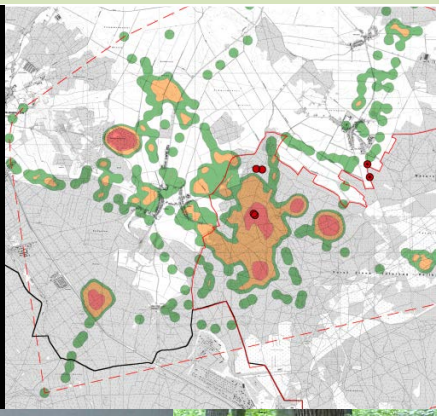
4th International Berlin Bat Meeting: Movement Ecology of Bats



Berlin,
13-15 March

2015

4th International Berlin Bat Meeting: Movement Ecology of Bats

Berlin, Germany, 13th – 15th of March 2015

Organised by

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FOREWORD

Because of powered flight, bats are one of the most mobile mammalian taxa, yet our understanding of their movement ecology and its implications for shaping biodiversity patterns is sketchy. This is mostly caused by the cryptic nature of bats and their small size, which limits technical applications that are widely used in other taxa. Recently, conventional or miniaturized GPS units are increasingly used on Chiroptera, and novel concepts triggered and strengthened a whole new research area, namely the study of movement ecology in bats. Movement ecology is now widely recognized as a highly relevant and rapidly developing research area. An improved understanding of bat movements is not only relevant to improve the conservation of endangered and protected species in anthropogenically influenced landscapes, but also to shed light on the origin and dynamics of recent zoonotic outbreaks. Besides, we have just started to understand how bats orientate and navigate, and what factors limit their capacity to travel far distances. We have invited you to attend the **4th International Berlin Bat Meeting** to discuss the '**Movement Ecology of Bats'**. This conference is part of a series of topical meetings that is organized by the batlab of the Leibniz Institute for Zoo and Wildlife Research (www.batlab.de). Past conferences have focused on a variety of themes, such as bat migration (1st IBBM in 2009), bats and infectious diseases (2nd IBBM in 2010) and bats in the anthropocene (3rd IBBM in 2013). We hope that you will find your visit to this conference and also to Berlin stimulating and pleasant.

This volume contains the contributions to the **4th IBBM**. The conference brings together more than 300 scientists and students from 32 countries with diverse and complementary backgrounds, such as researchers from universities and non-university research institutions, consultants, members of national and international non-governmental organizations and members of federal and governmental authorities. Oral and poster presentations cover a wide variety of topics related to the movement ecology of bats. Ultimately, the meeting would like to foster an exchange of ideas, introduce new methods and concepts to the field of movement ecology of bats and review what has been achieved in this research area so far.

The first section of this volume contains the abstracts of invited plenary speakers, followed by the abstracts of the 7 sessions. Contributions were solicited for the following topics:

- Movement ecology
- GPS based tracking of movements
- Morphological, physiological and sensory constraints of bat movements
- Sociality and bat movements
- Bat migration
- Moving bats and diseases
- The conservation of a highly mobile taxon

The abstracts in this volume are organized according to sessions. For each session abstracts of oral and poster presentations were listed separately, according to the

sequence of the speakers (oral presentations) or alphabetically (first author's name, poster presentations). All abstracts were printed as submitted. To help you find an abstract of interest we have included an index of authors and an index of keywords.

We thank Karin Sörgel, Karin Schneeberger and Sven Kühlmann for their significant contribution to the organization of this conference. We are grateful to the plenary speakers and chairpersons for their help in making the program highly attractive. We also thank Steffen Berthold, Dagmar Boras, Doris Fichte, Olga Heim, Sascha Hentschel, Yvonne Klaar, Linn Lehnert, Oliver Lindecke, Anja Luckner, Juliane Maaß, Manuel Roeleke, Julia Schad, Assja Schröder, Anke Schumann, Steven Seet, Anne Seltmann, Sara Troxell, Wolfgang Tauche and Silke Voigt-Heucke for all their assistance in the preparation of the conference and its scientific program. We are very grateful to the session organizers in putting together the program of their sessions. Finally, we are very grateful to the *German Research Council* (Deutsche Forschungsgemeinschaft) for supporting the conference financially, to *Eurobats* for general support of the meeting and financial support of selected speakers from East European countries. We would also like to draw your attention to the companies that display their products in brochures or at their stands to the participants of the 4th IBBM. We thank the *Federal Institute for Risk Assessment* (Bundesinstitut für Risikobewertung), the *Museum of Natural History in Berlin* (Museum für Naturkunde Berlin) for kindly providing the facilities for our conference and the banquet, respectively, and to the *Leibniz Institute for Zoo and Wildlife Research* (www.izw-berlin.de) for general support.

We hope that you will enjoy the scientific and social program of this meeting

Berlin, March 2015

Christian Voigt and *Stephanie Kramer-Schadt*

PLENARY TALKS

Plenary

Bat avionics and movement ecology

HOLDERIED MARC W.

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The term avionics is derived from the expression 'aviation electronics'. This field of engineering develops and provides systems for a wide variety of control, performance, