscape change from the desert to steppe caused by the drastic reduction of livestock after the collapse of the USSR in the early 1990s. We surveyed burrow distribution by counting burrow openings of each rodent species in 100-m segments of 19 3-km transects, totaling 57 km surveyed. We estimated burrow density, the length and the fraction of segments with and without burrows as measures of habitat quality, size, isolation, and connectivity. We performed surveys in 1980 ("the desert period") and repeated them in 2017 ("the steppe period"). We found drastic changes in the burrow abundance and distribution of keystone rodent species, as well as the evidences of desert habitat fragmentation and isolation caused by the expansion of tall-grass communities and overgrowing of sands. Burrows of the open-dwelling ground squirrel, *Spermophilus pygmaeus*, the dominant and keystone species during the desert period, almost disappeared from the rodent burrow complex by 2017, which indicates significant habitat loss. On the contrary, the burrows of the folivorous social vole, *Microtus socialis*, which was rare in 1980s, became abundant and ubiquitously distributed. Burrow density of the desert-dwelling psammophilous midday gerbil (*Meriones meridianus*), as well as the size of occupied patches decreased, while the inter-patch distance increased, indicating habitat fragmentation and isolation. Burrows of folivorous tamarisk gerbil (*Meriones tamariscinus*) were recorded only sporadically in both 1980 and 2017. The observed drastic changes in the rodent burrow complex, the keystone element of grazing ecosystems, can have long-term and important consequences for the dynamics of local rangelands and their sustainability.

Conservation and Ecosystem Services

The potential of small and medium mammalian carnivores to mediate rodent pest damage in commercial agriculture

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Rodents remain a key pest of grain crops globally. However, the use of chemical control to manage rodent populations is problematic due to increased rodenticide resistance in rodents and negative environmental effects. This has sparked interest in ecologically based rodent control (EBRM). Predation is a key component of EBRM that is often neglected. In this study we aimed to evaluate the potential of predation to mitigate rodent pest damage in commercial maize fields in the Free State Province, South Africa. We used camera trapping to quantify the occupancy and species richness of small mammalian carnivores. We used live trapping to assess rodent densities, and snap traps to investigate rodent diet. Finally, we applied a crop simulation model (APSIM) to estimate the effect of varying plant densities (which act as a proxy for varying rodent densities) on crop yields. Camera trapping studies showed that at least 8 mammalian carnivore species frequented the cropping areas, of which 6 species preyed on rodents. Grain damage was impacted by rainfall, planting density and the amount of seed incorporated in the rodent diet. The greatest impact of rodent seed damage (2-40% yield decline) occurred under high rainfall and densities of 10-30 rodents/ha. In contrast, under low rainfall, seed damage was less prevalent. In low rainfall seasons crops are severely limited by available soil water, and seed damage (up to 20%) will not affect crop yield, as the remaining crops have more water and can compensate for the seed losses with increased yields. Seed impact will only become evident at rodent densities 30-100 rodents/ha. Therefore, rodent densities up to 30/ha can be of concern, especially under ideal climatic conditions. Our results show that the combined predation of mammalian carnivores have the potential to significantly impact rodent biomass, and hence alleviate crop losses.

Conservation and Ecosystem Services

Rodents as indicators of the ecological impact of an open-cast iron ore mine in the Northern Cape, South Africa

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Rodents have been proposed as an important ecological indicator in various environments. In general, it is expected that rodent community structure change with varying levels of succession and habitat disturbance. In this contribution we report on the results of the first seven years of a long-term biomonitoring study, using small rodents and vegetation to measure ecosystem change on an open-cast iron ore mine. A total of 43 transects on the mine and surrounding farms were stratified to be at various distances and along a potential impact gradient radiating from the core mining activities. Wind speed and direction, vegetation units, sensitive plant areas and conservation areas were also taken into account. All transects were sampled annually at the end of the main rodent breeding season. Clear changes in both the plant and rodent communities closer to the mine activities were observed, with some transects already showing significant changes within the first year or two after mining commenced. These included 1) a decrease in rodent and plant species richness, 2) a disappearance of "specialist" rodent and "decreaser" plant species (generally associated with higher habitat integrity), and 3) a decrease in both plant and rodent species diversity. Similar changes were less apparent on transects further away from the mining activities, but were not observed on the furthest, least influenced, transects. A strong relationship between veld (vegetation) condition scores and total herbaceous dry matter production, and rodent species richness, diversity and indicator species' presence/absence were found, demonstrating the potential value of small rodents as ecological indicators of ecosystem integrity.

Conservation and Ecosystem Services

Rodents and their role in habitats in an tropical Africa context: the case of the DR Congo

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Rodents are a pervasive, yet interesting group of mammals when considering their role in ecosystems of either natural or agricultural lands. While playing an important role for ecosystem services, many species are known as pests in agriculture or can pose a serious problem for human health. We studied the role of rodents in agricultural lands and natural ecosystems (primary and secondary forests) by analysing the stomach content of animals captured at different sites, supplemented by literature data for the same areas. Our results show that the abundance of a species was not associated with damage to plant species according to stomach contents. We found an interesting role of rodents in seed dispersal. While there are no records in the wild for many species, some others showed useful effects for ecosystems; these comprise squirrels (e.g. *Funiciurus*, *Heliosciurus*, *Protoxerus*) or mice and rats of the genera *Malacomys*, *Lophuromys*, *Grammomys*, *Deomys* or *Cricetomys* for which stomach contents revealed the presence of pest or nuisance species for plants such as centipedes and millipedes or termites that destroy crops by breaking the germinating young plants. Some species of *Hylomyscus* or *Xerus* play a role in plant pollination as they feed on nectar, while many others play a role in the food chain as prey or by feeding on other species. The damage caused by rodents is linked to eating bird eggs, some mammal species, birds, reptiles or frogs apart from the known role of pest they have in agriculture or as disease vectors. Despite the controversy in balancing the ecosystem services and disservices, rodents play structural roles in ecosystems for example, by pruning or eliminating vegetation types, spreading seeds, competing with other animals or spreading diseases.

Conservation and Ecosystem Services

A valued rodent (*Rattus exulans*) population assessed for cultural harvest

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Kiore (Pacific rat, *Rattus exulans*) arrived in New Zealand with Ngatiwai, a Maori tribal group in northern New Zealand, and as such are culturally important in Ngatiwai histories and traditions. Kiore are a bioindicator, a traditional source of skins for cloaks, and one of many traditional foods. However, ecological and social contexts for this species have changed dramatically over the last 150 years. Once common, kiore are now restricted in their numbers and range, and widely regarded as pests in New Zealand. To safeguard cultural access to kiore, tribal environmental managers seek to understand and monitor the abundance and health of remaining kiore populations. To assist, we assessed body condition, reproductive status, and parasite and disease loads of kiore on one of the few remaining island populations within the Ngatiwai tribal area. We also compared detection devices to determine device suitability for ongoing monitoring of relative abundance. Of 16 kiore caught, body condition was similar to that recorded in studies on other New Zealand islands. Inflammation of the liver and/or bile ducts was present in 38% of captured kiore, attributed to the common nematode parasite *Capillaria hepatica*. People harvesting kiore can take precautions to prevent transfer of this parasite to humans. Subcutaneous fat levels were moderate, and lower in diseased individuals, especially females. Capture rate in live-traps was 19.3 kiore per 100 trap-nights, higher than in snap-traps (1.4). A one-night kiore tracking rate in inked footprint tunnels was 25%, and a one-night camera-capture index was 44%. Because live-trapping had a relatively high capture rate, permits inspection of animal condition using traditional and other methods, and enables release of juveniles and non-targets, it appears to be the most useful method for ongoing abundance assessment.

Response to Human-Induced Changes

Of city mice and village mice: behavioural adaptations of voles and mice to urban environments

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A fundamental question of current ecological research is to illuminate the drivers and limits of species responses to human-induced rapid environmental change (HIREC). Understanding behavioural responses to HIREC have been identified as a key component because behaviour links across fundamental hierarchical levels of organisation, i.e. from individual responses to population and community changes. Ongoing urbanization provides an ideal setting to test the functional role of behaviour for responses to HIREC because they occur at a fast time scale. In a first step, we aimed at testing whether urban and rural populations of four rodent species differ in mean trait expression, flexibility and repeatability of behaviours associated to risk-taking and exploration of novel environments. Using a standardized behavioural test in the field, we quantified exploration and boldness for a total of 305 individuals (the majority repeatedly) of 4 rodent species (voles: *Myodes glareolus*, *Microtus arvalis*; mice: *Apodemus agrrestis*, *Apodemus flavicollis*). We found differences in mean expression of behavioural traits and in behavioural flexibility between individuals from urban and rural populations in some species, with urban dwellers being bolder, more explorative and less flexible than rural conspecifics. In other species, no such differences existed. Therefore, behavioural responses to urbanized environments appear to be species-specific with some species adjusting behaviours to the novel environmental conditions of altered food availability and predation risk, while others retained species-specific patterns. As a result, individuals distribute themselves in a non-random way in response to human disturbance, which might play a key role in the successful coping with the challenges of human-induced environmental changes.

Response to Human Induced Changes

Genetic structure, reproduction and physiology features of the common hamster (*Cricetus cricetus*) in urban populations

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Traditionally, urbanization is seen as a negative phenomenon for biota. However, changes in the environmental parameters induced by urbanization might be favorable for some species. Therefore, we can consider this process not only as formation of new adaptations, but also as the disclosure of the deposited capabilities of sinurbic species. Over the past half-century the common hamster actively populates the cities. Its settlements exist in some European, Russian and Kazakh cities. During 2014-2017 genetic and physiological methods were used to reveal adaptations of the common hamster (*Cricetus cricetus*) to settle in the urban environment of several cities. Based on the allelic composition of 10 microsatellite loci and mtDNA sequences we shown that in urban territories the hamster population is divided into separate groups. The level of genetical distance between the groups is high and not dependent on spatial distance between locations inhabited by the groups. In outskirts of cities, on the territories adjacent to green areas and further to countryside, the level of distinction between neighbouring hamster groups decreased and intergroup genetic differentiation began to correlate with the spatial distances. Based on physiological methods we have shown that in urban territories the common hamster demonstrates extremely short hibernation (presumably because of additional food sources). This allows the species to start breeding very early (or even to breed all over the year) and to produce up to three litters. However, the life span of the common hamster in urban conditions is very short (less than 1 year) generally. We propose that the last phenomenon is due to high mortality as a result of dog predation, environmental pollution, and interspecies aggressions at the peak of breeding activity. This study was supported by RFBR No.17-04-01061.

Response to Human Induced Changes

Population recovery of *Mus musculus* in poultry farms of central Argentina. The role of local and landscape features

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Poultry farms in rural areas of central Argentina are dispersed within a landscape dominated by cropfields. The composition of the rodent community differs between farms and neighbouring fields: In the first habitats there is a dominance of commensal exotic species, as *Mus musculus*, *Rattus norvegicus* and, occasionally, *Rattus rattus*, and native species are rare. In cropfields and longitudinal edges between fields or along roads there are native species, and commensal species are rare. In this work we want to answer the question: where the *Mus musculus* individuals that recolonise poultry farms after control come from? The alternatives proposed were: from the surrounding of the farms, from other farms, that they are transported by men, or from the population recovery of remaining individuals. To answer this question we have used different approaches: description of rodent communities in farms and surrounding habitats, genetic studies in order to estimate gene flow according to geographic distance, models that relate *Mus musculus* abundance and environmental variables at local and landscape scale, tracking movements with fluorescent powders, experimental application of control at different spatial scales and enclosure experiments. Our conclusion is that immigration is from nearby farms and not due to passive transport by human or from surrounding habitats, that this species normally travels short distances and that dispersal movements are along cropfield borders or riparian habitats, and not through cropfields. Recovery after control is mainly due to reproduction of remaining individuals, and the abundance of *Mus musculus* in poultry farms is mainly related to intrinsic characteristics of farms. An increase in poultry activity in the area with a shortening of distances among farms may cause an increase in the levels of infestation by *Mus musculus* in these habitats, but probably not in other habitats.

Response to Human Induced Changes

Synanthropic rodents of north-east Siberia: changes in rodent population caused by urbanization, agrarian, and industrial development

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One of the groups of mammals that successfully utilize anthropogenic territories is *Rodentia*. The rodent fauna of North-Eastern Siberia is comprised of 23 species, whose relationship with human presence varies from eusynanthropy to exosynanthropy. The eusynanthropes are represented by two alien species: *Mus musculus* and *Rattus norvegicus*; their distribution is limited and they do not immigrate into surrounding natural biotopes. Among aboriginal species the propensity to synanthropy is most pronounced in *Myodes rutilus*, which is consistently found not only in rural settlements, but also in old cities. The invasion of the house mouse did not result in the disappearance of the native species but in mosaic dispersion of both species. Suburban areas in recent years have seen an increase in the abundance of the squirrel *Sciurus vulgaris* and a decrease of the chipmunk *Eutamias sibiricus*. Development of the cities and roads in the north is accompanied by disruption of the permafrost and consequent swamping of the territory; this has led to a decrease in abundance of *Spermophilus undulatus*. The agrophilous rodent population is comprised mainly of *Microtus* species, they can also be found on the territory of villages. The industrial development of the north is connected with deforestation and consequent formation of grass cover. Resulting rodent populations consists of ecologically flexible species: residual forest fragments are dominated by the northern red-backed vole; and open areas, by *Microtus oeconomus* and *Microtus gregalis*. In the tundra, due to typical moss and dwarf-shrub habitats being replaced by anthropogenic meadows, such typical tundra dwellers as lemmings are being replaced by voles *Microtus* genus. Among the obligatory exosynanthropes are stenotopic species confined to mountains (*Alticola*, *Marmota*) and specialized briophages (lemmings). Thus, synanthropic rodent communities in the north-east of Siberia are characterized by the prevalence of indigenous hemisynanthropes; and in conditions of ruderal communities, of agrophiles.

Response to Human Induced Changes

Effects of artificial light at night on behavior of two small mammal species

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Natural light functions as an important zeitgeber in many animal species which use this external stimulus to adapt to predictable environmental changes throughout the day and season (Zordan et al. 2001). Besides the increasing spatial spread and intensity of nighttime illumination there is a shift towards new lighting techniques such as light emitting diodes (LEDs) that are characterized by a broad spectrum with a large proportion of blue light (Gaston et al. 2012). This portion of the spectrum is known to most affectively suppress melatonin production (Brainard et al. 1984) and thereby influencing activity rhythms. What is missing are experiments under more natural conditions that clarify if laboratory results are applicable to animals in the wild and take into account possible effects of artificial light at night on species interaction and competition. In this study, the effect of artificial light at night emitted by LEDs on the activity and space use of bank voles (*Myodes glareolus*) and striped field mice (*Apodemus agrarius*) was investigated in semi-natural outdoor enclosures via automated VHF radio telemetry. The data indicates that both species show an increased spatial range during nights with artificial illumination that is similar to their home ranges during daytime. Additionally, they are less active during the day that follows an illuminated night. Changes in home range overlap between individuals could not be found in dyads consisting of the two different species but within one species reduced overlap when subjected to light at night. These observations indicate that artificial light at night effects individual space use as well as interactions between individuals which potentially has severe ecological consequences for natural populations and communities.

Response to Human Induced Changes

Microhabitat use of small non-flying mammals in a lower montane forest fragment in the central Cordillera, Luzon Island, Philippines

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Luzon Island in the Philippines is home to a diverse set of small mammals with 45 murid rodents endemic to the Island. Previous studies focused more on the general response of species to varying levels of habitat disturbances with very limited studies on microhabitat use. Patterns of microhabitat use of a community of endemic and exotic small non-flying mammals were investigated on a fragment of lower montane forest by employing live trapping techniques from February to April 2016. Canonical correspondence analysis was used to analyze patterns of habitat use using physical and vegetation variables, and capture data of six small mammal species. Two of the three endemic species, *Apomys abrae* and *Rattus everetii* were strongly associated with dense cover of broad-leaf trees while introduced species, *Rattus exulans*, *Rattus tanezumi* and *Suncus murinus*, preferred areas with dense cover of low-lying grass and forbs. The habitat characteristics associated with endemic and exotic species could be divided into montane forest habitats and open habitats, respectively, suggesting a macrohabitat-level preference. The preferences of two endemic species, *Apomys abrae* and *Rattus everetii*, were distinguished by difference in tree and forbs cover density, with the former associated with higher tree and forbs cover than the latter. In contrast, the third endemic species, *Apomys musculus*, preferred open areas with dense cover of the forb Eupatorium. Introduced species appeared to select microhabitats based on ground steepness and wetness, and tree density. *Rattus exulans* was more associated with areas steeper and higher in tree cover areas than *Rattus tanezumi*. In contrast, *Suncus murinus* preferred moderate slope and wet ground areas. These results suggest microhabitat level preference. However, these preliminary findings need to be validated by additional studies with larger sample sizes.

Response to Human Induced Changes

Where the wild rats go: the relationship between the socio-environmental gradient and rat abundance in slum communities

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Leptospirosis is a zoonotic disease with multiple mammalian reservoirs. In urban settings, synanthropic brown rats are the main reservoirs. Understanding the relationship between habitat attributes in urban areas and the presence and abundance of rodent populations can guide the design of interventions. Reducing carrying capacity of rat populations via environmental modification lowers transmission risk by reducing the density of *Leptospira*-shedding individuals, and thus, environmental contamination. Track plates, designed to measure rodent activity and serve as a proxy for abundance, were installed in a hundred randomized points in public spaces of four slum communities in the city of Salvador. In each sampling point, an environmental questionnaire was used to standardize the collection of data on habitat. An exploratory principal component analysis will inform the choice of landscape features that will be used in a step-wise model building to define the main environmental drivers of rat abundance. It is expected that the abundance of rats will be strongly correlated with the presence of pervious soil and vegetation patches (vacant lots, backyards, unpaved roads), indicating available burrow sites; and the presence of pet food dishes and points of solid waste accumulation, which act as constant food sources. Rat abundance is expected to have an inverse relationship with the distance of the sampled points to open sewers, and will show tendency to increase towards the lower altitudinal points of the communities, which are the bottom of the drainage valleys.

Response to Human Induced Changes

Peri-urban black rats host a rich assembly of ticks with no clear consequences for rat condition

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Zoonotic diseases have rapidly emerged as public health threats, alongside human modifications to the environment and ecological communities. Urban adapted human commensal species may support ectoparasite communities within and near urban areas, and in turn play a role in zoonotic disease emergence and transmission. The black rat *Rattus rattus* is globally distributed, and has been implicated in human disease for centuries; however its role in supporting ectoparasite communities in the cities that it has spread to around the world has not been fully explored. We examined the ticks parasitizing *Rattus rattus* in a remnant bush area within Sydney, Australia in order to explore the role of introduced rats in the ecology of ticks, and the relationship between *Rattus rattus* and ticks by testing rat characteristics as predictors of tick abundance. Here we show that six species of native Australian tick parasitize *Rattus rattus* in urban Australia. The majority of ticks parasitizing *Rattus rattus* are *Ixodes holocyclus*, a tick associated with significant impacts to companion animals, and some human health concerns. Two other species of *Ixodes*, *Ixodes hirsti* and *Ixodes tasmani*, were also common. Surprisingly, we found that ticks were more abundant on *Rattus rattus* in better condition. Our study shows that *Rattus rattus* supports a rich assembly of ticks in a remnant forest in urban Australia, and that as the *Rattus rattus* in best condition have the most ticks, tick parasitism at the level observed does not appear to negatively impact *Rattus rattus*. Urban human commensals, such as *Rattus rattus*, may play be important hosts for ticks in human modified environments, and further study should investigate the roles of these species in both tick and disease ecology.

Future Rodent Control Technologies

Safe assessment of CRISPR-Cas9 gene drive strategies in mice

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Invasive vertebrate pests including house mice cause significant environmental damage and loss of agricultural productivity. Current control and eradication methods have limited efficacy. A possible solution to this problem is the genetic modification of entire populations to suppress pest numbers. A CRISPR-Cas9 gene drive is a genetic construct that promotes its own inheritance and can therefore spread through a given population. Our recent *in silico* modelling indicates that CRISPR-Cas9 gene drives that induce female sterility or embryonic lethality have significant potential for eradication of rodents on islands. However, to date CRISPR-Cas9 gene drives have only been developed in a small number of species including flies, mosquitoes and yeast. Our goal is to develop an efficient mouse CRISPR-Cas9 gene drive, incorporating stringent safeguards against unintentional release. Using a ubiquitous Cas9-expressing strain, we have shown that gene drive activation in mouse zygotes promotes generation of indel mutations and not self-replication. We are also developing a “germline-active” gene drive using a similar strategy to the successful gene drive experiments in insects. This is the first attempt at developing CRISPR-Cas9 gene drive technology in rodents and provides an important step towards assessing their potential for population suppression of invasive mice.

Future Rodent Control Technologies

Global trends in the development of rodenticides and new approaches

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The history of research discoveries in rodenticide development, their pros and cons as well as current and future-focused research are explored. Research endeavouring to retain essential tools, develop new toxins and delivery systems and explore non-lethal control options has advanced. Lessons learned from the research, registration and technical challenges associated with advancing new technologies are presented. There are exciting opportunities for transformational change based on the integration of existing and new tools, such as advances in wireless technology for species recognition, new self-resetting traps, drones, species-specific toxin-delivery systems enhanced with advanced lures and new toxins which can increasingly combine “low-residue” characteristics with selectivity (e.g. norbormide) and humaneness. Putting our efforts into 'silver bullet' technologies for small mammal pest control is the wrong approach to biodiversity conservation. Research and development should focus on blending the practical skill of pest control practitioners with emerging technologies for transformational change, as well as novel fundamental research into biocontrol and new avenues.

Future Rodent Control Technologies

RNAi as the next generation tool for the control of rodent populations

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Rodents cause devastating damage to both agriculture and ecosystems worldwide. Invasive rodents are commonly found on islands, historically free of these animals, and have enormous negative impacts on both native plant and animal species. Rodents are exceptionally well adapted to their environments and therefore, quite challenging to control. Current control strategies often include large scale applications of toxicants, which have potential adverse effects on non-target wildlife. Therefore, the development of new species specific rodenticides would be a valuable advancement in the effort to control these pest species, especially for island eradications. To that end, we are investigating the use of RNA interference, RNAi, as a novel way to control rodent species. RNAi is a new technology that has shown much promise as both a therapeutic for human diseases and in the efforts to control insects and plant diseases. In essence, RNAi is a gene-silencing technology in which small, specifically designed sequences of RNA are introduced into cells and induce the degradation of sequences of RNA encoding a target gene of interest. This degradation of RNA means that the protein for which the RNA was coding is no longer synthesized. By inhibiting protein synthesis, RNAi enables researchers to selectively alter cell function in both normal and disease states. By screening the rodent genome, selecting genes of interest, and comparing the sequences of these genes to non-target species, we are able to choose genes that are present in the pest rodent species and not in the non-target species. Therefore, if non-target species consume the RNAi they will not be effected. The use of RNAi as a method to control pest rodents shows promise because of its species specificity and low non-target impact.

Future Rodent Control Technologies

Opportunities for using novel genetic control tools for the humane control of overabundant vertebrate pest populations

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Novel revolutionary genetic technologies have recently been developed that can force modified genetic traits into an animal population, defying the constraints of normal Mendelian inheritance. A highly specific gene editing system drives the duplication of a specific gene cassette between paternal and maternal chromosomes so that the trait is inherited by all offspring. There is currently very active global debate about the potential applications of this exciting new technology, including novel strategies to humanely control overabundant invasive pest animal populations. Delivered and spread through sexual reproduction the potential of this powerful new technology is unprecedented, making pest eradication theoretically feasible. At present, such technologies have only been shown to function in insects, but work in mice as a mammalian model system is currently underway. Much of the international debate focuses on the risks that might be posed by the technology, how they can be mitigated, how they should be regulated and even whether they can be used at all. The ability to safely control any putative genetic control approaches is paramount, to ensure protection of the target animal in its native distribution range. For any experimental research into genetic control tools it is essential to understand the risks, potential ecological and social implications, to develop physical, genetic and ecological containment measures as well as robust regulatory pathways. In Australia, a world leader in the biological control of invasive species, extensive consultations are currently bringing together key stakeholders. These groups cover a broad range of interests and include scientists from key disciplines, government regulators and public representatives. It is critical to ensure a transparent and informed debate from the outset, responsible conduct of science, and to identify key pathways and barriers to adoption of any putative genetic control tools.

Future Rodent Control Technologies

Evaluation of selected pesticidal plant extracts for maize (*Zea mays* L.) protection against *Mastomys natalensis* (Smith, 1834) in Tanzania

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The Multimammate rat (*Mastomys natalensis* Smith 1884) is a serious rodent pest in Tanzania, which causes damage to maize crops after sowing and during germination resulting into crop loss. In an attempt to reduce the damage, farmers use rodenticides for rodent management. To reduce rodenticides use, an alternative method was sought. The study aimed to investigate ten crude extracts from selected plant species namely *Euphorbia candelabrum* (leaves+latex), *Euphorbia tirucalli* (leaves+latex), *Lantana camara* leaves, *Tephrosia vogelii* leaves, *Capsicum anuum* fruits, *Capsicum chinense* fruits, *Jatopha curcas* seeds and *Ricinus communis* seeds to identify the suitable one. The crude extracts were evaluated under laboratory conditions by dressing to maize seeds at concentration 150, 200, 250 and 300 g or ml kg⁻¹ each. Each concentration was individually subjected to a total of 10 rats (5 females+ 5 males) under "choice" and "no-choice" cage experiments and observed for consecutive 7 days. Results revealed that *Ricinus communis* was effective against *Mastomys natalensis* for all seven days of the study by reducing rodent damage to 93% followed by *Jatopha curcas* and *Capsicum chinense*. It was therefore, suggest that *Ricinus communis* be used by small scale maize farmers for controlling *Mastomys natalensis* at sowing stage at a concentration of 150 g dressed in one kilogram of maize seeds. However, a study on rodent behavior responses is suggested for verification of the effectiveness for comparison of *Ricinus communis* with the less effective pesticidal plants. Also a study on the effect of *Ricinus communis* on maize seed germination is suggested to be carried out.

Future Rodent Control Technologies

Do avian and terrestrial predators empty self-service traps for common vole (*Microtus arvalis*)?

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The common vole's (*Microtus arvalis*) population cycle is defined by an extreme increase in population size within two to five years that results in an outbreak with up to 1,000 common voles per hectare, followed by a population breakdown. During outbreaks voles migrate from their primary habitat, undisturbed grasslands, to secondary farmland habitat, e.g. cereals or rapeseed. Farmers often use rodenticides to manage high common vole densities. Population dynamics studies indicate that the effectiveness of rodenticide application can suffer from asynchronous management action, re-colonisation and other issues. Non-chemical methods can be efficient on small-scale but organic farmers need a large-scale applicable approach. Involving the best vole predators could offer an additional tool for rodent management that is suitable for organic farming. We tested two types of traps catching voles and emptied by foxes, racoons, cats, raptors and other birds. We developed one trap with a triangular shape to fit in a ploughed furrow at the refuge-crop interface. The other trap (standby-box, Andermatt Biocontrol AG) has a lid that can be opened by terrestrial predators to remove captured rodents. In field studies, we tested with camera traps how frequently the two trap types were emptied by predators. Our newly developed trap was emptied more often and by a more diverse group of predators than the standby trap. Only house cats (*Felis silvestris catus*), racoons (*Procyon lotor*) and foxes (*Vulpes vulpes*) were recorded opening the lid of the standby-box to remove rodents. From the new trap type, voles were additionally removed by stoats (*Mustela erminea*) and a variety of raptors and other birds. Additionally, its opening allows several rodents to jump out of the trap. If we can answer the question, if predators learn to patrol field margins, our new trap can be an effective and useful tool of an ecologically-based management.

Future Rodent Control Technologies

Research progresses on the anti-fertility effects of a contraceptive bait of quinestrol and levonogestrel (EP-1)

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Rodent pest damage is still a severe problem in the world. Due to increasing rodenticides resistance, high risk to non-target animals or people, rapid population recovery and public concerns of traditional killing, fertility control as a non-lethal and sustainable approach has been proposed as an alternative of rodent management. However, fertility control often suffers disadvantages of low palatability, repeated baiting or environmental safety problems, we are still lacking of efficient approaches of fertility control. In this presentation, we will present a review about the research progresses of the anti-fertility effects of a rodent contraceptive bait with quinestrol and levonogestrel (EP-1), mostly in China. During past decades, baits containing quinestrol and levonogestrel have been shown to have effective anti-fertility effects on various wild rodent species in both laboratory and field conditions. In laboratory experiments, EP-1 showed significant anti-fertility effects in both male and females of rodents, including greater Mongolia gerbils, Brandt's voles, midday gerbils, etc. In field tests, a single baiting of EP-1 baits ranging from 10 to 50 ppm during the breeding season could significantly reduce the reproduction and population density for several months in several rodent species, including plateau pikas, Djungarian hamster, greater Mongolia gerbils, etc. Further studies indicated that the half-lives of quinestrol and levonogestrel in water and soil were short, ranging from a few hours to about 2 weeks, suggesting that these compounds were easily degraded by bacteria in natural condition. Studies also indicated that EP-1 had minor negative effects on populations and diversity in birds. In conclusion, we believe that EP-1 is very promising for practical use for rodent fertility control. More efforts are needed to test its effects on rodent species in other countries outside China.

Poster Session 1 – Form and Function

1 Comparative analysis of some weight and structural parameters for determination of sexual dimorphism in adrenal function of the Libyan jird, *Meriones libycus* (Lichtenstein, 1823)

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The existence of sexual dimorphism in the activity of some endocrine-metabolic functions has been well established in several animal species. Furthermore, very little work has been done on small Saharan mammals. In this concept, we compared in *Meriones libycus*, a nocturne Saharan species belonging to *Gerbillinae* subfamily, some metabolic functions by weight explorations including kidneys, adrenals, and pancreas, as well as by histomorphometric analysis of the adrenal cortex. The results show that the organs weights are in favor of the male compared to the female even though the differences are not statistically significant. Moreover, in the histomorphometric profile, it appears that the adrenal cortex is more developed in the female particularly in the fasciculata and reticularis zonae. In addition, cellular and nuclear analyzes confirm this sexual dimorphism in favor of the female of the adrenocortical activity since this development is essentially due to cellular hypertrophy in the cells of all adrenal cortex zones. These results indicate the existence of sexual dimorphism in favor of the female *Meriones libycus* in adrenocortical activity suggesting the involvement of sex hormones in the regulation of adrenocortical activity probably inhibited by androgens and stimulated by estrogens.

Poster Session 1 – Form and Function

2 Family-specified direction of selection in underground rodents

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Up to now the majority of studies of the analysis of genetic diversity within species and populations was carried out using a small number of molecular markers. However, this approach does not account for the molecular basis of adaptive variation, it remains unclear how many genes are involved in a particular adaptation, what is the origin of genetic diversity responsible for formation of adaptation. The comparison of genomes of phylogenetically close taxa but contrast in adaptations and phylogenetically distant but with similar adaptive traits may help in recovering convergence and parallelisms at the molecular level. This allows testing the hypothesis of the origin of mutations leading to similar phenotype effects and reveal the velocity at which mutation in the DNA may cause a phenotypic effect. In our study, we used annotated genomes of terrestrial and underground rodents from the Ensembl genome browser (ensembl.org). Seven species with well assembled genomes were used: *Cavia porcellus*, *Chinchilla lanigera*, *Rattus norvegicus*, *Mus musculus*, *Fukomys damarensis*, *Nannospalax galii*, *Heterocephalus glaber*. Of these species three are underground rodents, belonging to two phylogenetically distant families – *Spalacidae* and *Bathyergidae*. Ortholog genes were identified with protheintho program and dN/dS values were determined in PAML codeml program for each orthogroup. GO enrichment analysis was performed with Webgestalt software (<http://www.webgestalt.org/option.php>). First of all we identified ortholog genes that have the same direction of selection in all underground species. These genes are enriched with several GO terms, connected with many essential processes: "RNA binding", "metabolic processes", "regulation" and "transcription activity" etc. After that, we identified family-specified genes that belong to the immune response and defence to the stimulus. This study was conducted in Zoological Institute RAS under the research theme N №AAAA-A17-117042410167-2 and partially supported by the grant from RFBR N18-04-00730.

Poster Session 1 – Form and Function

3 Testicular luteinizing hormone receptor (Lhcgr) mRNA expression correlated to testis and seminal vesicles activities in the Libyan jird (*Meriones libycus*) in breeding season compared to non breeding season

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The Libyan jird (*Meriones libycus*) is a wild desert rodent and a seasonal breeder species that adapted to breed when the environment conditions are able to satisfy the energy and hydrous request of pregnant and nursing females that to ensure the birth at the most favorable time of the year. We assessed gene expression of testicular Lhcgr by QRT-PCR and testis activity by a histological method in adult male Libyan jirds during the resting and the breeding seasons. Our results showed that Lhcgr mRNA expression was increased in autumn during the non breeding season and decreased in spring during the breeding season. This expression varied in opposite manner with testicular structure or function and plasma testosterone levels. These results provided important information for understanding the seasonal sexual activity of this desert rodent correlated to the central regulation.

Poster Session 1 – Form and Function

4 Huddling conserves energy, decreases core body temperature, but increases activity in Brandt's voles (*Lasiopodomys brandtii*)

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Behavioral adjustments are primary means for the adaptation to cold in many animals. Our study aimed to determine the effect of huddling behavior on energy conservation, thermogenesis, core body temperature (T_b) regulation and body composition in Brandt's voles (*Lasiopodomys brandtii*). Adult captive-bred female Brandt's voles ($n=124$) (~50 g) in 31 cages with 4 individuals each were exposed to warm ($23\pm 1^\circ\text{C}$) and cold ($4\pm 1^\circ\text{C}$) ambient temperatures (T_a) and were allowed to huddle or were separated single individuals. The cold huddling (CH) groups significantly reduced food intake by 29 % or saved digestible energy 156.99 kJ/day per day compared with cold separated single individuals (CS); in warm huddling groups (WH) the reduction was 26 % or saved digestible energy 105.19 kJ/day per day in comparison to the separated single individuals (WS). Resting metabolic rate (RMR) of huddling voles was 37% lower than in separated single individuals at each T_a . Non-shivering thermogenesis (NST) of huddling voles was not affected by T_a , but in CS voles it was significantly increased in comparison to WS. Unexpectedly, huddling voles significantly decreased T_b by 0.25-0.50°C at each T_a . The decreased T_b was not only a direct result of the reduced metabolic rate during huddling, but also possibly caused by heat exchange between huddle mates through increased vasodilation in contact zones as well as relaxed temperature control. Nevertheless, activity of CH voles was higher than in CS voles. Thus, huddling is energetically highly effective because of reduced metabolic rate, thermogenic capacity and relaxed T_b regulation despite the increase of activity. Therefore, Brandt's voles can remain active and maintain their body condition without increased energetic costs during cold exposure. This study highlights the ecological significance of huddling behavior for maintenance of individual fitness at low costs, and thus survival of population during severe winter in small mammals.

Poster Session 1 – Form and Function

5 Stomach anatomy of *Praomys taitae*

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The genus *Praomys* (*Muridae: Murinae*) circumscribes a small radiation of rodents indigenous to sub-Saharan Africa. Of these, Carleton and Stanley (2012) identified three groups differing in external and cranial morphology, but the third designated species, *Praomys taitae* was left paraphyletic as it was later shown to contain individuals from two genetically and geographically distinct groups (Bryja et al. 2014). Among the morphological differences detected, the authors demonstrated subtle shape differences involving features related to mastication, which could be related to local differences in diet. Little is known however, on the diet or gastrointestinal anatomy of the *Praomys* species. In this paper, the gross and histological anatomy of stomachs of four *Praomys taitae* caught in two cloud forest fragments within the Dawida massif, Kenya were studied. All stomachs contained similar flower blooms and other pieces of plants. In all four specimens, also legs or other small pieces of insects were detected. A well-developed folded edge (margo plicatus) was prominent dividing the stomach into a large non-glandular region (2/3 of the stomach surface) and glandular region. Two low mucosal folds separated this non-glandular part into three compartments. Histological examination confirmed the typical proper (fundic) gastric glands on one side of the plicate border and non-glandular tissue on the other side. An ongoing dental analysis may provide additional insights into the diet of this little known rodent species.

Bryja, J., Mikula, O., Patzenhauerova, H., Oguge, N.O., Šumbera, R. & Verheyen, E. 2014. The role of dispersal and variance in the Pleistocene history of an East African mountain rodent, *Praomys delectorum*. *Journal of Biogeography* 41: 196-208. Carleton, M.D. & Stanley, W.T. 2012. Species limits within the *Praomys delectorum* group (*Rodentia: Muridae: Murinae*) of East Africa: a morphometric reassessment and biogeographical implications. *Zoological Journal of the Linnean Society* 165: 420-469.

Poster Session 1 – Form and Function

6 The effects of population bottlenecks on dental variation in arvicoline rodents

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The study aims to investigate dental variation in arvicoline rodent populations passing through natural or artificial bottlenecks. Phenotypic diversity arising from a limited number of founders is studied in 1) populations of invasive species that have passed through recent bottlenecks related to human-mediated introduction, either intended (*Ondatra zibethicus*) or non-intended (*Microtus rossiaemeridionalis*); 2) populations of native north-Eurasian species showing periodic depressions and outbreaks (*Myopus schisticolor*, *Microtus arvalis obscurus*); 3) captive colonies of arvicoline rodents reared through 3-11 generations (*Dicrostonyx torquatus*, *Microtus arvalis obscurus*). To study dental variation, we use interval and ordinal morphological variables that describe occlusal patterns of left and right m1, m2, m3, and M1, M2, M3 of each individual in the dataset (over 5,000 non-juveniles), with the exception of *Ondatra zibethicus*, which is represented by m1s from 513 individuals). We identify the groups of characters that vary independently of one another and those which reflect the variability of the dentition as a whole, and consider those groups with respect to the present-day knowledge of evolution, development, and function of arvicoline dentition. The results are summarized to answer the following questions. Which dental characters are the best to detect sharp reductions in population size and what kind of shifts are the most common? How many individuals does it take for a group to exhibit different types of phenotypic shifts? How soon can a founder effect and/or phenotypic distortion due to inbreeding be detected in isolated groups of animals? How do the periodic reductions in population size affect phenotypic variation in the absence of complete isolation? Based on comparisons among species, we identify general and species-specific phenotypic patterns that could be used to hypothesize the existence of a bottleneck in arvicoline rodent populations, living or extinct. Supported by Russian Foundation for Basic Research (grant 16-04-01486).

Poster Session 1 – Form and Function

7 Assessment of the activity of Neural Stem Cells in the postnatal brain of *Microtus thomasi*

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Different pools of Neural Stem Cells (NSCs) remain active in the postnatal mouse and rat brain. Multipotent NSCs are clustered in niches such as the Subependymal Zone (SEZ) of the lateral walls of the lateral ventricles and the Subgranular Zone of the dentate gyrus, while oligodendrogenic progenitors are widely distributed throughout the parenchyma. Here we extend the study of NSC function in the adult rodent brain by investigating the presence and activity of NSCs in the brain of Thomas' pine voles (*Microtus thomasi*), fossorial and burrowing rodents captured in the NW Peloponnese area of Greece. Because cytotogenesis in the SEZ mainly contributes to olfaction, by furnishing the olfactory bulbs with new neurons, we aim at exploring if adaptation to fossorial life involves adjustments in the activity of NSCs in the SEZ. NSCs and their progeny are identified using immunohistochemical analysis on coronal brain sections, with proliferating cells being immunopositive for PCNA, newborn neurons for Doublecortin, cells of the oligodendroglial lineage for Olig2 and astrocytes for glial fibrillary acidic protein. The density of mitotic cells, of neuroblasts and of oligodendroblasts is quantified within the *Microtus* SEZ and compared to that of the mouse and of the rat SEZ while the same comparison is performed for the mitotic activity of oligodendrogenic progenitors of the corpus callosum, an olfaction-independent system.

Poster Session 1 – Form and Function

8 A study of behavioral and biochemical indicators in brain regions of the vole *Microtus thomasi* (Rodentia, Arvicolinae), following the induction of epileptic seizures

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The aim of the present study was to investigate the effect of pentylenetetrazole (PTZ), an epileptic seizure-inducing agent, in anxiety/fear behavior and the activity of the G1 and G4 isoforms of acetylcholinesterase (AChE), in selected brain regions of the Thomas' pine vole (*Microtus thomasi*: Rodentia, Arvicolinae). Initially, the voles, captured from natural populations of NW Peloponnese, Greece, were divided into a control and a PTZ group (administration of 60 mg PTZ/kg of body weight). Twenty-four hours after PTZ administration, vole anxiety/fear behavior was checked, through the performance of an open field test, aiming at the measurement of the thigmotaxis time (rate of anxiety/fear). Afterwards, the voles were sacrificed and specific brain regions were isolated (central hemispheres, cerebellum and midbrain), in order to determine the activity of G1 and G4 {mostly found in the SS fraction (Salt- Soluble) and DS fraction (Detergent-soluble), respectively} isoforms of acetylcholinesterase (AChE), with Ellman's colorimetric method. Following PTZ administration, our results revealed: a) that thigmotaxis time did not differ significantly between the two groups b) a statistically significant reduction of the activity of the G4 isoform of AChE in all tested brain regions of animals under PTZ effect. With this opportunity, a comparison was also conducted between the control group of voles and a group of laboratory mice (Balb-c), and the significant differences that were detected, regarding both the thigmotaxis time and the activity of G1 and G4 isoforms of AChE, are commented.

Poster Session 1 – Rodent Behaviour

9 Reproductive behaviour of mothers facing infanticide risk

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The threat of losing offspring to infanticidal conspecifics is widespread in the animal kingdom. If infanticide occurs, this poses enormous fitness costs to parents, in terms of losing out on reproductive investment. Therefore, the level of infanticide risk that a parent perceives should affect its behavioural strategy, for instance, in terms of offspring protection. Using the bank vole, *Myodes glareolus*, as a model species we experimentally investigated how infanticide risk affects behaviour. Bank voles have rapid reproductive cycles, producing a new litter every few weeks, and infanticide has been shown to occur, especially by conspecific males that are unrelated to the offspring. Females show post-partum estrus, i.e. are receptive immediately after giving birth. Therefore, they need to encounter a mate to fertilize them while also providing parental care and protection to their existing litter. This makes rodent females especially prone to the trade-off between current and future reproduction, and ideal to study the existence of behavioural reproductive strategies in response to the level of infanticide risk. Females were mated indoors with known males and, shortly after parturition they were released (non-pregnant) with their litter in a nest box in outdoor enclosures. By spreading either the familiar scent of her litter's sire or the scent of a male unfamiliar to the female (stranger) in the enclosure, we simulated low and high infanticide risk respectively. Using automated radio telemetry and RFID reading stations, we studied the effects of scent treatment on female spatial behaviour, including her presence/absence at the nest, activity level and movement pattern. We discuss findings of how infanticide risk posed by a potential mate partner affects female behaviour indicative of her investment in future reproduction (e.g. time away from the nest to find the mate) versus current reproduction (e.g. time at the nest to guard her litter).

Poster Session 1 – Rodent Behaviour

10 Social Contact Network loggers – an open source, high resolution approach for monitoring interactions between small rodents

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Behavioural ecology is often a matter of interactions; understanding the processes underpinning behaviour such as competition, predation, sociality, sexuality or disease transmission therefore often requires the ability to monitor interactions between individuals. Until recently, such detailed knowledge of individual behaviour has been restricted to either captive, large or easily visible species. However, by exploiting recent advances in embedded software, chip miniaturisation and battery development, we have developed small (<2g) loggers which record when individuals come within a predetermined distance of each other, the id of the individuals and the time period over which the interaction occurs. Our SCoNe loggers, developed in collaboration with the Department of Engineering and the Department of Product Design at Universiteit Antwerpen, are small enough to be attached to animals over 40g in weight (ensuring the logger is <5% of the animal body weight), are rechargeable, and can be remotely programmed to adjust logger settings. Here, we present initial results from developing and calibrating our loggers using *Mastomys natalensis*, the multimammate mouse, in Antwerp and Tanzania. Loggers were initially tested on captive, colony bred *Mastomys natalensis* to trial different attachment techniques and ensure no harm or discomfort was caused by attachment. Field realistic trials were carried out in mesocosms in Tanzania using wild caught *Mastomys natalensis*. We present the initial results in the anticipation that these SCoNe loggers will have a wide appeal to ecologists working on a range of species.

Poster Session 1 – Rodent Behaviour

11 Comparative analysis of isolation-induced pup ultrasonic calls of five gerbil species

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Gerbils (*Gerbillinae*), inhabiting arid areas of Asia and Africa, display different ecological specializations and sociality. Adults primarily use ultrasound but some species produce also audible vocalizations. Pup vocal behaviour is poorly known. For five species (*Gerbillus campestris*, *Gerbillus perpallidus*, *Meriones unguiculatus*, *Meriones vinogradovi*, *Sekeetamys calurus*), we compared ultrasonic isolation calls of captive 6-10-day pups (each from a different litter; 5 pups per species, 25 in total). Each pup was recorded for 2 min at 22 °C using a recorder Pettersson D1000X (384 kHz, 16 bit), weighed and measured for body variables. Calls (5 per pup, 125 in total) were examined using Avisoft SASLab Pro software for duration and fundamental frequency variables and contour shape. Flat contours were common in *Gerbillus perpallidus* (60% of calls), chevron contours in *Gerbillus campestris* (52% of calls) and *Sekeetamys calurus* (56% of calls), ascending contours in *Meriones unguiculatus* (76% of calls), wavelike contours in *Meriones vinogradovi* (all calls). All the four contour variants occurred only in *Gerbillus campestris*. Most short calls were produced by *Gerbillus campestris* (85±52 ms) and *Gerbillus perpallidus* (89±32 ms) and the longest calls were produced by *Meriones vinogradovi* (184±37 ms). The maximum fundamental frequency was the highest in *Gerbillus campestris* (77.5±6.34 kHz) and ranged of 47.9-53.2 kHz in other species. Depth of frequency modulation varied from 8.2±4.0 kHz in *Gerbillus campestris* and 5.0±3.7 kHz in *Gerbillus perpallidus* to 11.7-16.0 kHz in other species. Pups of *Gerbillus campestris* were the smallest in body weight and size. The differences in fundamental frequency were higher between pups of *Gerbillus campestris* and *Gerbillus perpallidus* than between pups of species from different genus. Probably, such large differences were related to the differences in body size between these species, but further investigation is necessary to confirm this. Supported by the RSF grant 14-14-00237.

Poster Session 1 – Rodent Behaviour

12 Co-existence leads to diet shift of bank voles by competition with grey-sided voles?

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Grey-sided voles (*Myodes rufocanus*) and bank voles (*Myodes glareolus*) co-exist in boreal forests in northern Scandinavia. Previous studies suggest that the two species engage in interspecific interactions, with the grey-sided vole being the dominant species. We took muscle samples from voles in patches of old forest occupied by only bank voles and patches of old forest occupied by both grey-sided voles and bank voles. We found that (1) stable isotope ratios of bank voles differed in areas with and without grey-sided voles and that (2) the stable isotope ratios of bank voles were more similar to those of grey-sided voles in areas where grey-sided voles were absent. Our data suggests that grey-sided voles forced bank voles to change their diet due to interspecific competition.

Poster Session 1 – Rodent Behaviour

13 Sexual differences in home ranges of *Apodemus peninsulae* in Korea

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The spatial distribution of a species may imply their mating system strategies. In order to investigate home range characteristics of *Apodemus peninsulae*, we used capture-mark-recapture method from total 18,000 trap nights through 5 study sites in Korea. Home ranges were estimated with Minimum Convex Polygon method from individual data captured at least 3 different trap locations. Whether social ranks were related to home range patterns, generalized linear mixed models were employed with a Poisson error distribution and log link function. Fixed factors were weights (social ranks) and numbers of captures of each individual and random factors were study sites and years in study sites. Home ranges of 41 males and 26 females were estimated. Home ranges of males often overlapped with both males (23 in 41 males) and females (16 in 41 males) (Chi-square 1.723, df=1, p=0.189). However, home ranges of females overlapped more with those of males (19 in 26 females) than females (7 in 19 females) (Chi-square 9.308, df=1, p=0.002). Home range sizes increased with male weights but decreased with female weights. Home range sizes of both sexes increased with numbers of captures. Numbers of captures and weights in each sex were not correlated. Our results show two sexes of *Apodemus peninsulae* have different spatial distribution patterns. These patterns may imply that males of the species have a promiscuous mating strategy (polygynous mating) but females secure their territories in related to resource competition in order to maximize reproductive success of each sex.

Poster Session 1 – Rodent Behaviour

14 Find the needle in the haystack: tracing the dispersal of small palatable tree seeds in European beech forests

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Zoochory is of substantial importance for dispersal of palatable tree seeds. Besides primary dispersal, tree seeds might be detected by seed hoarding animals. Thereby, seeds might be either consumed or hoarded for later consumption. We analysed hoarding behaviour of small mammals in two different study areas in beech (*Fagus sylvatica*) dominated forests in Austria. Ground vegetation, terrain and predator guilds were comparable at both sites. Considering the relatively small dimensions of beechnuts we tested three different seed tagging methods: (1) wire threads with plastic flags fixed with solvent-free glue, (2) wire threads with plastic flags twisted around a beechnut, (3) and radio-transmitters fixed with solvent-free glue. We offered tagged as well as untagged seeds on experimental dishes to analyse seed removal rates. We did not find any difference in seed removal between different tags or untagged beechnuts. Nearly all seeds were removed within 25-35 days after exposure. However, transport distances differed between study areas and radio-tagged seeds generally experienced larger dispersal kernels with a maximum range of 60 m. Furthermore, seeds tagged with radio-transmitters were cached more frequently compared to flag-tagged seeds. In one study area, a higher quota of radio-tagged seeds could be recovered compared to flag-tagged seeds. We suggest to simultaneously use flag-tagged and radio-tagged seeds to obtain a realistic picture of dispersal kernels in situations with dense ground vegetation or irregular terrain.

Poster Session 1 – Rodent Behaviour

15 Low correlation between parameters from different behavioral tests in the common vole

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Several different tests or at least one under different conditions are often used for animal personality trait determination, especially in rodents. Then all the obtained data are extracted by the principal component analysis (PCA). In this study, we do not report on usual results of the indicated procedure – the personality traits of the tested animals, but we have focused on the similarity (correlation) of the same parameters and behavioural elements in different tests. We have tested 47 individuals of the common vole (*Microtus arvalis*) in three different apparatuses: in the classical "Open Field" test (OFT), in the Elevated plus maze (EPM) and in the closed space box "Phenotyper" (PT, Noldus). We got data on 21 behavioural elements and parameters in total. As a natural baseline of locomotor activity, we considered the distance covered in the PT box where the animals spent 72 hours. We found very low insignificant correlations with the distance covered in EPM ($r = 0.05$) and OFT ($r = 0.14$). In a similar way the correlation between the EPM pathway and the OFT pathway was very low ($r = 0.21$) and insignificant. The parameters obtained in the PT box did not correlate with any other parameters or behavioural elements of the OFT or EPM tests. A more pronounced significant correlation was found only between the total distance covered in the OFT and the time spent in observation on the open arm of the EPM ($r = 0.64$). Significant correlation between the same parameters was found in one case only – between the total time of rearing in the OFT and the rearing in the closed EPM arm ($r = 0.54$). The prevailing absence of significant correlations between individual tests reflects a complexity of the tests and leads to caution in the interpretation of obtained data.

Poster Session 1 – Rodent Behaviour

16 Relationship of breathing frequency to personality trait in the common vole (*Microtus arvalis*)

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Intraspecific variation of breathing frequency and its relation to personality traits were studied in the common vole (*Microtus arvalis*). This relationship is important for verification of behavioural determination of the personality traits through physiological parameter values. In general, the increase in the respiratory rate is associated with increased energy expenditure in physical and mental stress. Thus, in the study, we worked on the assumption that individuals determined in behavioural tests as shy will exhibit steadily higher respiratory rates than the bold ones. Individual respiratory rates were measured using a device consisting of a respirometric (RM) chamber coupled to a pressure sensor and an oscilloscope. Stress breathing frequency (SBF) was measured after an individual was put into the RM chamber and an audible alarm was produced causing a startle reflex. After about 5-10 min resting breathing frequency (RBF) was recorded. This procedure was repeated after 24 hours and then again after 30 days. Based on these repetitions, the Intraclass Correlation Coefficient (ICC) was calculated to show repeatability of the reaction. The stress and rest values were used for calculation of absolute and relative differences. Personality traits of the tested animals were obtained from a classic Open Field (OF) test and were represented by the length of the exploratory trajectory. It has been found that the common vole shows consistent inter-individual differences in breathing frequencies. ICC values ranged from 56 to 74%. The results also showed a very close negative dependence between SBF and the personality trait ($p = 0.031$) and between the relative difference of SBF-RBF and personality traits ($p = 0.001$). The higher the respiratory rate or increase during stress, the shorter the exploratory trajectory. RBF values indicated a weak relationship to personality traits.

Poster Session 1 – Rodent Behaviour

17 Secondhand horror: effects of direct and indirect predator cues on behavior and reproduction of the bank vole

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In the evolutionary arms race between prey and predator, early risk recognition by the prey species is of paramount importance. Mammalian prey species are able to detect direct predator cues, like odors and to display appropriate defensive behaviors. Not much is known about indirect predation cues in mammals, i.e. the scent of scared individuals detectable by conspecifics, and how they affect recipient behavior. Current theories predict also cross-generational, maternally transferred, effects of increased predation risk or fear to their offspring. To escape predation now or in the next generation, predation risk is suggested to delay or suppress reproduction. However, in theory, enhancement of reproduction, bet-hedging or terminal investment, may be an adaptive strategy as well. Not much is known about cross-generational effects of predation risk on offspring behavior and fitness. We assessed how direct and indirect predation cues, in the form of predator odor or odor of scared conspecifics, alarm pheromones, affect bank vole (*Myodes glareolus*) reproduction and pup fitness. In our experiment, we exposed males and females either directly to least weasel (*Mustela nivalis*) odor, to indirect alarm pheromones from weasel-scared male voles, or to control odor. The treatments were started before mating and lasted until the pups were born. Contradictory to our expectations both predator odor and alarm pheromones enhanced reproduction compared to control. Alarm pheromone treated females had a significantly higher pregnancy rate and pups from predator-treated parents were significantly heavier at birth. Stress metabolite levels were similar in the predator odor and alarm pheromone treatment. Our study provides two novel results: compared to a signal of general danger, i.e. predator odor, the odor of a scared conspecific convey an immediate risk of attack and possible death. Both cues can work at the same time and trigger enhancement of reproduction in form of final investment.

Poster Session 1 – Rodent Behaviour

18 Fear or curiosity: does a shelter help to be courageous?

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Anxiety and exploration are common subjects in animal behavior research. While anxiety is mainly driven by fear, exploration can be motivated by curiosity. Despite these differences, tests for anxiety and exploration are often used interchangeably in behavioral research. Part of this confusion is due to the fact that the assessment of anxiety and exploratory ability of animals rely on the analysis of the same behavioral elements in an open field arena, i.e., distance moved, etc. Additional confusion arises from the introduction or removal of elements by researchers to the experimental setup (e.g., shelter). Given the ubiquitous use of this test in animal experimentation and the numerous conclusions drawn from it, it is especially important to clarify how certain elements, namely the presence of a shelter, have in the animals' state and how they affect its behavior. The aim of this project is to evaluate the role of a shelter in inducing exploratory behavior in an open field arena. Our hypothesis is that the presence of a shelter in an open field test decreases the anxiety level of mice and thus induces explorative behavior in opposition to an open field setting where no shelter is present. To evaluate this we are analyzing the behavior of two species of wild mice (*Mus musculus domesticus* and *Mus spretus*) in an open field setting with and without a shelter and we will correlate their behavior with their anxiety levels, which we assessed through blood cortisol levels directly after testing in each experimental setup. We predict the presence of a shelter will induce an increase of exploratory behaviors and lower anxiety levels in both species. The shelter should have a higher influence on motivational state on *Mus musculus domesticus*, as the latter is a commensal species and is used to human/artificial environments.

Poster Session 1 – Rodent Behaviour

19 Social networks and parasite transmission in wild guinea pigs (*Cavia aperea*) in outdoor enclosures

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Social network analysis (SNA) provides a description of social structure. Studies of the causes and consequences of individual variation in network position that arise as a consequence of an individual's phenotype or patterns of group-living. SNA provide a framework for representing the implications of networks for dynamics of parasites; the contact between hosts that may allow the transmission of parasites. Contacts were assumed that individuals are scaled according to their parasite load. Alternatively, parasites were distributed randomly among node social networks. We used SNA to shed light on the importance of different aspects of sociality on parasitism in a caviomorph rodent, wild guinea pig (*Cavia aperea*). This study implied different stage of intensive research: animals caught from the wild, cavies remained free of infection, enclosures acclimatization, capture-recapture, direct behavioural observations, and compare networks over time. Social interaction was recorded on at least two days each week for 5 months. Sampling for social network formation matched the chronic nature of parasites in *Cavia aperea*. We used daily subgroup composition records to construct space-sharing weighted networks with centrality measures. Preliminary results indicate relative consistency and stability of social networks over different months. Networks with a clear partition of nodes into groups according nest distribution and animal density. Additionally, asymmetry networks show minimized edge crossing and uniform edge length. High clustering indicates that, on average, focal individuals became more likely to interact locally with a subset of others rather trying to maintain group-wide interactions. Physical contact patterns were heterogeneous. The parasite load of highly connected individuals was note necessarily greater than that of less connected individuals in the networks. We suggest that the wild guinea pig may be an important model species for better understanding the transmission of infectious disease in an ecologically valid context.

Poster Session 1 – Rodent Behaviour

20 Habitat selection by small mammals in hemiboreal mosaic landscape

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Small mammals have an important role in the food chain and thus belong to keystones of the ecosystem. We analysed the abundance of small mammals and their habitat selection over six years in different landcover types. Species richness and abundance were highest in the ecotones. *Myodes glareolus* was mainly found in the forests where they preferred older stands, moreover, their abundance decreased towards ecotones. *Apodemus flavicollis* was opportunistic towards different habitats. Among open areas they preferred natural dry grasslands and among forest habitats they preferred middle-aged deciduous forests. *Apodemus agrarius* was found in grasslands ecotones. We continue doing our research to get more detailed results about different years and habitat selection among small mammals.

Poster Session 1 – Rodent Behaviour

21 Ultrasonic pulse bouts of a blind fast-climbing rodent (*Typhlomys chapensis*): similarities and differences with echolocation calls of bats

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Bouts of ultrasonic pulses produced by blind Vietnamese pygmy dormice (*Typhlomys chapensis*) are reminiscent of ultrasonic calls of echolocating bats, however they display some remarkable differences in the acoustics. Echolocation pulses of the dormouse are organized in bouts. We examined 1,481 bouts that consisted of 1-6 pulses per bout; 51.3% of bouts contain more than one pulse. The number of pulses per bout affected bout duration and inter-bout interval, whereas the period from start of a previous bout to start of the next bout was constant (80.0 ± 2.9 ms) in spite of the number of pulses per bout. Ultrasonic pulses (540 pulses measured in a subset of 234 bouts), represented short (0.68 ± 0.15 ms) convex sweeps with the fundamental frequency slope from 127.3 ± 6.3 kHz to 64.1 ± 4.6 kHz and peak frequency at 93.3 ± 7.4 kHz, emitted with a within-bout pulse period 13.03 ± 3.01 ms. Single pulses and start pulses of multi-pulse bouts were lower in frequency than other pulses of the bouts. In contrast, pulse duration was independent on pulse position within bout. Pulses were reminiscent of echolocation calls of *Murina* and *Myotis* bats, but were higher in frequency, much shorter, fainter, displayed a convex contour of frequency modulation and displayed only the fundamental frequency band without harmonics. At the same time, the organization of the ultrasonic pulses in bouts is not characteristic for bat echolocation. In contrast, hippopotamus (*Hippopotamus amphibius*) uses clicks organized in bouts for echo-ranging in muddy waters. Probably, the Vietnamese pygmy dormice can also use their ultrasonic pulses for echo-ranging during their locomotion and jumps among bush branches. Compared to bats, the speed of the dormice locomotion is not so high. Therefore, they do not need vary strongly the period between the ultrasonic pulses as in the echolocation series of bats. Supported by the RSF grant 14-14-00237.

Poster Session 1 – Rodent Behaviour

22 Age-class differences in the acoustic structure of ultrasonic calls of yellow steppe lemmings (*Eolagurus luteus*)

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A common pathway of the vocal ontogeny of mammalian audible calls displays a descent of fundamental frequency from pups to adults. A distinctive pathway (increase of fundamental frequency with age) found in rodents ultrasonic calls (rats and mice) might be related with a distinctive production mechanism (whistle). We investigated the ultrasonic isolation calls in captive yellow steppe lemmings *Eolagurus luteus* at five age-classes: Age1 (1-5 days), Age2 (10-16 days), Age3 (20-28 days), Age4 (35-42 days), Age5 (57 days-adults), 5 individuals per age-class, 25 individuals in total. Each individual was recorded for 2 min at 22°C using a recorder Pettersson D1000X (384 kHz, 16 bit), then weighed and measured for body variables. Calls (5 per individual, 125 in total) were examined using Avisoft SASLab Pro software for duration, fundamental frequency and power variables, contour shape and nonlinear phenomena. Animal body weight and body length increased from 6.47±2.62 g and 43.8±8.39 mm at Age1 to 78.90±22.36 g and 127.3±11.9 mm at Age5. Frequency contours were most variable at Age1. Chevron contour prevailed at Age1 (60% calls), whereas the ascending contour at Ages2-5 (56-92% calls). Non-linear phenomena included both frequency jumps (44% calls) and biphonations (32% calls) at Age1 and only frequency jumps at Ages2-5 (28-60% calls). Duration decreased from 77±24 ms at Age1 to 30-33 ms at Ages3-5. Maximum fundamental frequency and depth of frequency modulation were higher at Ages1-2 (49.6-51.5 and 19.7-19.8 kHz respectively) than at Ages3-5 (38.3-42.2 and 8.7-13.3 kHz). Minimum fundamental frequency was lower at Age5. Peak frequency and power quartiles decreased from Age1 to Age5. Against expectations based on potential whistle mechanism of vocal production, the fundamental frequency and duration of the lemming ultrasonic calls decreased with age and body growth, displaying the common ontogenetic pathway of mammalian audible calls. Supported by the RSF grant 14-14-00237.

Poster Session 1 – Rodent Behaviour

23 Hibernation performance in free-ranging common hamster (*Cricetus cricetus*)

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The most of hibernation studies carried out in artificial conditions with photoperiod and ambient temperature control. So, animals unlikely display in full such natural seasonal patterns as hoarding, burrow digging, nesting and temperature dynamics itself. The best decision is to follow hibernation in nature, although it is quite difficult and risky. On experimental plot in Central park of Simferopol city (Russia), 4 hamsters (3 males and 1 female) used as focal to study temperature patterns during 1 season each. Animals were implanted intraperitoneally by Petrovsky thermologgers (interval – 30 min) and by radiotransmitters to follow the location of the animal. The same number of individuals were either lost, early died or records were not full for analysis. All focal animals found hibernated, body temperature dropped up to +2.3 °C (in female) and +4.9 °C (in males). The total number of hypothermic episodes were 11 in female, 11, 12 and 13 in males. The maximum duration of hibernation episodes in males were noted at the end of December – beginning of January (5 days), in females – at the beginning of February (5 days). The longest normothermia period between hibernation episodes lasted for 19 days. The hamsters in the City park start hibernate quite late (early December), and finish not late as early March. Also we watched above the ground activity of some other animals on the plot any winter months. The short hibernation of the Common hamster in Simferopol compare to other known data on this species in labs may be explain by good food resources here (walnuts, Gleditschia, hazelnut). These fruits probably reached by polyunsaturated fatty acids (for instance, linoleic). As shown by C. Siutz et al. (2018) such diet forward shortening of hibernation. The study was supported by RFBR 17-04-01061.

Poster Session 1 – Rodent Behaviour

24 Hibernation patterns in free-ranging common hamsters (*Cricetus cricetus*)

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The aim of this study is studying winter activity and hibernation of the common hamster in the natural environment, but in the urban area. In Simferopol city (Crimea) lives one of the largest natural populations of the common hamster in Europe. In the Central City Park in 2015 we established an experimental plot of 2.2 ha. For the analysis of hibernation, 4 hamsters were chosen as focal animals. To record the body temperature, animals under anesthesia were implanted intraperitoneally by Petrovsky thermologgers (measurement interval - 30 min) and a radio transmitter to determine the location of the animal. Throughout the experiment (2015-2018), all animals lived in the park. The total number of hypothermic episodes in female is 11, in male is 11 and 12. All focal animals found hibernating, body temperature dropped up to +2.3 °C (for female) and +4.9 °C (for males). The maximum duration of hibernation episodes in male was noted at the end of December – beginning of January, in females – at the beginning of February. The maximum duration of a hypothermic episode in female and males is 5 days 15 hours. After restoring of the body temperature, the animal either remained in normothermia state for 19 days and 11 hours. The data obtained in Simferopol Park show that animals can start to hibernate quite late (at the end of December), but hibernation periods are finished very early (in late February - early March). The common hamsters from Simferopol have a short hibernation, which may be due to the presence of polyunsaturated fatty acids (PUFAs, particularly linoleic acid) in the diet (Siutz, et al., 2017). The RUFAs (LA) in large quantities are contained in walnuts. Walnuts are the main feed for common hamsters in the Simferopol park.

Poster Session 1 – Rodent Management

25 Bio-economic model of muskrat control

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Bio-economic models provide a tool to choose between alternative strategies of management for pest- or predator populations. Such model was constructed for the case of Muskrat control in the Netherlands, in order to investigate under what assumptions qualified eradication would be economically more optimal than year-round control or no-control. The Muskrat is an invasive alien species endangering public safety by burrowing in levees and dams. The model consisted of three components, 1) a discrete logistic population model, and formulas capturing 2) the trapping process and 3) the costs of control, prevention and damage. The population and trapping components were calibrated with success against existing time series of catch and effort. The model results clearly point at qualified eradication as being optimal from an economic perspective, under realistic assumptions for Muskrat control in the Netherlands. It identified that trappers may be limited by time required for inspection and control of traps, which explains why-in practice-control tends to become less costly when a situation of greater control is attained. Furthermore the model points at the relative importance of the required investments in preventive measures versus the costs of damage inflicted by Muskrat. The first costs are related to the prevention of the most important damage and the reduction of risks for public safety by fortification of flood walls and/or banks of water bodies. For the case of the Netherlands, it is the sheer magnitude of the required investment in preventive measures, under a policy of no-control, that would make such strategy more expensive than qualified eradication, independent of the damage costs that can reasonably be expected.

Poster Session 1 – Rodent Management

26 Prevalence of rodenticide resistance in Singapore's rat population

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Rodenticide resistance poses a major challenge for vector control. Single Nucleotide Polymorphisms (SNPs) in the gene VKORC1 have been associated with anticoagulant rodenticide resistance in rats. Although extensive studies have been carried out mainly in Europe, few studies have been carried out in southeast Asia. The aim of this study was to characterise the frequency and distribution of VKORC1 SNPs in the rat population in Singapore. DNA was extracted from forty-two (42) *Rattus norvegicus* and *Rattus rattus* spp. tail samples collected from various parts of Singapore. Exon 3 of VKORC1 was amplified by PCR prior to Sanger sequencing. Electropherograms of the results were analysed for SNPs and codons of interest were located in exon 3, mainly 139, 128 and 120. There were no polymorphisms in VKORC1 exon 3 of the rat samples screened. However, four samples were found to have either heterozygous or homozygous missense mutation for codon 143 (Ala>Val). We did not detect any evidence of VKORC1 mutations associated with anticoagulant rodenticide resistance in the samples we have screened. More extensive sampling will be carried out to determine if anticoagulant rodenticide resistance is present among rodent populations in Singapore.

Poster Session 1 – Rodent Management

27 Which factors drive the genetic differences of Norway rats (*Rattus norvegicus*) on farms?

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Norway rats (*Rattus norvegicus*) commonly populates farms where they are controlled because they can be reservoirs and vectors for several human and animal pathogens. Understanding the biological and ecological processes that are involved in the distribution of rats is necessary for effective management measures. This is of particular importance because Norway rats have developed genetically based resistance to anticoagulant rodenticides that are commonly used for pest control. Distribution of resistant Norway rats seems to be determined by intrinsic factors such as sociality and dispersal as well as by application of anticoagulant rodenticides. We describe the distribution of Norway rats on farms located within the resistance area of Germany. Therefore, we analysed genetic differences at population level defined by the frequency of resistance (mediated by Y139C alleles) and the kinship of more than 200 individuals. Besides rodenticide application practice, also farm and landscape structures were assessed as potential extrinsic factors. We will present preliminary results and highlight the importance of local factors determining resistant rat distribution.

Poster Session 1 – Rodent Management

28 Phenology of Norway rats, *Rattus norvegicus*, in the sewer system of Barcelona (Spain)

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Norway rats are a synanthropic species and they represent a problematic pest species in cities all around the world. Effective surveillance and control strategies demand information on the biology, ecology and behaviour of this species. Norway rats can reproduce all year round, declining activity in winter, especially where temperature drops under 0 °C. The Agència de Salut Pública de Barcelona, in the framework of the rodent surveillance and control program carried out in the city, started, in 2016, a project that included a study on the biology and ecology of the brown rat population in Barcelona. From December 2016 to November 2017, a total of 580 Norway rats were captured with kill traps placed in the accessible sewer system of the city. All dead rats were dissected, and we determined their sex, age and reproductive activity. The results show that in winter, both male and female rats have the highest rates of sexual inactivity (30%-60% for males and 40%-55% for females), while most of them are active for the rest of the year. Although temperature inside the sewer system of Barcelona rarely descends under 10 °C, reproductive activity apparently stops during the months of December and January. The highest frequencies of pregnant females and females with scars in their uterus were found from March to June, suggesting a reproductive peak in spring, and contrary to what other authors have reported, no reproductive peak was found in autumn. The results of the present study will be very useful to the design of surveillance and control strategies for this species in the city.

Poster Session 1 – Rodent Management

29 Predation by *Rattus rattus* on the *Hantavirus* reservoirs rodent, *Oligoryzomys longicaudatus* in Laguna del Laja National Park, Chile

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Rats are known to introduce disease and to displace native small mammals through competition and predation. In spite of the dramatic impact on other animals (e.g. seabird, small lizard, snakes eggs and insects), the effects of rat predation on small mammals may be overlooked because it is poorly known, difficult to document, and has not been the focus of research. In Chile, the black rat *Rattus rattus*, is widely distributed with naturalized populations that had invaded natural areas in the Mediterranean zone and coastal forest but, limited by desert, high altitude and high latitude. Here, we recorded the species richness and abundances of rodents in a deciduous forest (Laguna del Laja National Park, South of Chile) during winter and spring of 2013 and, correlated these data, with the potential predation by the black rat. Our outcomes account the winter as more diverse (five species) and abundant (52 individuals) season for the presence of rodents, with the species *Abrothrix olivaceus*, *Abrothrix longicaudatus*, *Oligoryzomys longicaudatus* and the exotic *Rattus rattus*, being *Oligoryzomys longicaudatus* and *Rattus rattus*, the most and less plenty respectively. In spring, only nine individuals of *Abrothrix olivaceus* and *Oligoryzomys longicaudatus* were recorded. The analysis of teeth and hair under electron microscope images of the stomach contents for the five *Rattus rattus* captured in winter, are showing a selection for the abundant long-tailed pygmy rice rat *Oligoryzomys longicaudatus*, a native rodent considered as the major reservoir of *Hantavirus* in Chile and Patagonian Argentina. In addition, our results are indicating a seasonal distribution of the black rat in the area (not present in spring), and open the question on its predation conduct on this *Hantavirus* reservoir in other places of its distribution, as well as on the other small mammals and small animals in Chile.

Poster Session 1 – Rodent Management

30 Common vole dynamic and its crop preferences in the agroecosystems during a ten-year study

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In the Czech Republic data on the common vole (*Microtus arvalis*) abundances (burrow index - BI) were collected in various agricultural crops in spring and autumn. A ten-year data set may cover enough spatial and temporal variation in the natural population fluctuations to allow for the test of the effect of various crops and climate on the common vole, which is the most abundant central European herbivorous rodent. The highest BI was in permanent crops (i.e. alfalfa, clover, grasslands, meadows and orchards). The winter crops were also suitable habitats. Higher densities were found in winter rape compared to winter wheat which provides higher cover and availability of biomass in autumn and winter. We assume that the vole population migrated to spring crops (e.g. spring barley, sugar beet) as soon as some food biomass was available, their populations went fast up to higher densities compared to winter crops. Three minima and maxima in common vole burrow densities were found within ten years. Low but non-zero densities were found in foraging crops. We suppose that during low population densities these habitats being a refugium for common vole populations. In contrast to this, the population of common vole in winter cereals reached the population minimum (mostly zero BI). The climate (expressed by NAO index) has affected common vole populations in all types of crops equally. Positive values of spring and winter NAO (which indicates mild and wet weather) were negatively correlated with BI. We assume that mild weather during winter and early spring may cause flooding of the burrow system and rain and subsequent freezing severely limits their access to food. On the other hand, BI was positively correlated with negative value of winter NAO, indicating a positive effect of more snow days.

Poster Session 1 – Rodent Management

31 Effects of anticoagulant exposure on non-target species using four species of reptiles as surrogates

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The introduction of rodents and other non-native mammals to island ecosystems poses a serious risk to native species. These native species have often evolved without pressure from predators and therefore, invasive rats frequently cause a precipitous decline in population size leading to these species being listed as threatened and endangered or extinct. Moreover, rodents cause serious damage to agricultural crops and pose a threat to human health through the spread of disease. Because of these negative impacts there has been a concerted effort to control rodent populations and eradicate introduced rodents from islands. Anticoagulant rodenticides are the mainstay for these rodent control operations. However, the risks they pose to non-target reptiles have not been well characterized. As an initial step to determine potential non-target risks, four reptile species, ameivas (*Ameiva exsul*), boas (*Boa constrictor*), wood turtles (*Glyptemys insculpta*), and iguanas (*Iguana iguana*), were orally dosed with two levels of the anticoagulants diphacinone and brodifacoum. Animals were dosed twice and monitored for 14 days for signs of anticoagulant intoxication. Residue levels of both diphacinone and brodifacoum were determined. None of the turtles, boas, or ameivas died due to anticoagulant exposure. However, anticoagulant exposure is suspected as the cause of death in one iguana that was dosed with brodifacoum. Liver residue levels were higher than whole body remainder residue levels for all species. Unlike the other species, turtles had higher diphacinone residue levels than brodifacoum. This study provides data for future assessments of the risks to non-target reptiles associated with anticoagulant use.

Poster Session 1 – Rodent Management

32 Developing ecologically-based rodent management for smallholder farmers in Zambia

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Rodent pests have significant negative effects on smallholder farming communities in Zambia. Currently, farmers often do nothing to control rodent pests and sometimes use rodenticides when problems become severe. As the use of rodenticides is both expensive for smallholders and a danger to wildlife and farmers, there is an urgent need to develop humane and ecologically based rodent management strategies. The current study seeks to understand the effect of habitat fragmentation on the diversity of rodents and their small mammal predators; understand rodent population dynamics in Zambian maize fields; understand how landscape issues may affect anti-predator and foraging behaviours of rodents; and to compare the effects of using fertility control vs. mortality control on rodent population dynamics and maize crop damage. Sherman live traps will be used to capture rodents while rodent predators will be surveyed using camera traps, stratified across a range of habitats and seasons. The population dynamics of rodents in smallholder maize farms will be assessed using capture-mark-recapture (CMR) techniques. Foraging behavior of rodents in relation to different habitats and predator abundance will be assessed using giving-up densities to assess the landscape of fear. To compare the effect of fertility and mortality control on rodent populations in maize farms, three trapping grid treatments (replicated twice across two seasons) will be established in different maize fields. After a baseline population assessment, each grid will be exposed to a different treatment (contraceptive bait, rodenticide bait and untreated bait). The population of rodents will be monitored monthly during the maize growing season using CMR, and rodent damage assessments will be taken using standard methods. Outcomes of this study will help enable the development of ecologically sustainable and humane methods for controlling rodent pest populations in Zambia.

Poster Session 1 – Rodent Management

33 Modelling and simulation of the toxicokinetics of fungicides in common voles (*Microtus arvalis*)

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Environmental risks from plant protection products (PPPs) need to be assessed to ensure safe use. In the EU risk assessments are governed by regulations and guidelines. Within these the common vole represents a focal species for small herbivore assessment due to its wide geographical distribution, preferred agricultural habitat and life history traits. The risk assessments are dose based and carried out using conservative theoretical estimates of external exposure, which are then compared to dose related toxicity endpoints established in toxicity studies with laboratory species. The aim of this study was to determine the actual internal dosimetry of PPP active ingredients (AIs) in a population of common voles to provide the basis for informed higher tier risk assessment. As a proof of concept, the toxicokinetics of two fungicidal AI (fludioxonil and cyprodinil) were investigated in laboratory, enclosure and field applications. The results were used to develop and verify 'population toxicokinetic models' (popTK) that could predict the range of internal exposure experienced by a vole population in the field. In the laboratory, the AIs were coadministered to wild caught voles via oral gavage and intravenous bolus at doses ranging from 1 to 200 mg/kg. Feeding experiments on treated grass were also performed in cage experiments. AI blood concentrations to determine toxicokinetic parameters were obtained by repeated microsampling (10 µl) followed by LC-MS/MS analysis. From the laboratory data, popTK models were developed and then used to simulate the range of blood concentrations in a semi-natural enclosure setting as well as in a field experiment. In both cases stochastic simulations successfully described the range of measured concentrations observed in semi-natural and natural populations. While this study directly used a particular focal species, the approach could also be adopted for alternative species and improve the risk assessment through greater realism and under natural conditions.

Poster Session 1 – Rodent Management

34 Diversity and abundance of rodent pests and their impact on rural inhabitants of Khyber Pakhtunkhwa, Pakistan

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We have very limited knowledge on the status and biology of rodent species present in Pakistan. The present project is designed to explore the species composition, abundance and biology of rodents present in the villages of province Khyber Pakhtunkhwa, Pakistan and to assess the impact of rodent pests on farmer communities. The project aims to generate awareness among people towards rodent pest species, their health hazards and economical impact on their lives. Training rural communities towards rodent management practices is the main focus of the present study along with the collecting of baseline ecological data on rodent species present in the area. This will help in up scaling skills of farmers in rodent control tools and technologies. The project will generate useful information to develop an ecological based management plan for the control of major pest species occurring in the area and will equip farmers with the necessary training and expertise to manage both indoor and outdoor pest species.

Poster Session 1 – Rodent Management

35 Low rates of resistance to anticoagulant rodenticides in the population of Norway rats, *Rattus norvegicus*, in Barcelona (Spain)

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Rodent pest management nowadays depends on the anticoagulant rodenticides because of their outstanding efficiency and excellent safety profile. Anticoagulant resistance is known as one of the major factors interfering with rodent control. Within this context the Agència de Salut Pública de Barcelona, in the framework of the rodent surveillance and control program carried out in the city, started, in 2016, a project that included a study to determine the presence of anticoagulant resistance mutations in Norway rats in Barcelona, northern Spain. From December 2016 to November 2017, we captured with death traps 236 rats in different sections of sewer system. A piece of tail was taken from each rat for further analysis. DNA was screened for the presence of mutations in the VKORC1 gene responsible for anticoagulant resistance. None of the samples presented mutations associated to anticoagulant resistance, and consequently the proportion of anticoagulant resistant individuals should be very low (0%, 95% confidence interval 0-1.6%). Results from this study indicates that anticoagulant resistance is not currently a problem for the control of rats in the city of Barcelona. Nevertheless, monitoring for resistance is important if we are to understand the scope of its spread and to manage resistant rodent populations.

Poster Session 1 – Rodent Management

36 Spatial and temporal changes of diet of multimammate rat (*Mastomys natalensis*, Smith 1832) in relation to the breeding patterns in semi-arid areas in Tanzania

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The diet and breeding patterns of *Mastomys natalensis* in semi-arid areas of Isimani division, Iringa region, Tanzania were investigated in maize fields and fallow land. The aim was to investigate the influence of diet on breeding patterns of *Mastomys natalensis*. Removal trapping was used to capture rodents and analyse diet categories while capture-mark-release trapping was used to investigate breeding patterns of females *Mastomys natalensis*. *Mastomys natalensis* comprised 94% of the total captures, and the remaining 6% comprised of six other species. Statistical analysis of food preferences indicated that both vegetative materials and seeds were significantly ($p < 0.0001$) higher in the diet of *Mastomys natalensis* during the wet and dry seasons compared to other food materials. There were no significant differences in the proportions of both vegetative materials and seeds consumed in fallow land ($p = 0.42$) and maize fields ($p = 0.31$). Similarly, there was no significance ($p = 0.61$) of diet on the reproductive activity *Mastomys natalensis*. Time of year and season did not affect reproductive activity ($p = 0.96$); however, there was a clear non-linear effect ($p = 0.0005$) of time of the year on the proportion of reproductively active animals in the population. Vegetative materials and seeds comprised the largest proportions of the diet of *Mastomys natalensis* and therefore, these food categories correlated positively with reproductive activity. The proportion of vegetative materials and seeds found in the stomach of *Mastomys natalensis* correlated positively with reproductive activity during wet and dry periods respectively. It is recommended that there will be necessary to reduce breeding activity by preventing access to fresh vegetative food (e.g. young sprouting grass).

Poster Session 1 – Rodent Management

37 Regional rodent control approach in a countryside in Germany: fostering synergy effects between participating players

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Commensal rodents cause numerous damages on agricultural operations. Most importantly rodents are carriers of various pathogens that cause human and animal diseases. The control of neophobic rodent populations is therefore common and widespread. Different studies show the importance of pest control strategies in regard to bait station sides, development of resistances against anticoagulant rodenticides as well as collaboration of farmers and Pest Control Operators (PCOs). The aim of the current study is to enhance the effectiveness of pest control measures by applying a comprehensive control of rodent pests in a countryside in Germany. It is known from preliminary analyses, that the participation of farmers to pest control measures can be increased by start-up financing. Therefore, in the current project, the financial contribution of the North Rhine-Westphalian Animal Disease Fund (TSK) will provide incentives to comprehensive pest control measures of commensal rodents in an area of high densities of livestock farming of all kind by PCOs. Indirect monitoring of rodents at the beginning, during and after pest control measures should give information about the colonization of various structures (different livestock farming, communal enterprises and others) with rodents, and their associated pathogenic micro-organisms (viruses, bacteria, parasites). Furthermore, it is part of the project to survey the aspects of the start-up financing and intensive involvement and consulting of all parties on the willingness to participate in the project, as well as active compliance during the program by standardized interviews with farmers and PCOs. To increase long-term implementation of pest control, the intention is to identify supporting and inhibiting factors of implementation practices. Thereby, the regional approach should enhance positive effects of control measures beyond efforts on individual operations. Finally, the synergetic aspects in the guidance of farmers will lead to a decrease in rodent populations in livestock farming thereby preventing enzootic diseases in farm animals in Germany.

Poster Session 1 – Phylogeography

38 Effects of rivers on gene flow in small rodent populations

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Understanding the role of dispersal barriers is crucial for predicting population responses to landscape and environmental changes. That is why in this study we assessed the role of a medium size lowland river (Biebrza), which is a natural barrier, on gene flow and connectivity in the root vole (*Microtus oeconomus*) population in Biebrza National Park (Poland). This is a hygrophilous rodent species which settles on the banks of the rivers, lakes and other watercourses and swims very well. We analysed molecular data of 176 voles, based on eleven DNA microsatellite loci. Voles were caught at six sites – three on each river side in autumn in years 2009 and 2015. Contrary to our expectations we found a strong effect of the river on genetic distance between the root vole populations in some locations only, whereas in other locations we did find none. Our results show that for small rodents, a well-visible river barrier does not have to impact the gene flow. Interestingly, it follows that some of the barriers, invisible to a human, such as type and amount of vegetation, presence of small roads or pastures may strongly influence root vole genetic structure.

Poster Session 1 – Phylogeography

39 Aquatic and terrestrial water voles: phylogeography and morphometrics

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Water voles from the genus *Arvicola* display an amazing ecological versatility, with aquatic and terrestrial populations. Their taxonomic status and evolutionary relationships have caused a long-standing dispute. Two aquatic (*Arvicola sapidus*, *Arvicola amphibius*) and one fossorial species (*Arvicola scherman*) are currently described. We used mitochondrial cytochrome b (cytb) gene sequences to reconstruct the phylogenetic relationships among fossorial and aquatic water voles belonging to *Arvicola amphibius* (formerly *terrestris*) collected in various regions of Europe. We combined 147 new sequences collected mostly in France, Germany and Great Britain, with available datasets from the entire range to provide an up-to-date phylogeny of this species. Phylogenetic and network reconstructions retrieved 4 major lineages all containing fossorial and aquatic morphotypes, discarding the view of each ecotype corresponding to a distinct species. Morphometric analyses of skull shape were performed on a set of aquatic and fossorial populations documenting the main lineages. Fossorial and aquatic populations tend to display convergent morphological features related to their ecology, blurring a part of the phylogenetic signal. Different allometric trajectories related to the constraints of the aquatic vs. subterranean habitats may contribute to this morphological convergence.

Poster Session 1 – Phylogeography

40 Local persistence of Mann's soft-haired mouse *Abrothrix manni* (*Cricetidae*, *Sigmodontinae*) during Quaternary glaciations in southern Chile

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Here we present results of a phylogeographic study focused on the recently described sigmodontine species *Abrothrix manni* that is distributed in the temperate Valdivian forests in southern Chile and its neighboring areas of Argentina. Analyses were based on the first 801 bp of the mitochondrial gene Cytochrome-b from 49 individuals of *Abrothrix manni* from 10 collection localities, covering most part of the known distribution range of the species. Genealogical and demographic analyses depict for *Abrothrix manni* a history of local divergence and population long-term persistence even when facing Pleistocene climate oscillations. This information adds up to the growing evidence of a lowland coastal refuge, which would also include low altitude Andean sites.

Poster Session 1 – Phylogeography

41 Root vole *Microtus oeconomus* in the post-glacial landscape: how the history of the Pleistocene glaciations and a contemporary distribution of habitats reflects the genetic structure of the population

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The contemporary distribution of habitats in central and north-east Europe is largely the result of the processes occurring during the Pleistocene glaciations. This is due to the fact that the quaternary successive glaciations in the northern hemisphere in Eurasia had a diversified and generally smaller range. We checked, therefore, whether and how the landscape shaped as a result of subsequent glaciations affects the diversity and sustainability of the population, expressed by the genetic diversity of the species. We assumed that in Europe and Asia: (1) different history of glaciation at different latitudes translates into (i) different number and different character (e.g. connectivity) of favorable habitats and also (ii) various time of colonization by species in post-glacial landscape zones; (2) a different number of favorable habitats and a different level of their connectivity/isolation means a various course of in situ evolution; (3) different connectivity of favorable habitats, their different attractiveness and different availability translate into various directions and intensity of modern species migration. We studied root vole *Microtus oeconomus* (*Arvicolinae*, *Cricetidae* *Rodentia*), model species of small mammals preferring humid habitats. The research was carried out in eastern Poland in 33 locations in different landscape zones shaped by subsequent Pleistocene glaciations: Sanian 1, Sanian 2, Odranian, Warthanian, Vistulian and at different distances from the southern boundary of the present occurrence of the species. Samples of tissue were collected from 439 individuals of root vole during live trapping in boggy and meadows habitats. Based on the analysis of 908 bp of cytochrome b (mtDNA) and 12 microsatellite loci, the genetic structure of *Microtus oeconomus* in studied area was determined. The results show the genetic dissimilarity of some populations in zones. The relationship between genetic diversity and zonal variability of the post-glacial landscape and the distribution of optimal habitats in these zones was found.

Poster Session 1 – Phylogeography

42 Genetic variation and population structure of the red squirrel (*Sciurus vulgaris*) in Lithuania

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Red squirrels (*Sciurus vulgaris*) are occurring in many types of coniferous and mixed deciduous forests and are widely distributed throughout Europe and part of Asia, this species is the only one native to Lithuania. Seventy years ago almost 200 individuals of *Sciurus vulgaris exalbidus* were introduced to Lithuania from Altai. The motivation of introductions was to improve fur quality. The data of genetic diversity of red squirrels in Lithuania are scarce. Red squirrels have been investigated only using random amplified polymorphic DNA method. The aim of this study was to investigate the genetic variability of red squirrels using mitochondrial DNA and microsatellites. All specimens of the red squirrel used in this study were found dead on the road or in the forests. A total 39 samples during the 2001 – 2018 period was collected from different areas of Lithuania. DNA was isolated from frozen muscles of each individual. For microsatellite analysis seven different primers were used to obtain genetic diversity of red squirrels. For mitochondrial DNA analysis primers of D-loop sequence were used, average number of nucleotide differences (k) between Lithuanian red squirrels was 10.167, more than 10 haplotypes (h) were determined. The results revealed high-level genetic diversity of red squirrels in Lithuania.

Poster Session 1 – Phylogeography

43 Phylogeography of the striped field mouse (*Apodemus agrarius*, Pallas 1771): new data from the western part of the disjunctive range

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The striped field mouse (*Apodemus agrarius*, Pallas 1771) is a typical species of mesic open habitats. It is widely distributed in the temperate zone of the palearctic and oriental regions. The range of *Apodemus agrarius* is represented by two main parts: western part (Europe, Siberia, Kazakhstan) and eastern part (Far East, China) separated by arid and mountainous regions of inner Asia. Due to the wide distribution and presence of numerous local specific populations, the striped field mouse is an excellent model for studying genetic variability and phylogeography. Numerous studies are devoted to the intraspecific genetic variability in *Apodemus agrarius* in the context of phylogeny and phylogeography of the genus *Apodemus*. However, there are almost no data from the central part of northern Eurasia. Thereupon, complete cyt b (1140 bp) and D-loop (865 bp) sequences of 133 specimens of *Apodemus agrarius* from 35 localities in the Urals, western Siberia and Altai were analyzed. The data from the territories studied for the first time expand significantly the geography of the investigations of the species genetic variability. Results of the analysis clarify the phylogeographic structure of the species and allow us to verify the previous hypotheses concerning historical roots and phylogenetic relationships of *Apodemus agrarius* in the western part of the range. The study was supported by RFBR №16-04-01625.

Poster Session 1 – Population Dynamics

44 The effect of habitat connectivity on colonisation of forest fragments with rodents

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Habitat fragmentation through anthropogenic modification/urbanisation can have an impact on the distribution and population abundance of the small mammal fauna. Increased fragmentation and the presence of landscape elements that block distribution may minimise recolonization of suitable habitat by small mammals after the population crash phase. This is relevant as the human population expands and requires more and more space, which increases fragmentation. We determined the degree of connectivity of habitat fragments in north-west Germany formally by allocating permeability values to the habitat structures present at landscape scale. These data were related to surveys of the colonisation of forest fragments by rodents to assess relationships between fragmentation and repopulation after rodent outbreaks. Such information is not only important for the assessment of land use effects but can also contribute to a better understanding of processes driving population dynamics in rodent species prone to outbreaks such as bank voles (*Myodes glareolus*). In addition, risk related to rodent-borne diseases can be considered. First results are presented and discussed.

Poster Session 1 – Population Dynamics

45 Recent information on population status of *Meriones dahli* that is close to extinction in the Middle East

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Meriones dahli is psammophilic (living in sand) inhabiting ecologically dispersed areas and suitable habitats are fragmented. This rodent is distributed in a small area spread over the northern skirts of Mount Ararat on the borders of Iğdir province in Turkey. Abu jail (*Calligonum polygonoides*) is found in the desert ecosystem where the plant is dominant, and *Meriones dahli* lives in the burrows dug into the bottom of the Abu jail plant. In the mid-1980s, the global population size was estimated to be 5,000-6,000 individuals. The information about the *Meriones dahli* population seems to consist of scattered records, but there is a steady decline in populations according to the information available. Within the scope of the study, the counting method used in the species action plan was used in determining the population size. Considering that it is breeding 3 times a year according to the literature data, about 10 days after the first frying season, field trials were initiated and 100 Sherman type traps were used during the landing (5 consecutive days). The mark-recapture method was used according to the transect method and the traps were spread homogeneously over the whole area starting from the point locations given in the literature records, leaving a 10 m gap between the traps. At the end of the study, a total of 4 individuals were caught and 1 of them was juvenile, 1 was female and 2 were males. The cause of the sudden decline in the population is observed as habitat disposal, material intake, construction activities and excessive grazing. Some suggestions have been made to prevent this decline: protecting the area immediately; suggesting the selection of alternate areas by the Municipality of Aralık as a garbage area; organization of training activities in the towns and villages of muhtars, schools and settlements in Aralık, especially raising awareness of shepherds; field type information displayed on signboard and warning plate.

Poster Session 1 – Population Dynamics

46 Recent bamboo flowering in Chittagong Hill Tracts of Bangladesh: anticipating new rodent outbreaks

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Rodent outbreaks resultant from bamboo flowering is a real phenomenon that damages farmer crops in parts of the world particularly Chittagong Hill Tracts (CHT) of Bangladesh, Mizoram in India and Chin State of Myanmar. In 2006 *Melocanna* bamboo flowered in CHT and severe food shortage was reported of that regions until 2011. Recently *Dendrocalamus longispathus* (Kurz) and *Denrocalamus giganteus* (Munro) have flowered in CHT where farmers are predicting a new rodent outbreaks due to bamboo flowering. Following the bamboo flowering, six community meetings were organized in different places to understand the timing of bamboo flowering and magnitude of bamboo flowering. The farmers reported that bamboo flowering started in January and may produce seeds in May-June. Previous research suggests that timing of bamboo flowering and seeding coincided with the increase of the rodent population and damage and crops loss. Effective monitoring of bamboo seeding as well as early awareness of the rural people about the increase of rodent population with the use of appropriate technology like community trapping, trap barriers system might avoid crops loss and damage to household belongings by the rodents. Government and non-government institutions along with rodent experts need to take immediate measures to avoid food shortages and associate risks derived from rodent outbreaks in CHT.

Poster Session 1 – Population Dynamics

47 Trophic niche partitioning by small mammals in forest environments. Influence of food types and availability, measured using stable isotope analysis in hair

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We analysed the carbon and nitrogen isotopic composition in hair from 173 rodent individuals (12 field mice, 122 yellow-necked mice and 39 bank voles). They were caught on four 0,5 ha transects, each consisting of 100 traps controlled twice a day for five days, located in different forest environments: wet alder forest, coniferous forest, deciduous forest dominated by hornbeam and lime and a habitat dominated by planted pine with understory typical for a coniferous forest. 147 samples of potential rodent food were collected on all transects and their isotopic composition was analysed. Due to differences in humidity and fertility of the study sites, we found large differences in the isotopic composition of the isotopic "background" (nitrogen and carbon isotopes of primary producers). This indicates the importance of using isotopic data on food and consumer from exactly the same habitat in this type of study. In the deciduous forest male yellow-necked mice consume more animal prey than females, indicated by higher $\delta^{15}\text{N}$ values. We found no other sex-dependent differences in isotopic niches. Rodents from the coniferous forest had the largest isotopic niches, and this study site was also the one with the lowest rodent density. On the other hand, individuals from the alder forest differed least in isotopic composition, despite having the highest density of all study sites. This indicates a limitation of population dynamics by resource availability rather than pressure from predators. Analyses of the isotopic mixing polygons suggest that a food source with higher $\delta^{15}\text{N}$ values than plant material has not been taken into account. This is probably insects and other soil invertebrates. Samples from this organisms will be collected and analysed before the presentation of this results.

Poster Session 1 – Population Dynamics

48 Population size and distribution of Norway rat, *Rattus norvegicus*, in the sewer system of Barcelona (Spain)

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Urban rat population size in cities is usually unknown and cannot be considered when elaborating rat surveillance and control programs in municipalities. The Agència de Salut Pública de Barcelona, in the framework of the rodent surveillance and control program carried out in the city, started, in 2016, a project that included a study to determine the urban rat population size and to model its distribution in Barcelona. It was performed from December 2016 to November 2017 mainly in the accessible sewer system of the city, where rat densities are the highest and the Norway rat is present. Rats were censused with kill traps in 63 sewer sections (90 m long each). In each section, 30 traps were placed and checked daily during four consecutive nights. Several environmental factors, potentially related to rat abundance, were calculated for each section to determine which combination of them explained better the rat abundances found. Considering only those factors whose data could be obtained for the entire city, the result was a formula containing the amount of food establishments, the human population size, the streets' width and the canopy surface. With that information, a SIG model was elaborated to predict the rat abundance in all the accessible sewer system of Barcelona. In some areas the prediction matches closely with the abundance of citizen complaints for rats, but in general terms there is no correlation between them. This study provides, for the first time, the Norway rat population size in the accessible sewer system in Barcelona, which is estimated at $106,739 \pm 37,884$ individuals. Additionally, it provides information about their distribution in the city. The results of this study will modulate the rodent surveillance and control program in Barcelona. If the study is replicated in the future, it will allow for tracking the population dynamics in the city.

Poster Session 1 – Population Dynamics

49 Rodent population dynamics: multimodality amplified by climatic fluctuations

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A mathematical model aimed at describing rodent population dynamics is proposed. The model takes into account the population age structure and density-dependent regulation of birth rate. It is revealed multimodality in the model proposed. This phenomenon consists in the existence of various dynamic modes under the same values of parameters, a transition to these modes determined by the initial conditions. In particular three modes: for example 1-, 3- and 4-cycles alternatively appear, which is noteworthy because both three-year and four-year cycles as well as fluctuations disappearance are observed in rodent populations. We proposed multimodality identification approach in real population. It is based on the model parameter estimates obtained for survey and the observation data of population dynamics. Modeling of the real bank vole population dynamics (*Myodes glareolus*) shows the model trajectory describes well enough the dynamics tendency but weakly captures the real values of the population size peaks. To improve the approximation quality a climatic factor was included in the model. This model study showed climatic factor influence leads to a change in form of dynamic mode attraction basins or model parameter values. As a result the population size is shifting from some mode attraction basin to the attraction basin of another one. In other words population dynamics can be described by the following scheme. In the current year with certain climatic conditions the population develops and tends to a stable mode. Next year with different climatic conditions this mode cannot be achieved or does not exist and the population adapting to new conditions tends to another stable mode. In particular the real dynamics of the bank vole can be represented by a sequence of alternating transients that give fluctuations with 3-, 6-, 7- or 14-year period under constant climatic conditions. This work is partially supported by the Russian Foundation for Basic Research (Project no. 18-04-00073) and the Fundamental Research Complex Program "Far East" (Project no. 18-5-051).

Poster Session 1 – Population Dynamics

50 Drivers of *Microtus arvalis* population dynamics : lessons from a 17 year time series

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Common vole population dynamics appear to be strongly correlated to landscape configuration. In comparing time series of vole populations in various regions of France, Delattre et al. (1992) reported a variety of patterns, ranging from low density populations prone to local extinction in intensively tilled homogeneous agricultural landscapes, to multi-annual large-amplitude variations of population densities in permanent grassland landscapes. These observations support the Trophic ROMPA (Ratio of optimal to marginal patch habitat) Integrated Model (TRIM) outlined by Lidicker (2000), which combines the exploitation ecosystems hypothesis (Oksanen and Oksanen 2000) with the effect of spatial arrangements of habitats on vole dispersal and predator communities. In landscape of high productivity and large proportion of optimal habitat Lidicker (2000) TRIM and Delattre et al. (1992) conceptual models predict that (1) vole population dynamics will be driven mostly by extrinsic rather than by intrinsic factors. In practice, population dynamic features, except for seasonality (reproduction stop in winter) should not be driven by reproduction variation; (2) population peaks will last longer and at the extreme tend to produce larger amplitude fluctuations with only seasonal variation and no cyclicity. In this presentation, we consider a 17 year (1979-1996) time series of *Microtus arvalis* population fluctuation in eastern France, in a landscape where the ratio of permanent grassland in farmland is near 100%. We show that: (1) large multiannual population variation (> 5 years) and long (multi-annual) high density peaks (hundreds ind./ha) can be observed with no delayed density dependence (thus no cyclicity); (2) meteorological conditions have a delayed and direct impact on reproduction parameters but not on population dynamics and (3) population declines in spring and summer are not explained by reproduction variation, hence explained by mortality increase. This corroborates Lidicker and Delattre's models and indicates that the drivers of population dynamics might be a combination of predation/disease/social stress. To isolate or weigh each of these factors is however virtually impossible yet for methodological reasons.

Poster Session 1 – Population Dynamics

51 Population dynamics, breeding pattern and home ranges of rodent species in fallow lands of Mukwe Constituency, Kavango-East Region, Namibia

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Rodents have a very important role in ecosystems; they act as bio-indicators of environmental conditions because of their rapid turnover and ability to invade disturbed areas. In addition, some rodents are agricultural pests in rural communities causing crop damage and food shortage across Africa as well contribute to the spread of zoonotic diseases. Rodent species show spatial and temporal patterns in numbers, often linked to environmental factors. The main aim of the study was to determine the population abundance, breeding patterns, species diversity and home range sizes of rodents in Mukwe Constituency, Kavango-East Region (Namibia). The capture-mark-recapture method was carried out over a period of two years in two (labelled DVA and DVB) 70 x 70 m grids (49 Sherman traps each). The rodent species composition in Diyogha Village Grid A (DVA) was: *Mastomys natalensis* (28.6%), *Gerbilliscus leucogaster* (49%), *Saccostomus campestris* (18.6%), *Steatomys pratensis* (0.7%) and other species (2.4%) and for Diyogha Village Grid B (DVB): *Mastomys natalensis* (12.6%), *Gerbilliscus leucogaster* (72.6%), *Saccostomus campestris* (13.7%) and *Steatomys pratensis* (1.1%). All three dominant species showed a significant temporal variation within grids: *Mastomys natalensis* ($t = 2.6672$; $P < 0.05$), *Saccostomus campestris* ($t = 3.2925$; $P < 0.05$) and *Gerbilliscus leucogaster* ($t = 4.6728$, $P < 0.05$). Although most species seems to breed during the wet season, *Gerbilliscus leucogaster* showed breeding signs in the dry season. Most captured animals were adults, while sub-adults and juveniles were rarely present. Sex ratio did not differ significantly from the 1:1 ratio. Home range overlap was found within and between species, indicating that animals are not territorial.

Poster Session 1 – Population Dynamics

52 Estimating the absolute abundance of rodents and their mammalian predators from camera traps in the southern Yukon, Canada

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Camera trapping has been used largely to determine presence or absence of large vertebrates, and the question of whether it can ever be used to estimate absolute abundance is an open one. We will report on 6 years of research in the southwest Yukon, Canada, to determine if camera images can reflect absolute abundance of mice, voles, red squirrels and snowshoe hares. For these smaller vertebrates the answer is yes. We have now embarked on a larger question of whether cameras can detect and census larger vertebrates in the boreal forests of the Kluane Lake area, Yukon. We have deployed remote cameras on game trails year-round to capture images of all vertebrates including bears, bison, wolves, wolverine, coyotes, lynx and marten and we report on progress here. We are doubtful that we can recognize individuals of most of these species for standard mark-recapture estimates. We are testing new methods of determining density of unmarked animals with camera trap photos. Many of these predator species fluctuate in numbers dramatically in response to the 10-year hare cycle, but others are more stable. The eyes of cameras may be an important technique to provide data 24/7 on the state of this boreal forest ecosystem under rapidly shifting climate in northwestern Canada.

Poster Session 1 – Population Dynamics

53 Regulation of reproduction in Brandt's voles

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Seasonal breeding is a universal strategy in many animals living in non-tropical regions. Brandt's vole (*Lasiopodomys brandtii*) is a small, non-hibernating, herbivorous, and social rodent that is mainly distributed in the grasslands and steppes of China, the Republic of Mongolia, and the Baikal Lake region of Russia. Brandt's voles show striking seasonal breeding and only breed from spring to autumn, which caused dramatically annual fluctuation of their population. By a four-year investigation, we demonstrated the annually photoperiod-synchronized reproductive activity of wild Brandt's vole population. Male adult voles displayed a strict seasonal rhythm of gonadal mass with the precise annual peak around summer solstice. Cooperatively, hypothalamus genes, *Dio2*, *Rfrp-3*, *Kiss-1* and *GnRH*, predictively initiation of reproductive inhibition occurred in the best stage of breeding season by response to ambient condition, possibly including photoperiodic signal and variation of temperature and food supply. After long term domestication, inhibition of gonadal development of juveniles gradually disappeared in non-breeding season while the photoperiod response was still retained. These results indicate that the photoperiod response is only a predictive indecisive mechanism. Limited by short life span, an age-dependent reproductive strategy divergence occurred in the main breeding season: overwintered voles could keep reproductive activity across the season, while most of newborn males inhibited the development of gonadal gland except few born in early breeding season. In the wild population, male biased dispersal is a key mechanism of inbreeding-avoidance while it facilitated the reproduction of early born voles, which was testified by completely inhibiting of reproductive activity of newborn voles when overwintered voles were coexisted in the semi-natural enclosure.

Poster Session 1 – Population Dynamics

54 Species composition and community structure of small pest rodents (*Muridae*) in cultivated and fallow fields in maize growing areas in Eastern Uganda

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A capture-mark-recapture study was undertaken in eastern Uganda for three years to establish species composition and community structure of small rodents and their population dynamics in a maize associated cropping system. The study was conducted in two fallow field mosaic habitats that were dominated by *Lantana camara* and other perennial and annual grasses and shrubs (CMR 2 and CMR 4) and cropped fields that initially were planted with maize but subsequently rotated with other seasonal crops (CMR 1 and CMR 3). Ten species were recovered with *Mastomys natalensis* being the most dominant species (58.6%), *Muscus* spp. (16%), *Aethomys* spp. (7.4%), *Lemniscomys barbarus* (5.2%), *Lophoromys* spp. (4.4%), *Arvicanthis niloticus* (0.9%), *Gerbilliscus* spp. (0.1%), *Graphiurus* sp. (0.1%), *Steatomys* spp. (0.1%), *Grammomys* sp. (0.1%). Spatial variation in small rodent population abundance was highly significant ($F_{3,859.5}=4.706$, $P<0.004$). Using Turkey's (HSD) test, CMR2 showed the highest abundance (26 ± 3 animals/0.5 ha) which significantly differed from other grids. The lowest abundance was recorded in CMR1 (13 ± 3 animals/0.5 ha). The pattern of the individual species variation did not follow similar trends and were very variable and non-significant except for *Mastomys natalensis*. Temporal variation in terms of weather seasons showed significant differences in total small rodent population abundance ($F_{3,721.598}=3.859$, $P=0.012$). The post hoc comparison of treatment means showed higher abundances in the yearly second wet season (Wet 2), with 24 animals/0.5 ha significantly different from other seasons. The yearly first dry season (Dry 1) displayed the lowest trap catches (12 animals/0.5). There were also year-to-year changes in species population density and generally, with highest population peaks occurring in 2015 compared with year's 2016 and 2017. The study findings provide insights into the species diversity of important small rodent pest species found associated in maize farming systems in eastern Uganda and form basis for design of an appropriate ecologically sound management strategy.

Poster Session 1 – Population Dynamics

55 Population fluctuation and breeding patterns of multimammate mouse, *Mastomys natalensis* (Smith 1834), in maize associated cropping system in Eastern Uganda

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Multimammate mice (*Mastomys natalensis*) continue to constrain farmers efforts towards obtaining optimum outputs from cereal crops production in sub-Saharan Africa through their pre and post-harvest damage they inflict. They are by far the most involved species in most rodent outbreaks reported in the region and once they occur, often they result into crop damage and may cause heavy losses. This study thus aimed at establishing the population dynamics and breeding patterns of *Mastomys natalensis* in maize associated cropping systems Eastern Uganda. The population of the multimammate mouse varied significantly ($F_{10,0.705} = 7.838$, $P < 0.0001$) with months. The highest population peaks were recovered in the second rain season (September to October) but specifically in October 2015, where 73 animals/0.5 ha and 66 animals/0.5 ha were captured in fallow and maize fields respectively. Also, *Mastomys natalensis* was observed to be sexually active throughout the year in the study area, with some breeding peaks noted towards end of first rainy season towards maize harvesting stage (May- July). This suggests that breeding is constantly occurring but with an increase during maize harvesting periods. The higher population abundance recorded in September to October is an indication of a buildup population from breeding in previous months. In conclusion higher population abundances of multimammate mice in both habitats were observed to be driven by rainfall patterns but peaking in the second yearly season. This could be as a result of continued population build up from first rainy season which is followed by a short dry period and then another second rainy season. This phenomenon played a role in providing food and vegetation cover which allowed continuous breeding and survival thus population peaking in October. It is therefore advisable that control should be initiated in the first planting season to break the buildup of populations to higher numbers.

Poster Session 1 – Population Dynamics

56 Probability of bank vole and red vole hybridization in different geographical localities

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The overlapping area of closely related bank vole (*Myodes glareolus*) and red vole (*Myodes rutilus*) is very wide and conditions of their coexistence differ a lot within this territory. Besides, the bank vole is rapidly spreading to the east and to the north extending this area. Ancient hybridization between bank and red voles was found recently: one of the *Myodes glareolus* genetic lineages has mitochondrial DNA similar to that of the *Myodes rutilus*. To test the hypothesis that hybridization could occur in the absence of conspecific males we conducted the following experiments. 19 groups of voles were maintained in outdoor enclosures 120 m² in size. All experiments lasted not less than two months. Each group contained two bank vole females, two red vole females and four bank vole males. This way we simulated the conditions that promote hybridization in mixed populations of *Myodes glareolus* and *Myodes rutilus*. 9 groups contained animals trapped in western Siberia where population density of these species is similar and where bank vole appeared not so long ago. 10 other groups contained voles trapped in Valday Hills. It is the south-western point of the overlapping area and the border of red vole area. The bank vole is a numerous species there while red vole is a stenotopic one mosaically living in dark coniferous forest. Peculiarities of interspecific relations in two kinds of groups occurred to differ from each other as well as the reproduction success of red vole females. 10 out of 18 red vole females in western Siberia groups bore hybrids. In Valday Hills groups only one red vole female out of 20 had a litter. Thus voles existing under conditions which enable them to hybridize (low density of one of the species) have got specific adaptations holding back the hybridization.

Poster Session 1 – Population Dynamics

57 Development and evaluation of a genome-wide SNP panel for invasive ship rats (*Rattus rattus*) in New Zealand

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Single nucleotide polymorphisms (SNPs) have become the marker of choice in molecular ecology because they offer a variety of advantages over microsatellite markers in genetic studies: SNPs are highly abundant throughout the genome, allow higher throughput and are less error prone to amplification and scoring mistakes, enabling standardization across laboratories. This makes SNPs powerful markers for studying the evolutionary history of populations, demography, genetic variation and kinship. Ship rats count as the most ferocious invasive species in New Zealand, posing the biggest threat to many endemic species, especially on small near-shore islands, which are important breeding grounds for many seabird species. Previous ship rat studies in New Zealand have been carried out utilising solely mitochondrial or microsatellite markers, because currently no SNP markers are available for ship rats in public databases. In this study, a first SNP marker panel was developed for ship rats in New Zealand with the aim of utilising the SNP panel for pest management, studying the genetic structure and population dynamics of this invasive species. Upon initial discovery of ~72 million variants from paired-end sequencing reads of a single ship rat individual in reference to the *Rattus norvegicus* genome, a reductive filtering workflow allowed selection of 300 high-quality SNP markers. This SNP marker panel was subsequently tested by performing MassARRAY genotyping of 65 ship rat samples, representing a wide geographical distribution of individuals across New Zealand, to remove markers under ascertainment bias. This final verification step provided a set of informative SNPs and first results will be presented. Utilization of a SNP panel for genetic evaluation and implementation in future conservation management projects will provide another level of information, increase accuracy of population structure and invasion histories, while allowing higher throughput with lower costs.

Poster Session 1 – Population Dynamics

58 Frequency of acorn mast years can act as a potential driver of rodent population and phenotype characteristic

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Scientific research studying population fluctuation of rodents generated an abundance of factors influencing patterns in rodents abundance (e.g. climatic factors, local weather, intensity of acorn production or competition). Whilst studies have shown that a rodent population is dominantly influenced by the quality and quantity of acorn production, the effect of the frequency of acorn mast years on the demographic and phenotype characteristics of rodent populations are understudied. The structure of our data allowed us to divide it into two parts (i.e. first part included irregular spread of acorn mast years, the second part included time series where the acorn production occurred almost at every year). The first part contains six-year time series (2002 – 2007), and the second part contains four-year time series (2009-2012). In this study we evaluate the influence of frequency of acorn mast years on the relationship between environmental factors (biotic and abiotic) and phenotypic characteristics of two species of rodents (*Apodemus flavicollis* and *Apodemus sylvaticus*) in Central Europe. The results of the generalized linear model provide evidence that rodents influenced by irregular spread of acorn mast years were more affected by abiotic and biotic conditions than rodents influenced by the steady occurrence of mast years. In addition, by comparing the median value of body length by Wilcoxon test we can conclude that individuals influenced by the steady occurrence of mast years were significantly larger than individuals influenced by irregular spread of acorn mast years.

Poster Session 1 – Population Dynamics

59 Kinship analysis revealed reproductive success skewed toward overwintered Brandt's voles in semi-natural enclosures

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Age structure and seasonality influence the population fluctuation of small rodents. Age determines body weight and social experience, while seasonality regulates the duration of breeding season and sexual maturity of newborn offspring. Therefore, reproductive success and skew usually occur in different age groups. Brandt's vole (*Lasiopodomys brandtii*) is a social, short lifespan, and seasonal breeding small rodent with a dramatic seasonal population fluctuation. However, it is still not clear about reproductive skew in this species. In present study, we studied the kinship in semi-natural enclosure populations by microsatellite marker based on genotyping, analyzed the reproductive skew between genders and between overwintered and newborn voles, and monitored variation of male reproductive activity by testing fecal testosterone levels around the year. Our results showed that the majority of overwintered voles had reproductive success along with striking increase of the population size in three enclosures; and all biological fathers and 77.8% biological mothers were overwintered voles and they have all and 87% offspring, respectively. Compared to overwintered voles, reproductive skews were significantly higher in potential overwintered and newborn parents, implying the possible reproductive suppression of newborn voles from dominant overwintered voles. Moreover, both heavier body weight and higher testosterone levels of overwintered males supported their potential social status in the population. Therefore, our study provided some new evidence for reproductive skew and differentiation of postnatal gonadal development patterns of different age groups in Brandt's vole.

Poster Session 1 – Population Dynamics

60 House mouse population dynamics and impacts on invertebrates in the absence of other mammals

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Mesopredator and competitor release can lead to population increases of invasive house mice after larger introduced mammals are controlled or eradicated. In New Zealand, mammal-resistant fences have enabled multi-species eradications of pest mammals to protect indigenous species. When house mice are the only mammals remaining in these biodiversity sanctuaries, they may reach high population density, with potential consequences for their indigenous prey. We studied mouse populations and their invertebrate prey in the absence of other mammals for 5 years. We compared two forest sites within independent mammal-resistant fences. The sites had contrasting levels of mouse management, reversed half-way through the study. At site Q, mice reached 30-46/ha seasonally, then were eradicated. At site M, mice were initially undetectable but increased during the study to 23/ha. Ground-dwelling invertebrates common in mouse diet increased in numbers at site Q and declined at site M; site differences in these 5-year temporal trends were significant. Results were consistent for beetles, spiders and weta (large flightless orthopterans) in pitfall traps; beetles, spiders and caterpillars (lepidopteran larvae) in leaf litter; weta tracks in ink tunnels; earthworms in litter and soil. Beetle and earthworm species richness and beetle and weta body sizes followed similar temporal trends. The highest mouse densities were similar to estimates in New Zealand forests after mass seeding (masting) events, but lower than in another sanctuary and on some islands lacking larger terrestrial mammals. With no competition or predation from other mammals, food limitation may have prevented further growth of these mouse populations. The significant impacts of mice on invertebrate numbers and community composition may affect ecosystem processes including the supply of food for indigenous birds. However, their effects on indigenous vertebrates are likely small compared with the combined impacts of the many successfully removed mammalian predators and browsers.

Poster Session 1 – Population Dynamics

61 Impacts of non-monotonic interactions on population and community dynamics

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Species interaction is often assumed to be monotonically-related to population density, but in nature species interaction is often non-monotonic, e.g., in seed-rodent dispersal system, rodents impose both positive and negative impacts on plant seeds, largely depending upon the seed and rodent abundances. Yet the impacts of non-monotonic interactions on population and community dynamics are largely unknown. This presentation will briefly review previous studies on this subject, and present our recent modeling results. We demonstrate that for four kinds of non-monotonous interactions shift signs to negative or neutral interactions at high population density stabilizes ecological networks, while non-monotonous interactions shift signs to positive interactions at high population density destabilize networks. Further analyses showed that dome-shaped non-monotonic interactions performed better in maintaining both high persistence and biomass or biomass flow in more complex networks, but resulted in larger variations of species biomass. These results suggest cooperation or mutualism among antagonists may be important in maintaining stable and complex ecological networks.

Poster Session 2 – Workshop Rodent-Borne Diseases

62 *Schistosomiasis* in the Senegal River Basin and the role of wild rodents as reservoir hosts

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Schistosomiasis is a neglected tropical disease (NTD) of profound medical and veterinary importance caused by dioecious trematodes of the genus *Schistosoma*. This NTD affects over 240 million people globally, with the highest burden in sub-Saharan Africa. *Schistosoma* parasites are characterized by complex multi-host dynamics and interspecific interactions leading, under certain conditions, to viable hybridizations between human and animal schistosomes with subsequent zoonotic transmission. Anthropogenic land-use changes and the progressive loss of ecological barriers may have also favoured interactions between different *Schistosoma* species. Our study elucidated the role of wild rodents as potential reservoirs of zoonotic *Schistosoma* species and hybrids in the Senegal River Basin, a region subject to dramatic anthropogenic change. Between May 2016 and November 2017, we trapped, humanely euthanized and necropsied small mammals from sites around Lake Guiers and the town of Richard Toll, Senegal, applying a multi-locus molecular analysis to identify the isolated *Schistosoma* spp. and estimate local prevalence. A total of 671 small mammals were captured over 4,089 trap nights. *Schistosoma mansoni*, occasionally coupled with zoonotic *Schistosoma haematobium*/*Schistosoma bovis* hybrids, and *Schistosoma bovis* were isolated in the portal system and/or mesenteric vessels of 24 out of 367 *Mastomys huberti* mice (prevalence 6.6%; intensity range 2-64) and 6 out of 257 *Arvicanthis niloticus* rats (prevalence 2.3%; intensity range 1-44). Infection prevalence was highly focal among study sites, with rates up to 52.6% and 28.6% in the villages of Gueo and Temey, respectively. Our findings emphasize the role of *Mastomys huberti* and *Arvicanthis niloticus* as important zoonotic reservoirs of *Schistosoma* species and hybrids, potentially amplifying transmission to humans. In the Senegal River Basin, as in many other endemic areas of sub-Saharan Africa, the breakdown of ecological barriers warrants the application of a One Health, multi-host framework to better tailor setting-specific *schistosomiasis* control programmes, enhancing public health interventions.

Poster Session 2 – Workshop Rodent-Borne Diseases

63 Rodents diversity and pathogen carriage at Limpopo National Park villages, Mozambique

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The Limpopo National Park (LNP) is a Mozambican Trans Frontier Conservation Area of global interest. Within the park, people, domestic and wild animals live together, as well as potential high diversity of rodents and rodent-borne pathogens also. Rodents are known pests and important carriers/reservoir of pathogens but also food source in rural communities increasing human exposure risk. Some data confirm occurrence of *Toxoplasmosis*, *Leptospirosis* and plague in Mozambique but little is known about rodent role in these diseases ecology in the country. As climate change may increase contact between humans and wildlife and therefore increase pathogens spillover, it is critical to study diseases occurrences and dynamics in risky areas like LNP. The present study aims to understand the diversity of rodents at LNP villages, their pathogen carriage and roles in disease ecology. Thus, with the permission of LNP authorities and villagers a total of 6 villages from core (2) and buffer (4) zones were studied. Rodents were trapped and specimens were ethically sacrificed. Skull, skin and tissue samples for DNA analyses (COI and Cytb genes) were used for taxonomic identification. Specimens' health-status was recorded and samples collected during meticulous necropsies. Pathogens screening is now being carried out (LAT for *Toxoplasma gondii*; MACROLepto for *Leptospira* "S" spp.). Thirty-five rodents of three different genera (*Rattus* sp., *Aethomys* sp. and *Mus* sp.) were captured, a rich rodent tissue and parasites collection was assembled and identification at species level is in process. The general health-status was poorer in rodents from core zone than those from buffer zone villages. Buffer zone rodents only had fleas while core zone rodents had mites, fleas and large endoparasites. *Toxoplasma gondii* and *Leptospira* spp. screenings are still under analysis. This study can assist other One Health approach studies and may allow health prediction and disease risk mapping in Mozambique.

Poster Session 2 – Workshop Rodent-Borne Diseases

64 Mice in and around the city of Utrecht, The Netherlands, are carriers of *Clostridium difficile* but not ESBL-producing *Enterobacteriaceae*, *Salmonella* spp. or MRSA

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Globally, the house mouse (*Mus musculus*) is the most widely spread mammal apart from man and is a commensal, benefiting from food and shelter available from humans and their kept animals. Mice in buildings are a hygiene hazard because they harbour several zoonoses and animals diseases. The aim of this study was to gather information on specific antibiotic-resistant bacteria in house mice caught in the urban environment. Mice caught in snap traps during pest control activities in and around the city of Utrecht, the Netherlands, during May – June 2014, October – November 2015 and September – November 2016 were collected for analysis. The gut contents were analysed for ESBL/AmpC-producing *Enterobacteriaceae*, *Salmonella* spp., and *Clostridium difficile* and the oral cavities were swabbed for methicillin resistant *Staphylococcus aureus* (MRSA). In total 109 house mice and 22 wood mice (*Apodemus sylvaticus*) were examined. ESBL-producing *Enterobacteriaceae*, *Salmonella* spp. and MRSA were not found. Of n = 80 mice, 35.0% carried *Clostridium difficile* (ribotypes in descending order of frequency: 014/020, 258, 002, 005, 013, 056, 081, and two unknown ribotypes). In conclusion, mice in and around the city of Utrecht are not important carriers of ESBL/AmpC-producing *Enterobacteriaceae*, *Salmonella* spp. or MRSA but their droppings are a hazard for transmission of *Clostridium difficile* to humans and the environment.

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65 Detection of *Rickettsia* pathogens in small rodents and their ectoparasites in Lithuania

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Rickettsiae are emerging pathogens causing public health problems in many countries around the world. The reservoir role of small rodents in rickettsiae life-cycles is still unclear and there are a lack of studies focusing on the investigation of rickettsial pathogens in rodents and their ectoparasites across Europe. We aimed to investigate the presence and prevalence of *Rickettsia* spp. in rodents and their ectoparasites (ticks, mites and fleas) in Lithuania. A total of 238 small rodents representing six species *Apodemus flavicollis*, *Myodes glareolus*, *Micromys minutus*, *Microtus oeconomus*, *Microtus agrestis* and *Microtus arvalis* were trapped during 2013–2014. Altogether, 1,261 ectoparasites (596 *Ixodes ricinus* ticks, 550 mites of five species and 115 fleas of eight species) were collected from these rodents. The overall prevalence of *Rickettsia* spp. in rodents was 27.6 %, with a higher prevalence detected in *Micromys minutus* (45.9%), followed by *Apodemus flavicollis* (32.8%), and *Myodes glareolus* (14.3%). *Rickettsia* DNA was detected in eleven species of ectoparasites. The highest infection rate was found in fleas (43.5%), followed by *Ixodes ricinus* ticks (MLE=26.5%) and then mites (MLE=9.3%). Sequence analysis of partial *gltA* and 17kDa genes revealed the presence of *Rickettsia helvetica* in rodents, while in rodents ectoparasites were detected *Rickettsia helvetica*, *Rickettsia felis*, *Rickettsia monacensis*, *Rickettsia* sp. and rickettsial endosymbionts. In rodents' fleas four *Rickettsia* spp. were identified, while in *Laelapidae* mites three *Rickettsia* spp. occurred in *Ixodes ricinus* ticks only *Rickettsia helvetica* was found. This is the first report of the occurrence and molecular characterization of *Rickettsia* spp. in rodents and their ectoparasites in Baltic countries.

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66 Detection of *Leptospira* and seasonal prevalence of fleas collected from rodents in Mukwe Constituency, Kavango-East Region of Namibia

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Biotic and abiotic factors can alter abundance and community composition of rodents and that of associated parasites. Aim of the study was to measure the impact of climatic variables (temperature/relative humidity) on rodent populations and on population dynamics of associated micro- and ecto-parasites. We monitored the prevalence and diversity of pathogenic *Leptospira*, the etiological agent of leptospirosis, and fleas, arthropod vectors of medical importance in mammals sampled over a period of 11 months in the Kavango East region of Namibia. In total, 121 small mammal hosts were examined for *Leptospira* infection through real time PCR, yielding an overall prevalence of 9.9%. However, only a single *Leptospira* species could be genotyped and identified as *Leptospira kirschneri* in one host species (*Saccostomus campestris*). Throughout the study period, almost all mammal species harboured the same flea species, which included *Cryptonella numae* (1.8%), *Pulex irritans* (43.0%), *Parodontis riggenbachi riggenbachi* (12.9%), *Synosternus caffer* (3.9%) and *Xenopsylla* species (38.3%). Using the Kruskal-Wallis test, the monthly population fluctuation of fleas varied significantly on *Mastomys natalensis* ($\chi^2=29.440$, $df=10$, $P=0.001$), *Steatomys pratensis* ($\chi^2=30.521$, $df=10$, $P=0.001$) and *Saccostomus campestris* ($\chi^2=32.681$, $df=10$, $P=0.0001$). However, no significant difference in the number of fleas per month was found for *Gerbilliscus leucogaster* ($\chi^2=10.831$, $df=10$, $P=0.371$). The Pearson correlation showed a weak positive trend between the abundance of fleas on small mammal hosts with temperature ($r=0.3$, $df=9$, $N=11$, $P=0.310$) as well as weak positive trend between flea abundance and relative humidity ($r=0.6$, $df=9$, $N=11$, $P=0.109$). Lastly, there was a very strong positive correlation ($r=0.8$, $df=9$, $N=11$, $P=0.0058$) between average abundance of small mammals and average abundance of fleas. Therefore, climatic variables (temperature and relative humidity) were found to have an influence on the abundance of small mammals and fleas. The impacts of seasonal patterns highlighted by this investigation on human health are discussed.

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67 Rodents from a rice milling station in Bangladesh infected with *Toxoplasma gondii*

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In order to complete its parasitic cycle of life, *Toxoplasma gondii* reproduces in feline animals as these are the protozoan's definite host. Because rodents are prey animals to cats, rodents contribute to the transmission and reproduction of *Toxoplasma gondii*. Not much is known or scientifically published about the occurrence of *Toxoplasma gondii* in Bangladesh. Therefore we tested rodents from a typical Bangladesh rice mill for *Toxoplasma gondii*. We found 2.9% of the rodents (n=34) to be positive for *Toxoplasma* DNA, which shows that rodents present in rice-production facilities could carry *Toxoplasma gondii*. To determine the prevalence of *Toxoplasma* in rodents from Bangladesh, we will carry out further research based on a larger sample size.

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68 Leptospirosis and toxoplasmosis in wild rodents in The Netherlands

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Because rodents are known to carry zoonotic pathogens, it is of the essence to be aware of the rodent-borne pathogens that are present. There is impaired knowledge on rodent-borne diseases in The Netherlands, which limits the opportunities for preventive measures and complicates the assessment of risk of transmission to humans. In order to increase the knowledge on rodent-borne pathogens, we selected *Leptospira* spp. and *Toxoplasma gondii* from a list of prioritized emerging pathogens relevant for The Netherlands. Leptospire have the ability to survive in moist environments, and can be transmitted to living organisms via contact with a contaminated water source. In total, 351 rodents were tested for leptospira, and 284 for *Toxoplasma gondii* presence. Rodents were trapped at food production sites; on pig farms and dairy farms in various regions of the country. We found 5.7% of the rodents (n=351) positive for *Leptospira* DNA, and none of the rodents tested positive for *Toxoplasma gondii* DNA. Our results show that rodents could be useful as an indicator for the environmental contamination and/or the contamination in wildlife for *Leptospira* spp.

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69 Leptospirosis in rodents in peri-urban Bangladesh

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Leptospirosis infections come to attention as an increasing global health problem. *Leptospirosis* is a re-emerging zoonosis of world-wide significance with south-east Asia as one of the most noteworthy epicentres. It is assumed that rodents are critical as host for a variety of leptospiral serovars. The south-east Asian country Bangladesh has humid climate which is perfect for the survival of *Leptospira*. Presence of rodents in this country could be a serious risk for human infection, especially in peri-urban areas on locations where food is stored. We carried out a study on rodents living in a rice mill in Bangladesh to gain more understanding of the multi-host epidemiology of *Leptospira*. Of the 221 rodents tested, 11.8% were infected with pathogenic *Leptospira*. To identify the *Leptospira* species we sequenced the results, indicating the presence of *Leptospira interrogans* and *Leptospira borgpetersenii*. Rodents of the *Bandicota* species (20/100) were significantly more likely to be infected than those of the *Rattus* class (3/87). These results endorse the prominence of rodents as hosts of pathogenic leptospires. Furthermore, the results show that human exposure to pathogenic *Leptospira* may be considerable. Our study stresses the necessity to improve rodent management and to further quantify the public health impacts of this neglected emerging zoonosis in Bangladesh.

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70 Detection of *Bartonella* spp. in red squirrel (*Sciurus vulgaris*) and their ectoparasites in Lithuania

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Bartonella are vector-borne gram-negative bacteria causing blood-borne infections. Small mammals are reservoir hosts of *Bartonella* spp. and their ectoparasites such as fleas, ticks, sand flies, lice and mites are potential vectors. Rodents are one of the most important reservoirs for *Bartonella* pathogens. *Bartonella washoensis* was found in squirrels as the main reservoir and was isolated from human in the USA. The aim of this study was to investigate the presence of *Bartonella* infections in red squirrels and their ectoparasites using molecular tools in Lithuania. DNA from red squirrels was extracted by using a genomic DNA purification kit, according to the manufacturer's instructions. DNA from fleas and ticks was extracted by using 2.5% ammonium hydroxide. *Bartonella* DNA in samples was detected using a nested-PCR of the ITS region. Positive PCR products were selected for DNA sequencing. A total of 39 red squirrels victims of road traffic were found. Squirrels were found to be infested with *Ixodes ricinus* ticks (191) and *Ceratophyllus sciurorum* fleas (36). *Bartonella* spp. DNA was detected in 15 (38.5%) samples of squirrels, 2 (1.0%) sample of ticks and 20 (55.5%) samples of fleas. The ITS region sequences showed that *Bartonella washoensis* were detected in squirrels and their ectoparasites. The results of this study suggest that *Ceratophyllus sciurorum* fleas may be substantial vector for transmitting of *Bartonella washoensis* in red squirrels in Lithuania.

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71 Genetic diversity of *Bartonella* strains in small rodents

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Bartonella infections have been documented in a wide range of mammals and 15 *Bartonella* species have been detected in small rodents. Several rodent-associated *Bartonella* species have been related to human diseases. However, there is a lack of studies on the presence and diversity of *Bartonella* pathogens in small rodents in Baltic region. The objectives of this study were to investigate the prevalence and genetic diversity of *Bartonella* strains in different species of small rodents from Lithuania. We collected spleens from seven small rodent species captured in different parts of Lithuania during 2013-2016. The presence of *Bartonella* was examined by real-time PCR targeting the *ssrA* gene. Species identification and molecular characterization of bacteria strains were based on sequence analysis of two housekeeping genes (*rpoB*, *groEL*) and the intergenic species region. *Bartonella* DNA was detected with different prevalence in *Apodemus flavicollis*, *Micromys minutus*, *Myodes glareolus*, *Microtus oeconomus*, *Microtus agrestis* and *Microtus arvalis* rodents. Sequence analysis of *Bartonella* isolates showed that the *Bartonella* strains circulating among the investigated rodents are heterogenic and belonged to *Bartonella grahamii*, *Bartonella taylorii* and *Bartonella rochalimae* genogroup. Phylogenetic analysis based on each of the targets demonstrated the presence of different *Bartonella grahamii* and *Bartonella taylorii* strains associated with different species of rodents. This is the first report on molecular characterization of *Bartonella* strains in multiple rodent species from Baltic region. Our findings provide evidence of wide distribution of human pathogenic *Bartonella grahamii* in Lithuania.

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72 Resistance to last-resort human antimicrobial agents among gram-negative bacteria recovered from Barcelona Norway rats (*Rattus norvegicus*)

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Gram-negative pathogenic bacteria are shared between humans and animals but also the intra- and the inter-species exchange of genetic determinants of resistance are common between bacterial pathogens. Recent reports have identified multidrug-resistant bacteria from sewage samples in different parts of the world but there is no data regarding the potential role of urban rats as reservoirs and source of antimicrobial resistant bacteria that are relevant to human health. From January through November 2017, two hundred and twelve Norway rats (*Rattus norvegicus*) were captured with kill traps in different sections of the Barcelona sewers. Intra-rectal samples from captured animals were cultured on selective media for the isolation of ESBL and/or carbapenem resistant gram-negative bacteria. Species identification was performed by MALDI-TOF/MS and antimicrobial susceptibility was determined by disc diffusion, and Etest and microdilution when necessary, following EUCAST guidelines. Detection of genes encoding ESBL and carbapenemases was performed by PCR and Sanger sequencing. Pulsed-field gel electrophoresis was used to study the clonal relatedness of all isolates and MLST analysis was performed on selected isolates. Overall, 229 isolates were recovered and identified, in order of abundance, as either *Escherichia coli*, *Klebsiella pneumoniae*, *Enterobacter* spp., *Raoultella ornithinolytica*, *Serratia* spp., *Citrobacter* spp., and *Pseudomonas* spp. Resistance to extended-spectrum cephalosporins was high among *Escherichia coli*, *Klebsiella pneumoniae* and *Enterobacter* spp (>50%) associated with carriage of ESBL. Resistance to carbapenems was identified in roughly 10% of the isolates, mostly associated with carriage of KPC and NDM carbapenemases. Isolates with the same mechanism of resistance were clonally related but overall there was high clonal diversity. Our results show alarming levels of antimicrobial resistance to clinically relevant antibiotics among gram-negative bacteria colonizing the intestinal tract of Barcelona rats. Additional studies to analyze transmission of resistance mechanisms and bacterial strains between humans and urban rats are ongoing.

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73 Evaluation of rodent control to fight Lassa fever through mathematical modelling

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The Natal multimammate mouse (*Mastomys natalensis*) is the reservoir host of Lassa virus, an arenavirus that causes Lassa haemorrhagic fever in humans in West Africa. Because there exists no vaccine for human use and therapeutic options are limited to the broad-spectrum antiviral ribavirin, rodent control and adjusting human behaviour are currently considered the only options for Lassa fever prevention. In order to investigate the efficiency of rodent control performed during a four-year field experiment in Upper Guinea, we developed a mathematical model to test different control strategies (yearly density control, continuous density control and rodent vaccination). For the field study, rodenticide baits were placed each year in three rural villages, while three other villages were used as controls. Rodents were trapped before and after every treatment and their antibody status and age were determined. Data from the field study was used to parameterize the mathematical model. In the field study, we found a significant negative effect on seroprevalence over the years in the treatment villages, but the effect (5% reduction per year) was small given the effort. As the populations also recovered rapidly after the rodenticide treatment, we conclude that a yearly control strategy is unlikely to significantly reduce Lassa virus spillover to humans. In agreement with this finding, the mathematical model supports the use of continuous density control and rodent vaccination to eliminate Lassa virus from the rodent population, but discourages the use of yearly density control. Our model can be used by policymakers as a first indication of how long, frequent and when rodent control should be done in order to eliminate Lassa virus in rural villages.

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74 Responses of rodent reservoirs of zoonotic diseases to anthropogenic land-use change: a meta-analysis

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Rodents are important reservoirs for a large number of zoonotic pathogens. The replacement of native habitats by productive lands (e.g. agricultural crops and forestry plantations) can increase the abundance of rodent reservoirs, which can generate an increase risk of pathogen exposure to humans. In this study, we conducted a meta-analysis concerning the responses of rodents to land-use change, in order to assess the general effect of land-use change on abundance of rodent species in relation to their reservoir status for several pathogens. We collected data from the PREDICTS database and we grouped rodent species into three categories (reservoir, non-reservoir and future reservoir), according to a recently published reservoir status categorization of rodents species. We retrieved 58 case studies dealing with 54 rodent species from several geographical areas. Rodent reservoirs were significantly more abundant in areas with non-native vegetation compared to sites of native vegetation. On the other hand, non-reservoir species were more abundant in sites of native vegetation. Future reservoirs did not show a clear pattern regarding their response to habitat modification. To our knowledge, this is the first study that evaluates globally the effect of land-use change on rodents with implications for disease risks. Our findings are in agreement with the hypothesis that rodent reservoirs tend to respond differently to human disturbances than non-reservoir species. This study may help the assessment of potential risk of rodent-borne diseases when land-use change occurs.

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75 First bacteriological screening of Norway rats, *Rattus norvegicus*, in Barcelona (Spain)

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The control of commensal Norway rat infestations by local authorities has been largely considered part of the public health protection. Norway rats carry several zoonotic pathogens and because rats and humans live in close proximity in urban environments, there is potential for transmission. Within this context the Agència de Salut Pública de Barcelona, in the framework of the rodent surveillance and control program carried out in the city, started, in 2016, a project that included a bacteriological study of Norway rats in the city of Barcelona. To identify some zoonotic bacteria agents carried by rats in Barcelona, from December 2016 to November 2017, we captured with kill traps 212 rats in different sections of sewer system. Samples from intestine and stool were analysed for *Listeria* spp., *Yersinia* spp., *Campylobacter* spp., *Salmonella* spp. and *Escherichia coli* resistant to beta-lactam acids, and kidney and bladder samples, for *Leptospira* spp. The results showed the following prevalences: *Listeria monocytogenes* (59%), *Yersinia enterocolitica* (18%), *Campylobacter jejuni* (7%), *Salmonella* spp (7%), *Escherichia coli* resistant to beta-lactam acids (71%) and *Leptospira* spp (12%). It should be noted the high prevalence of *Listeria monocytogenes* and *Escherichia coli* resistant to beta-lactam acids and with a moderate prevalence *Yersinia enterocolitica* and *Leptospira* spp. The risk of human exposure to these pathogens is a significant public health concern. Because these pathogens cause non-specific and often self-limiting symptoms in humans, infection in human populations is probably underdiagnosed. In conclusion, the results show that rodents could be a risk for the transmission of rat associated zoonoses in Barcelona.

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76 Education in health associated with gamification against leptospirosis

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Outbreaks of leptospirosis are reported in urban centers of several developing countries around the world. In Brazil, more than 12,000 cases of leptospirosis occur every year, mainly during urban epidemics, with the lethality of 12%. Most of these cases are related to low-income populations with precarious basic sanitation infrastructure, inadequate housing and high human concentration. Urban leptospirosis is the most prevalent in Brazil in recent decades. In the city of Salvador-Bahia/Brazil, new cases of leptospirosis happen annually in the peripheral districts during the rainy periods. The transmission occurs mainly in the domestic environment, where the soil-water interface is present, at regions prone to floods served by open-air sewers or with inadequate rainwater drainage. The level of the knowledge, attitudes and practices (KAP) of residents of these vulnerable areas can contribute to the identification of environmental factors favorable to rodents and of actions that can reduce the risk of contamination by *Leptospira*. Education in health practices associated with the gamification strategies (challenges, competition, performance feedback, collaborative work, rewards etc.) can motivate people to become aware of environmental risk factors with greater engagement and motivation. The objective of this study is to evaluate the KAP with young people and their families through the methodology of education and health associated with the strategy of gamification in two peripheral communities in Salvador. For this reason, workshops are being held in one public school and in two groups of young people and their families, using applications based on gamification.

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77 No role for rodents as alternative hosts for cutaneous leishmaniasis in S. Ethiopia

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Cutaneous leishmaniasis (CL) is a disease caused by members of the trypanosomid parasite genus *Leishmania*. It is a zoonotic and vector borne infection with the pathogen being transmitted between hosts and from hosts to humans by phlebotomine flies. Females of these so-called sandflies feed on blood of mammals and when they ingest host macrophages infected with the amastigote stages of the parasite, the latter will develop into promastigotes that are then transmitted to another host at a next blood meal. The epidemiology and pathology of CL is complicated. In southern Ethiopia, the disease has a patchy distribution, linked to the ecological conditions that are important for the host and vector. *Hyaxes* (genera *Procavia* and *Heterohyrax*) are thought to be the major mammal host and consequently the disease is mostly found close to the rocky outcrops where these animals live. In some cases however, this is less clearly so and it has been suggested that rodents may be an alternative host, since they are known to be hosts for other species of *Leishmania* in other regions. We collected small mammals, mostly rodents, in Ochollo, a village with a high endemicity of CL in Arba Minch Zuria in the south of Ethiopia. Life traps yielded 138 rodents (8 species) and three shrews (1 species), captured near houses, in surrounding fields or near the places where hyaxes are living. Organ samples were taken and investigated for *Leishmania* DNA (kDNA real-time PCR, ITS1). kDNA was found in a single *Mus mahomet* but this was not confirmed in the ITS-1. On the other hand, of 25 hyaxes investigated, 5 were positive. So, while *Leishmania* was present in small mammals in the area, rodents do not seem to be an alternative host for this parasite.

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78 *Puumala hantavirus* dynamics in bank voles: identification of environmental correlates to predict human infection risk

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The *Puumala orthohantavirus* (PUUV) is a zoonotic pathogen of high relevance for public health in Europe. The widely distributed and forest-living bank vole (*Myodes glareolus*) is the reservoir of PUUV. PUUV infections in humans lead to a mild to moderate form of hemorrhagic fever with renal syndrome, called nephropathia epidemica. Time series of beech fructification, host abundance and human PUUV infections were analysed to reveal general patterns of PUUV epidemiology in central Europe. Spatially and temporally replicated live-trapping and serological analyses were performed to reveal seasonal and multi-annual dynamics of PUUV prevalence within host populations in relation to abundance. Further, the influence of various weather parameters on vole abundance was determined by time series analyses to predict outbreak dynamics of bank voles. Relevant weather criteria were then extrapolated to future climate scenarios to evaluate possible long-term changes in host dynamics. Results show that human PUUV infections are highly correlated to rodent host abundance in the present year and to beech seed production in the previous year. Rodent host dynamics were related to multi-annual and seasonal fluctuations of PUUV within host populations. Weather-based models predict bank vole abundance and hence human PUUV infection risk several months in advance. The extrapolation of climatic determinants of bank vole abundance to future climate scenarios indicated an increase in bank vole population outbreak frequency in the future, which might further PUUV epidemics in central Europe.

The studies provide new knowledge about general patterns of PUUV epidemiology in central Europe. Climatic determinants promoting tree seed production as driver of rodent host populations but also fluctuations of PUUV prevalence within reservoir populations in relation to population outbreaks can facilitate the future development of prediction models for human PUUV infections in central Europe.

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79 Survey on zoonotic helminthiasis in Norway rats, *Rattus norvegicus*, from the city of Barcelona

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The parasitological analysis of synanthropic rodent populations in urban settings has shown the presence of various zoonotic helminths, with implications on public health. However, the scarcity of studies from cities around the world is surprising. As part of a multidisciplinary study undertaken in the city of Barcelona (relative abundance, population structure and dynamics; viral, bacterial as well as parasitic –protozoa and helminths–zoonoses; and anticoagulant resistance), the helminthological analysis of 100 *Rattus norvegicus* individuals captured in the sewage system (85) and in parks (15) was carried out. Of the 10 species found, 5 were zoonotic: *Hymenolepis nana* (17%), *Hymenolepis diminuta* (33%), *Calodium hepaticum* (17%), *Gongylonema neoplasticum* (20%) and *Moniliformis moniliformis* (6%). The influence of sex and age of the rat on the prevalence of the zoonotic species was analysed by means of binary logistic regression. Age had an influence on the prevalence of *Hymenolepis diminuta* ($\chi^2=5.199$; $P=0.023$), higher in adults (OR=3.04), and in the case of *Calodium hepaticum* ($\chi^2=16.622$; $P<0.0001$), lower in adults (OR=0.10). The present study is the first helminthological analysis carried out in *Rattus norvegicus* in an urban area in Spain. Moreover, the presence of *Gongylonema neoplasticum* and *Moniliformis moniliformis* as parasites of Norway rats is reported for the first time in an urban environment in Europe. The results show the importance of peridomestic rodents, especially the brown rat, in the transmission of helminth zoonoses, acting as spreaders of the infective stages (eggs) of *Hymenolepis nana* and indirectly of *Calodium hepaticum*, and as reservoir of the three other species detected. Further studies at an urban level are required to shed more light on the role of the Norway rat in the transmission of parasites to the human population. Also, health care professionals should be better informed about the impact of parasitic zoonoses related to these rodents.

Poster Session 2 – Taxonomy-Genetics

80 Geographic variation of the genus *Arvicanthis* (Rodentia: Muridae) from Sudan

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Arvicanthis niloticus (Demarest, 1842) populations are highly variable throughout the Nile valley (Egypt and Sudan) and also in western, central and eastern Africa but knowledge of their geographic variation is lacking, especially from Sudan. Therefore, the phenotypic variation in *Arvicanthis niloticus* populations of Sudan was assessed by geometric morphometric approach (GMA). Univariate and multivariate analyses of skeletal characters (shape and centroid size) differences for the dorsal and ventral views revealed little variation between and among localities for most characters. A significant skull shape difference (dorsal and ventral views) between the five populations of Sudan was evident (P-value <0.05) and that was mostly localized in the zygomatic area. Also, significant correlations (P-value <0.05) between skull geometry and some climatic variables were evident. The previous inter-population variability was largely explained by the masticatory muscles, degree of commensalism, local climatic-environmental variables, and/or the secondary consequence of the interaction between them, which may have induced some ecological, functional and behavioral adaptations. Clearly, the adaptive roles of the previous variables require further biological studies to predict the cranial evolutionary changes of *Arvicanthis niloticus* throughout its distributional range.

Poster Session 2 – Taxonomy Genetics

81 Maternal divergences within *Myospalax* and introgressive hybridization in the eastern Qinghai-Tibet Plateau

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The zokor (genus *Myospalax*) is a subterranean solitary species. It remains unknown what had caused the morphological complexity and difficulty in species circumscription within *Myospalax*. Hybridization and gene flow are proposed for explaining such a scenario, especially for ambiguous hybridization origin of *Myospalax smithii*. The morphological characters of this species suggested its relationship to both old and young species; however, hybridization usually occurs between young species or lineages with recent divergences. Our phylogenetic analyses of mitochondrial cytochrome b gene (Cyt b) and 12S rRNA gene obtained from 102 individuals representing all eight species of the genus *Myospalax* produced well discerning maternal phylogeny within the genus. Our results further rejected a hybridization origin hypothesis of *Myospalax smithii* between *Myospalax cansus* and *Myospalax myospalaxi*. However, we found that morphologically defined *Myospalax smithii* individuals interweaved with those belonging to *Myospalax baileyi*. These individuals from two species clustered into two well supported clades. We suggest that *Myospalax smithii* should be recognized as separate species, but the extensive hybridization and gene flow between it and *Myospalax baileyi* might have swamped out most pure *Myospalax smithii* individuals possibly due to heterosis of hybrids. Our results are consistent with the previous assumption regarding occurrence of hybridization between recently divergent lineages with close relationships. However, this conclusion was drawn based only on a combination of morphological and maternal evidence; further evidence with genetic signatures from both parents (e.g. nuclear genes) is needed. Overall, these results suggest that *Myospalax* provides a model system for studying speciation, reproduction isolation and gene flow of small mammals.

Poster Session 2 – Taxonomy Genetics

82 Systematics of an Andean akodontine, *Akodon mimus* (Cricetidae, Sigmodontinae): insights from molecular markers

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Akodon mimus (Thomas, 1901) is a medium-sized member of one of the most diverse genera of the second largest tribe of sigmodontine rodents, *Akodontini*. The scarce available data indicate that *Akodon mimus* is a monotypic form distributed in eastern Andean slopes between 2,000-3,700 m from southeastern Peru (Puno department) to central Bolivia (Cochabamba, La Paz and Santa Cruz departments), and inhabiting primarily elfin forests. Originally described in the genus *Oxymycterus*, it was later selected as the type species of *Microxus*, an entity coined by Thomas in 1909, in order to allocate several small-bodied long-nosed mostly Andean forms. After the influential treatise of Cabrera in 1961, *Microxus* was subsumed under *Akodon*, and never properly revisited its generic rank. With the advent of molecular markers in sigmodontine systematics, the placement of *Akodon mimus* nested in *Akodon* was cemented on the basis of one specimen from Puno, Peru. However, more recent studies retrieved an unstable position of *Akodon mimus* regarding the remainder species of *Akodon* or even to close genera such as *Castoria*, *Deltamys* and *Thaptomys*. We examined the phylogenetic position of *Akodon mimus* and also the relationship between Cochabamba and Puno populations referred to the species. Based on four loci and a dense taxonomic approach covering most of the *Akodontini*, we performed parsimony, maximum likelihood and Bayesian analyses. Our phylogenetic results point to the validity of the genus *Microxus* or, alternatively, to return to a polytypic *Akodon* composed by several subgenera (i.e., *Akodon s. s.*, *Deltamys*, *Castoria* and *Microxus*). In addition, we detected high levels of genetic divergence between Cochabamba and Puno populations (ca. 10% p distance – cytochrome b locus), suggesting that they represent different species. In this context, *Akodon mimus* appears as another case of an Andean sigmodontine largely overlooked but with an unsuspected diversity.

Poster Session 2 – Taxonomy Genetics

83 A phylogenetic study on Anatolian endemic *Dryomys laniger* (Mammalia: Rodentia) to determine an in-situ conservation area

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Dryomys laniger is an endemic rodent living in Turkey. It distributes along Taurus Mountain range and Anatolian diagonal mountain range between Antalya and Erzurum in Turkey. The main distribution range in these areas extends from about 1,500 meters up to 3,000 m a.s.l. in rocky habitats. In this study we aimed to offer suitable areas for potential in-situ conservation areas for the species by investigating cytb genetic diversity along with distribution areas. We collected 31 samples from 6 localities between 2015 and 2017. According to results, we expanded the distribution area of the species by determining some new distribution areas. We used the cytb gene region to find out genetic diversity and to draw a phylogenetic tree. According to the phylogenetic tree there are two main clades in Turkey. There are geographical barriers between clades which cut gene flow between the clades. On the other hand, we found that gene flow continues within clades. It might be pointed out that populations in Turkey would be divided into two different subspecies for the taxa. So, we offer two different areas to protect each of the subspecies.

Poster Session 2 – Taxonomy Genetics

84 The traits of contact zones between different chromosomal races of *Mus musculus domesticus* (Rodentia: Muridae) in two Robertsonian (Rb) systems of Greece

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The otherwise conservative acrocentric karyotype of the house mouse, *Mus musculus domesticus* (Rodentia, Muridae), demonstrates in various Euro-Mediterranean locations extreme chromosomal evolution, through the accumulation of Robertsonian (Rb) fusions: non-homologous uni-armed chromosomes fuse at their centromere, creating bi-armed chromosomes ($2n=40-22$). Homozygous populations for specific sets of Rb fusions, termed Rb races, that share a common origin form Rb systems. In Greece, three Rb systems have been described, namely, in Peloponnese, E Sterea Ellada and Ipiros. In most Rb systems, the characteristics of the contact (hybrid) zones between different chromosomal races have been the object of intensive research. We targeted specific contact zones at the Rb systems of E Sterea Ellada and Peloponnese, based on the karyological analysis of 50 house mice from 18 localities. Regarding the Rb system of E Sterea Ellada, we focused on areas of Attiki, where it was shown that the Rb population, ranging from $2n=39$ to as low as $2n=27$ (GRT2xGRT1 Rb races) is placed peripherally of Athens, in positions N and E of Mt Imittos. Overall, the whole study area behaved like a contact zone possibly between GRT2 with $2n=28$ and the acrocentric population, the most interesting trait of which was the abrupt transition (ca. 6 km wide) from $2n37$. On the other hand, in the Rb system of Peloponnese, we examined an area, where two well-known Rb races, GROL with $2n=24$ and GRKA with $2n=28$, characterized by monobrachial homology, were expected to come very close but form no hybrids. Indeed, our study revealed no hybrids between them; instead, the acrocentric population had entered between them, forming hybrids ($2n=33-39$) with either of them. Surprisingly, Rb(4.16) and Rb(8.17), were sporadically found in the study area, which have not been described before in Peloponnese and could have resulted from type 'b' whole arm reciprocal translocations.

Poster Session 2 – Taxonomy Genetics

85 Karyology of *Meriones dahli* Shidlovsky, 1962 (Rodentia: Mammalia) in Turkey

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The material of five (2 male, 3 female) specimens of *Meriones dahli* was collected from east Anatolia. The specimens were investigated for aspects of their karyological characters. The data obtained from specimens was compared with the ones previously studied. The karyotypes of the specimens have $2n = 50$, $NFa = 78$ and $NF = 74$. The karyotype consist of 13 pairs that are meta/submetacentric and 11 pairs that are acrocentric. The X chromosomes are medium-sized metacentric and the Y chromosome is small submetacentric.

Poster Session 2 – Taxonomy Genetics

86 A new chromosomal race of the Evoron voles *Alexandromys evoronensis* of two isolated populations in the Russian Far East

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The Evoron vole *Alexandromys evoronensis* (Kowalskaia et Sokolov 1980) ($2n = 38-40$, $NFa = 51-54$) was described as an endemic of the Evoron-Chukchagir plain (ECh) of the lower Amur region in the Russian Far East. Morphologically, this species looks like Maximowicz's vole *Alexandromys maximowiczii* (Schrenck 1858) ($2n = 36-44$, $NFa = 50-60$). With their multiple chromosomal polymorphisms, both species have different chromosomal rearrangements (Meyer et al., 1996). As a result of hybridization of two species, sterile hybrids F1 were obtained (Kowalskaia et Sokolov 1980, Meyer et al., 1996). Biologically, the two species are reproductively isolated while in terms of the mtDNA control region they differ as subspecies of one species (Haring et al., 2010); and some researchers tend to consider them as one species *Alexandromys maximowiczii* (Lisovskyi et al., 2018). Recently, an Evoron vole was discovered in two isolated mountain valleys of the Zeya and Bureya rivers: Verkhnezeiskaya Plain (VZ) and Verkhnebureinskaya Depression (VB). This vole species' diagnostics was performed using karyological and mtDNA control region data. For the first time, a karyotype with $2n = 36$ in VZ and $2n = 37$ in VB population was described for the species (Sheremetyeva et al., 2017a, b). Comparing differential staining of chromosomes from the Evoron voles from three populations enabled us to suggest the existence of two chromosomal races: (i) in VZ and VB and (ii) in ECh. Hybridizing two geographically close populations of two species (36 chromosomal Evoron voles from VZ and 40 chromosomal Maximowicz's voles from Zeya City locality), made it possible to obtain the sterile 38 chromosomal F1. The results obtained testify the taxonomical species status both for *Alexandromys evoronensis* of VZ and *Alexandromys maximowiczii* (from Zeya).

Poster Session 2 – Taxonomy Genetics

87 Karyological study of the house mouse, *Mus musculus domesticus* (Rodentia, Muridae), at the Robertsonian (Rb) system of Ipiros, Greece

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The house mouse, *Mus musculus domesticus*, is a small rodent with an almost worldwide distribution that is typically characterized by an all-acrocentric karyotype. However, this karyotype often displays Robertsonian (Rb) fusions: the merging at the centromeric region of non-homologous, acrocentric chromosomes, in order to form bi-armed chromosomes. As a result, the diploid chromosome number in nature can range from $2n=22$ to $2n=40$. This karyotype trait concerns only several European and some circum-Mediterranean populations of the house mouse and in Greece three Rb systems are known so far. This work is part of a wider effort to study the least known Rb system, located in Ipiros, W Greece. For this Rb system, most data were derived from around the city of Ioannina, NW Ipiros, where the lowest recorded $2n$ is $2n=28$, characterized by Rb(15.17), Rb(3.10), Rb(5.12), Rb(14.16), Rb(8.9) and Rb(2.11). However, no data exists on the actual dimensions of the Rb system, its Rb races, etc. Therefore, the aim of the study was to seek the SE border of this Rb system by surveying an area ca. 65 S-SE of Ioannina. Thirty mice from 17 localities N-NE of Amvrakikos lagoon were karyologically studied. Among these, only one belonged to the acrocentric population ($2n=40$), whereas the remaining 29 were characterized by $2n=34-39$. All six Rb chromosomes known from around Ioannina appeared with different frequencies in the studied sample, confirming that the surveyed area does belong to the studied Rb system, which apparently occupies a significant part of Ipiros. The high percentage of Rb heterozygotes in our sample suggests that the study area rather constitutes a relatively wide contact zone with the acrocentric population located at the east. In conclusion, the new data clarify important issues, regarding the Rb system of Ipiros, however, several questions remain to be pursued with our future studies.

Poster Session 2 – Taxonomy Genetics

88 Genetic structure of a peripheral population of the Northern mole vole: re-evaluation after eliminating nuclear pseudogene contaminants

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Mole voles (the genus *Ellobius*) are highly specialized subterranean rodents. Areal fragmentation, coupled with some features of reproductive system described for mole voles, is expected to result in low intra-population genetic diversity and strong inter-population differentiation. In the course of our previous study of the Northern mole vole, *Ellobius talpinus*, in the Novosibirsk region of Russia (Kuprina et al., 2016), an unexpected high haplotype diversity of the mitochondrial control region fragment had been revealed. In addition, there was a high sequence divergence (5.6%) between two predominating haplotypes. However, our subsequent molecular investigation (Kuprina et al., 2018, this volume) discovered that one of these haplotypes was actually a cryptic nuclear pseudogene. Using the new primers designed to amplify a target portion of the mitochondrion control region only, a 417-base pair fragment was sequenced. In total, 5 haplotypes defined by 6 polymorphic sites were identified among 56 individuals from 3 subpopulations. Thus, overall, a relatively high haplotype ($H=31\%$) and low nucleotide ($\pi=0.15\%$) diversities have been detected. The genetic variation within each of two most peripheral subpopulations was extremely low ($H=0\%$, $\pi=0.00\%$, $n=11$ and $H=10\%$, $\pi=0.03\%$, $n=37$). An analysis of molecular variance showed a very strong genetic differentiation among subpopulations on high geographic scale (~ 100 km; $F_{st}=0.91$) and the absence of differentiation on low scale (~ 10 km; $F_{st}=-0.04$). These reevaluated data consist with both theoretical predictions and information on population genetic structure of other studied social subterranean rodents. The research was funded by the RFBR (projects 16-04-00479 and 16-04-00888). Technical and financial support: Chromas and MCT RRCs of SPbSU.

Poster Session 2 – Taxonomy Genetics

89 Is there subspecies structure of the common hamster (*Cricetus cricetus* Linnaeus, 1758) in Russia? Craniometric analysis

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Genetic research on the common hamster has long been of interest and has generated a compelling picture of its evolutionary relationships and possible migration flows. However, despite the fact that most of the species range is located in Russia, the works devoted to the subspecies structure are still solitary. Most of the researchers adhere to the traditional notions of 7-10 subspecies inhabiting the territory of Russia, but there has been no substantiated confirmation to this. Recently provided analysis of sequences of an mtDNA control region and *cytb* gene revealed at least three phylogenetic lineages. Most of the species range (approximately 3 million km²), including central Russia, Crimea, the Ural region, and northern Kazakhstan, is inhabited by a single, well-supported phylogroup - E0. Phylogroup E1, previously reported from southeastern Poland and western Ukraine, was first found in Russia (Bryansk Province). Hamsters inhabiting Ciscaucasia represent a distant phylogenetic lineage, named "Caucasus". It is a sister to the phylogroup "North" from western Europe. However, the phylogeographical structure of the species may not coincide with the subspecies. The present study was carried out to perform a comparative analysis of the common hamster skulls belonging to the phylogeographical lineages «Caucasus» and E0. We studied 60 museum skulls from 3 Russian collections using 28 parameters. The analysis showed that the craniometric measurements of the Caucasian phylogroup significantly differ from E0 and coincide with the molecular-genetic data. Thus we confirmed that the Caucasus is inhabited by separate subspecies described by S.I. Ognev as *Cricetus cricetus stavropolicus*. The E0 phylogroup most likely corresponds to another subspecies of *Cricetus cricetus rufescens*. Here only the preliminary data are presented and the subspecies structure of this species in Russia requires further study. This study was supported by Russian Science Foundation №16-14- 10269 and Presidium of the Russian Academy of Sciences program "Biodiversity of Natural Systems and Biological Resources of Russia"

Poster Session 2 – Taxonomy Genetics

90 *Gerbillus dasyurus* (Rodentia: Gerbillinae) record from Hatay Province in Turkey

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Wagner's gerbil, *Gerbillus dasyurus*, is distributed in most parts of Sinai, the Arabian Peninsula, and in the Middle East. The species has been recorded from the Kilis Province in south eastern Turkey only. In the present study, 10 specimens from three localities in the Hatay Province were collected. *Gerbillus dasyurus* lives in rocky hills and slopes with poor soil and vegetation on blocky igneous rocks, and also in the rocky lava flow area in the north eastern part of the Hatay Province. The karyotype of the specimens was found to be $2n=60$, $NF=70$, $NFa=66$. The population density was estimated to be 2.74. The mean of the baculum length is 2.37 mm, and the maximum median width is 0.52 mm ($n=3$). M1 has three roots, M2 has three, M1 and M2 have two, and M3 and M3 have one root. The tail is markedly longer than the head and body. All peculiarities verify that the samples investigated belong to *Gerbillus dasyurus*. However, the differences seen in the root number of M1, the proportion of the tail, and the shape of baculum etc. imply that a detailed study that covers all distribution area is necessary to show inter- and intrapopulational variations.

Poster Session 2 – Taxonomy Genetics

91 New records of Robertsonian (Rb) variability in Greek house mouse, *Mus musculus domesticus* (Rodentia: Muridae), populations from S Sterea Ellada

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Many mammalian species are characterized by chromosomal variability, which, occasionally, can even promote speciation events. Specifically, the karyotype of the house mouse, *Mus musculus domesticus*, is well-known for the appearance of Robertsonian (Rb) fusions, which cause non-homologous acrocentric chromosomes to fuse at the centromeric region and to form biarmed (Rb) chromosomes, leading to the reduction of the diploid chromosome number ($2n=22-40$). This phenomenon is prominent in Europe and in Greece, three distinct Rb systems have been described so far, i.e. in Peloponnese, Epirus and E Sterea Ellada. This work further investigated the recently discovered Rb variability in areas of SW Sterea Ellada and scanned new areas for additional Rb populations of the house mouse. Therefore, a total of 27 house mice were collected from western and eastern areas of S Sterea Ellada, and were karyologically studied, using the G-banding staining technique. Based on our results, even though the acrocentric population occupies most of S Sterea Ellada, surprisingly, a few individuals from SE Sterea Ellada were characterized by $2n=39$, possibly heterozygous for Rb(11.14), a new Rb chromosome for Greece. Whether this population is phylogenetically linked to any of the known Rb populations of Greece, remains to be determined. On the other hand, near Messologhi, SW Sterea Ellada, a new Rb race with $2n=34$ was found, which, interestingly, is related to the GRP1 Rb race ($2n=30$) from Patras, NW Peloponnese, i.e. on the opposite side of the Corinthian bay, because they both carry in common Rb(9.16), Rb(13.15) and Rb(11.17)! Incorporating data from previous surveys, the new Rb race forms a contact zone, ca. 15 km wide, with the acrocentric population at least at its eastern border. A hypothesis is presented on how the new Rb race is phylogenetically linked to the Rb system of Peloponnese, and the next research steps are proposed.

Poster Session 2 – Taxonomy Genetics

92 Taxonomic separation of the red-cheeked ground squirrel from South-East Kazakhstan

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At least three species of ground squirrels are known from south-east Kazakhstan. These species are often considered as one wide-range polymorphic species, the red-cheeked ground squirrel *Spermophilus erythrogenys* sensu lato. The distribution area and taxonomic borders of this combined species remain questionable. We used molecular and bioacoustic tools for taxonomic separation of ground squirrels inhabiting the Dzungarian Alatau region of south-east Kazakhstan and adjacent territories. We examined 30 live-trapped individuals from three different populations (10 individuals per population) for acoustic structure of their alarm calls and for nucleotide polymorphism of the mtDNA C-region (1005-1006 bp) and cytb (1140 bp). We also examined DNA of eight museum specimens of *Spermophilus brevicauda*, *Spermophilus intermedius*, *Spermophilus carruthersi* and *Spermophilus iliensis* originating from the species complex distribution area. Additionally, six cytb sequences from Genbank were used (*Spermophilus iliensis* AF157856, AF157857; *Spermophilus relictus* AF157876; *Spermophilus pallidicauda* AF157866, AF157869; *Spermophilus erythrogenys* AF157875). The alarm call variables were similar between the three study populations and distinctive by their maximum fundamental frequencies (8.46 ± 0.75 kHz) from those of *Spermophilus erythrogenys* from the Kurgan region of Russia (5.62 ± 0.06 kHz). The study animals were conservative in the structure of mtDNA (variation in C-region 3%, in cytb - 2.5%). On the phylogenetic tree based on the cytb polymorphism, the ground squirrels from south-east Kazakhstan and adjacent territories divided on three clades with high (98–100%) bootstrap support: 1) *Spermophilus iliensis* (west of species area); 2) *Spermophilus intermedius* (center); 3) *Spermophilus brevicauda* (= *Spermophilus carruthersi*) (south-east). Study populations of *Spermophilus intermedius* probably deserve the species-level taxonomic rank. These data suggest that *Spermophilus erythrogenys* represents a paraphyletic taxon on both genetic (mtDNA) and phenotypic (alarm call) traits. A new taxonomic revision is needed. Supported by the RFBR grant 18-04-00400.

Poster Session 2 – Conservation and Ecosystem Services

93 Testing the “density-benefit” relationships for invasive alien species: does black rat density influence their role as pollinators?

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Alien species that have both positive and negative impacts in ecosystems are complex to manage. A way to do this could be to use “density-benefit” curves that describe the relationship between the density of an alien and the positive services it provides. We investigated how the density of alien black rats (*Rattus rattus*) affects their efficacy as pollinators of a native plant in Sydney, Australia. First, we used chew cards to determine the densities of black rats in bushland fragments. Then, we created artificial pollination networks and used wildlife cameras to investigate the pollination behaviour of visiting black rats. Pollination potential was measured by the number of black rat visits, the total time they spent foraging on inflorescences, and the number of deposited pollen grains on flowers. We show how these pollination metrics vary with rat density by fitting a “density-benefit” curve and identifying any thresholds in pollination services. This is the first time that alien black rats have been observed successfully pollinating a native plant, which creates a management challenge: do we remove the rats to mitigate their other impacts or do we allow them to persist for the pollination services they provide? Our experiments will provide helpful data that will assist in tackling these thorny management problems.

Poster Session 2 – Conservation and Ecosystem Services

94 Habitat preferences of small mammal species distributed in the eastern Black Sea region in Turkey

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Turkey has rich mammalian fauna due to geographic location and various environmental factors (climate, such as topography and vegetation). Over the last 100 years, more than 160 mammalian taxa have been identified in Turkey by both foreign and Turkish scientists. This work was carried out on the borders of Trabzon and Rize, covering İyidere and Solaklı Basins. Within the boundaries of the planned study area, it is fully revealed that terrestrial small mammal fauna and species are associated with habitats. The study was conducted between June and September 2012. Sherman traps were used to catch small mammal species. Specimens that cannot be identified are embalmed and moved to the laboratory. The standard 4 external dimensions (total length, tail length, hind and ear lengths) and weights (g) were measured according to Harrison and Bates (1991). Habitat types found in the study areas with an altitude of the basin under 1,000 m are: aquatic areas (streams, tea and rivers), agricultural areas (large-scale tea cultivation and little nuts and similar gardens), settlements, beech forests. Species sampled from these habitats are: *Rodentia*: *Apodemus flavicollis*, *Apodemus mystacinus*, *Apodemus uralensis*, *Apodemus sylvaticus*, *Rattus norvegicus*, *Myodes glareolus*, *Muscardinus avellanarius*, *Soricomorpha*: *Crocidura suaveolens*, *Sorex raddei*, *Talpa levantis* and *Erinacomorpha*: *Erinaceus concolor*. The habitat types encountered over 1,000m are: step, mountain and alpine meadow, rocky, mixed forest ecosystems. The species found in these ecosystems are: *Rodentia*: *Apodemus flavicollis*, *Apodemus uralensis*, *Myodes glareolus*, *Microtus daghestanicus*, *Sciurus vulgaris*, *Chionomys roberti*, *Chionomys gud*, *Apodemus mystacinus*; *Soricomorpha*: *Crocidura suaveolens*, *Sorex raddei*, *Sorex volnuchini*, *Sorex satanini*, *Talpa levantis*; and *Erinacomorpha*: *Erinaceus concolor*. In the study area, habitat types, EUNIS habitat classes were excluded and habitat preference of small mammal species was determined.

Poster Session 2 – Conservation and Ecosystem Services

95 Coarse woody debris in home ranges of bank vole *Myodes glareolus*

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The role of coarse woody debris in the functioning of small mammal populations of the order *Rodentia* has already been rather well examined in north America, but still requires research in Europe. As coarse woody debris in different stages of decomposition perform an important role in the functioning of ecosystems and constitute a significant and often indispensable component of habitats for many species of small mammals, an attempt was made to analyse the way of area usage within the context of the habitat's local heterogeneity, with particular consideration of coarse woody debris. In August 2017, pilot telemetry studies were performed on 6 individuals of bank vole *Myodes glareolus* (1 male, 5 females) in the commercial forest stands of the Białowieża Forest. Within the 1-hectare research area and within the borders of home ranges extending beyond the designated area, a detailed inventory of both standing and lying coarse wood debris was made. The collected data about coarse wood debris were mapped together with the home ranges of the examined bank vole individuals. The size of the areas determined for each individuals was between 214 and 589 m² for females and 2,276 m² for the males (areas determined with the Core Convex Polygon method, TRACKER 1.0). It was noticeable that among the total number of bearings for each of the individuals, the situations in which the animal was directly on, beneath or inside coarse woody debris – stump, log or branch pile – constitute a relatively high proportion (between 38% and 64.8% of all collected bearings). This research is an introduction to a project concerning the role of coarse woody debris in shaping the species diversity, population factors and in the usage of forest complexes by small mammals *Micromammalia*.

Poster Session 2 – Conservation and Ecosystem Services

96 A review of methods for studying the seed-rodent interaction

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Although seed dispersal by rodents is one of the most important mechanisms in the ecology and evolution of mutualistic systems, we still have very limited knowledge about the seed dispersal systems due to limitation of research methods of identifying the relation between seeds and rodents at individual level. Most of previous methods in studying seed-rodent interactions , e.g. direct observation, metal-tagged, oil paint-marked, thread-marked, fluorescent-pigment, radioisotope- labeled method, are not able to track the individual or species hoarding seeds. Recently, we developed a method combing seed tagging and infrared cameras tracking methods which could identify the individual relation between seeds and rodents. Our method allows us to estimate the seed-rodent interaction strength, and to assess the benefits and losses of scatter hoarding and conspecific or interspecific seed pilferage, which is essential for exploring the mechanism of species coexistence and network stability of seed-rodent systems.

Poster Session 2 – Conservation and Ecosystem Services

97 When will beavers build a dam? A study in Belgian lowland

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Beavers have returned to Belgium after more than 150 years of absence and are now spreading along waterways in the densely populated landscape. While their presence is applauded for nature conservation reasons, there is also a serious concern about the damage beavers may cause by their burrowing activity, by destroying crops or by constructing dams that may cause flooding upstream. Beavers, however, do not always build dams and in this study, we investigated under which conditions they do. We took measurements in 28 beaver territories in Flanders in 2013, 13 of them without dams and 15 with one or more dams. We measured river water depth in Summer, river width, bank height, stream velocity and distance to woody vegetation. Of these, water depth turned out to be the most important one and in fact the best predictive model for dam construction was one in which water depth was the only variable. A significant logistic regression showed that if river depth in late Summer was less than 68 cm, probability for dam construction was high, of it was more than 68 cm, dam building was unlikely. If a dam was constructed, water level rose on average 47 cm, indicating a risk for flooding if bank height was less than that. These results provide a simple tool to assess the probability of floodplain inundation by beaver dam building, that can help to identify where beavers may constitute a real risk for flooding in the densely populated Flemish landscape where often agriculture, houses and industry are situated close to rivers.

Poster Session 2 – Conservation and Ecosystem Services

98 The effect of urbanization on the growth indices and parasite infestation of wild brown rats, *Rattus norvegicus*

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Currently, urbanization has been blooming all over the world, especially in developing countries. The process of urbanization could not only alter the natural environments but also impact the life of urban animals. The brown rat (*Rattus norvegicus*) is commonly observed in both urban and rural areas, and it is reasonable to argue that there could be differences based on its living environment. To test this hypothesis, the body condition and parasite infestation of wild brown rats captured from urban and rural areas in Henan Province, China were analyzed. The results demonstrated that, 1) the urban brown rats showed bigger body length (urban: 18.8 ± 2.2 cm; rural: 16.9 ± 1.6 cm), heavier body mass (urban: 147.0 ± 51.2 g; rural: 105.1 ± 27.7 g), and higher body mass index (urban: 0.401 ± 0.067 g/cm²; rural: 0.360 ± 0.044 g/cm²) than that of the rural counterparts; 2) the cysts of *Taenia* sp. were found in the brown rats' liver, and the prevalence was 20.0% (5/25) in urban brown rats and 8.3% (2/24) in rural brown rats; 3) the blood parasite *Trypanosoma* sp. was observed in the brown rat, and the prevalence was 4.3% (1/21) in urban brown rats and 37.5% (9/24) in rural brown rats. Urbanization may affect the body condition through changing the food resources offered by human activities. Moreover, urbanization also could influence the life cycle of some parasites, therefore it could alter the infestation with these parasites. Therefore, increasing attention shall be put on investigating the relation between urbanization and urban wildlife. The study was financially supported by Undergraduate Training Project of Zhengzhou University (2016XJXM282).

Poster Session 2 – Conservation and Ecosystem Services

99 Intraspecific pilferage and pilferage avoidance in *Sciurotamias davidianus*

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Pilferage by conspecifics is one of the causes of food loss in food-hoarding animals. The reciprocal pilferage hypothesis states that animals keep high intensity of scatter hoarding under the conditions of high pilferage because they can compensate for food loss through pilfering from others, but it is not well tested by experimental evidence. *Sciurotamias davidianus* is a good model to test the reciprocal pilferage hypothesis because individuals live in solitary with overlapped home ranges and primarily hoard plant seeds in scatter. Here, we tracked seed-hoarding and pilferage (nuts of *Juglans regia*) between paired squirrels using far-infrared camera traps in a semi-natural enclosure (50 m × 40 m). We tested whether food loss through pilferage by other individuals could be compensated by pilfering from others (reciprocal pilferage hypothesis), harvesting from seed sources, or both of the two ways. We found that 1) caches animals pilfered from others were not different from those pilfered by other individuals, supporting the reciprocal pilferage hypothesis; 2) seeds animals harvested from the seed sources were more than those pilfered by others, suggesting that *Sciurotamias davidianus* tended to compete for food sources rather than to steal from others' stores, under the conditions of high pilferage; 3) total caches harvested from seed sources and pilfered from others was much more than food loss pilfered by other individuals, suggesting that food loss by pilferage can be compensated by competing for food sources and pilfering from others in *Sciurotamias davidianus*. We propose the pilferage-source compensation hypothesis and that scatter-hoarding animals compensate for food loss through pilfering others' food, and competing for food sources under the conditions of high pilferage.

Poster Session 2 – Conservation and Ecosystem Services

100 Manipulation of plants based on seed survival rates: complex spatial patterns delay seed retrieval in rodents

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Spatial heterogeneity is generally deemed a central causal factor influencing the physiology and behavior of animals in ecological systems. However, knowledge remains limited about how such patterns influence seed recovery by animals. We hypothesized that variation in spatial patterns benefits seed survival. To prove this hypothesis, we tested seed retrieval parameters by *Apodemus agrarius* and *Lasiopodomys brandtii* in different heterogeneous environments. Our results showed that seed retrieval time increased with increasing spatial heterogeneity. Furthermore, the frequency of invalid excavations was exponentially correlated with spatial heterogeneity. Finally, spatial heterogeneity significantly influenced the frequency heterogeneous objects were explored. Our results indicate that spatial heterogeneity significantly influences the foraging behavior of animals. Consequently, increased spatial heterogeneity will impair the seed retrieval success of rodents. In conclusion, this phenomenon might be an effective strategy of plants to manipulate the seed recovery rates of hoarders, which would ultimately enhance seed survival and the establishment of seedlings.

Poster Session 2 – Responses to Human-Induced Changes

101 Searching for signatures of genetic adaptation to climate in bank voles

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Temperature and patterns of precipitation are changing on a global scale. This has strong effects on many existing species, influencing the physiology, behavior and range of many populations. In contrast to these ecological effects of climate change, evolutionary responses to climate change are less well studied. With ongoing climate change, adaptation has recently become the focus of much ecological genomic research. Differences in climatic variables between environments influence the spatial distribution of phenotypic and genetic variation across a meta-population which can lead to local genetic adaptation. Thus, the detection of climate-mediated evolutionary responses can potentially shed light on the genetic basis of adaptation to climate change. Bank voles (*Myodes glareolus*) have a widespread distribution from western Europe into Scandinavia and western Russia, where they encounter a wide range of different climatic conditions. It is an important mammal species used to study the phylogeographic response of European fauna to climate change following the Last Glacial Maximum, but still little research has been done regarding adaptation to local climatic conditions in the bank vole. Therefore, the aim of our study is to uncover signatures of genetic adaptations to local climatic conditions among populations of bank voles. For this, we used a ddRAD sequencing approach and scanned the genome for signatures of genetic adaptations. Using this data, we report on population differentiation and the populations genetic structure of 14 bank vole populations distributed across Europe. By using a variety of tests we identify loci that are under putative selection showing a correlation between allele frequencies and climatic variation across the European continent.

Poster Session 2 – Response to Human Induced Changes

102 Association of rodents with man-made infrastructures and food waste in urban Singapore

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A previous rodent-trapping study at 16 high rise residential estates in Singapore demonstrated high levels of *Rattus norvegicus* activities in waste bin chambers that hold household waste discarded from the apartments. Situated on the ground level of apartment blocks, each chamber serves two columns of apartment blocks and is equipped with a floor trap which is connected to a network of sanitary lines that drains any waste water from the bin chambers. The rodents were observed to access bin chambers via damaged floor trap covers. Here we report a subsequent study on the activity and movement of rodents among the bin chambers and sanitary drain-lines. Passive infra-red hunting cameras were placed in bin chambers with rodent activities and adjacent inspection chambers to capture rodent activities. A capture-mark and release study was then conducted to track the movement of rodents in the sanitary-drain lines that serve the entire block of flats. During the 3 days of observations, the rodents were generally active from afternoon till early mornings, with spikes of activity recorded after lunch and dinner times of local residents. Our cameras did not detect movement of marked rodents to other infested bin chutes connected by the sanitary drain-line network. They were observed to move only between the bin chamber where they were caught and two closest inspection chambers, 2.5 m away. Further investigation with an industrial endoscope revealed that rodents were living in underground cavities below bin chambers with breached floor trap pipe. The study showed how rodents use man-made infrastructures to harbour and access food waste; and the importance of infrastructure design and maintenance in controlling the population of urban population of rodents.

Poster Session 2 – Response to Human Induced Changes

103 Personality dependent corridor use in a grassland species

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The effectivity of corridors connecting isolated patches has been investigated for more than three decades with animals of different species. It is already known that the presence and the properties of corridors are crucial for the species' dispersal and mobility in a landscape. But corridor use may also depend on the behavioural traits of its users. Animal personality, i.e. consistent among-individual differences in behaviour, might affect the space use in general, but also the usage of corridors. We investigated whether the width of grass stripes and the personality of the individual are important for the corridor use of common voles (*Microtus arvalis*). If so, corridors may allow passage only for a proportion of individuals in a population and may thus affect individual mobility and population gene flow. We studied movement behaviour of male common voles in experimental grassland corridors of different width (1 m and 3 m). Voles were tested with established behavioural tests to parametrise boldness and activity. Automated and hand VHF telemetry was used to observe the individual movement of the tested animals (N=34) and to determine whether the animal perceives the structure as a corridor. Results on movement will be discussed in relation to animal personality and corridor width to allow predictions of dispersal abilities of personality types in habitats with different degrees of fragmentation.

Poster Session 2 – Response to Human Induced Changes

104 Diet shift by livestock grazing shape the gut microbiota composition and co-occurrence networks in a local rodent species

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Gut microbes play key roles in maintaining physiological functions and health of their hosts. However, most studies on gut microbes are conducted in model systems under laboratory conditions. The response of gut microbiota to diet changes under field conditions has rarely been investigated. In this study, we utilize field and laboratory studies to test whether sheep grazing induces a diet shift and thus alters the gut microbiota of a small rodent species living in grassland. First, using a field enclosure experiment, we found that enclosures subjected to grazing were mostly dominated by *Cleistogenes squarrosa* (an unfavorable plant species for both sheep and voles), and that voles in grazing enclosures harbored gut communities with distinct microbial taxonomic composition and co-occurrence networks compared to those in control enclosures. Specifically, voles in grazing enclosures exhibited significantly lower abundances of *Firmicutes*, increased abundance of *Bacteroidetes*, and significant lower measurements of alpha diversity. PICRUSt analysis suggests a low mineral absorption capacity of the gut microbiome of voles from grazed enclosures. The microbiota from voles in the grazing enclosures had a smaller but more complex network with more positive interactions. We verified our findings using laboratory experiments where voles were exclusively fed either *Cleistogenes squarrosa*, *Stipa krylovii* or *Leymus chinensis*. We observed similar changes in the gut microbiome, confirming that the effects of sheep grazing on the gut microbiota of Brandt's voles were related to grazing-induced diet shifts. Our results provided evidence for a contribution of grazing-induced diet shift in changes of gut microbiota in Brandt's vole, which in turn may explain the negative interaction between large domestic herbivore and small rodents in the field.

Poster Session 2 – Response to Human Induced Changes

105 Small mammal richness and diversity in the changing landscape of central Italy

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Most research on small mammal decline has focused on limited spatial and temporal scales, especially for the Mediterranean region. To better understand this process, its causes and contexts, a broader spatio-temporal scale approach is needed. In our study we hypothesized that: I) small mammal assemblages are changed through time and that the primary cause is land use and climate change; II) the biodiversity indices of small mammals are related to landscape predictors, especially to a mosaic of natural and anthropogenically influenced habitats. We used a recent extensive dataset about distribution, abundance and traits of small mammals derived by common barn-owl (*Tyto alba*) pellets, covering a 30-year time span. Through a framework of linear models we assessed the relationship between small mammal diversity (richness, Shannon index and functional diversity) and landscape variables (land use and landscape metrics) for 21 small mammal species (10 *Rodentia* and 11 *Euliphotypla*) occurring in a 10,000 km² area in central Italy. We also explored the variation through time (1980 – 2017) of nine guilds (i.e. herbivore arboreal forager diurnal, herbivore ground forager diurnal, herbivore ground forager nocturnal, insectivore fossorial, insectivore ground forager diurnal, insectivore ground forager nocturnal, omnivore arboreal forager nocturnal, omnivore ground forager nocturnal, and omnivore ground forager diurnal) selected by a FMDA (factor analysis of mixed data) from 18 qualitative and quantitative functional traits. On a temporal scale, we found a significant decrease in richness and diversity for carnivore species, while omnivores increased significantly and herbivores did not show a trend throughout time. On a spatial scale, richness, diversity and functional diversity of small mammals were higher and positively related to heterogeneous landscape, especially in combination with land use coverage and spatial arrangement of patches affecting each diversity in different ways. Our study provided insights into the complexities of small mammal responses, with an emphasis on community-level changes and can serve as a foundation to predict shifts and trends for future scenarios.

Poster Session 2 – Response to Human Induced Changes

106 Multiple paternity in common hamster (*Cricetus cricetus*) from urban and suburban population

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The common hamster (*Cricetus cricetus*) over the past fifty years dramatically decline in wild. Along with this, it began actively to settle in the cities. Urban areas are characterized by special environmental conditions. Animals that inhabit the city demonstrate a variety of adaptations, led to breeding strategy changes. In this connection, it is interesting to compare their reproductive strategy in the city and in the wild. During three years, we studied the structure of the urban population of the common hamster in the Gagarin park (Simferopol, Russia) on the plot of 2.2 hectares. In April 2016, during the peak of breeding activity, we observed 5 mating groups simultaneously. Each one has included one female and up to five males. Chasing and mating of males with females occurred several times during 2–3 hours. These observations allowed us to suppose a multiple paternity possibility. In the spring, 2017 in the city Park we found a dead female at the last stage of pregnancy. Another dead pregnant female was found in Chisten'koe village (10 km apart Simferopol – agrophytocenosis habitat). Estimation of the population density by active burrows calculating has shown that in urban population of the common hamster the density is about 50 animals/ha that is at least 3 times higher as in Chisten'koe village ones. Samples of fifteen embryos and the mother from Gagarin park and of the female with eleven embryos from Chisten'koe were used for molecular-genetic analysis. Allelic composition of 10 microsatellite loci of nDNA, has shown that in the urban population we assumed at least 3 fathers of the litter and at least 2 fathers in the suburban habitat. Thus, for the first time, we have evidence for multiple paternity in *Cricetus cricetus* in the urban and as well as in wild habitats. The study was supported by RFBR grant 17-04-01061.

Poster Session 2 – Future Rodent Control Technologies

107 Evaluation on repellent effects of extracts from castor (*Ricinus communis* L.) for protecting maize seeds against multimammate rat (*Mastomys natalensis* Smith, 1834)

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A fractionation method was used to extract compounds from *Ricinus communis* L. seed using ethanol, hexane, dichloromethane and ethyl acetate solvents. Identification of bio-actives in each extract was done using thin layer chromatography. The extracts were then formulated into oil and powder forms and their repellent effects evaluated with *Mastomys natalensis* at Rodent Control Centre, Morogoro Tanzania. Each extract was dressed at concentrations of 20, 30 and 50 g/kg (for powder) and 20, 30 and 50 ml/kg of maize seed. Treated maize (200 seeds) was subjected in crucible to individually caged *Mastomys natalensis* in no choice experiments with five replications. Observations were made for four consecutive days where number of damaged maize seeds was daily recorded. Results revealed that there was significant difference between treatments (<0.00001) with lower damage observed in ethanol (CR) and dichloromethane (D) extracts. Regarding concentrations effects and form, 20 ml of CR-oil and 20 g of D-powder had significantly lower maize seed damage. Therefore, this study recommends the use of CR-oil and D-powder at level 20 g and ml, respectively, for dressing 1 kg of maize seeds before sowing to protect against *Mastomys natalensis* damage at germination stage. However, bioassay study was suggested to investigate whether the products have an effect on maize seed germination.

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6th International Conference of Rodent Biology and Management and 16th Rodens et Spatium

The joint meeting of the 6th International Conference of Rodent Biology and Management (ICRBM) and the 16th Rodens et Spatium (R&S) conference was held 3-7 September 2018 in Potsdam, Germany. It was organized by the Animal Ecology Group of the Institute of Biochemistry and Biology of the University of Potsdam, and the Vertebrate Research Group of the Institute for Plant Protection in Horticulture and Forests of the Julius Kühn Institute, Federal Research Centre for Cultivated Plants. Since the first meetings of R&S (1987) and ICRBM (1998), the congress in Potsdam was the first joint meeting of the two conferences that are held every four years (ICRBM) and every two years (R&S), respectively.

The meeting was an international forum for all involved in basic and applied rodent research. It provided a platform for exchange in various aspects including rodent behaviour, taxonomy, phylogeography, disease, management, genetics and population dynamics.

The intention of the meeting was to foster the interaction of international experts from academia, students, industry, authorities etc. specializing in different fields of applied and basic rodent research because thorough knowledge of all relevant aspects is a vital prerequisite to make informed decisions in research and application.

This book of abstracts summarizes almost 300 contributions that were presented in 9 symposia:

1) Rodent behaviour, 2) Form and function, 3) Responses to human-induced changes, 4) Rodent management, 5) Conservation and ecosystem services, 6) Taxonomy-genetics, 7) Population dynamics, 8) Phylogeography, 9) Future rodent control technologies and in the workshop "rodent-borne diseases".

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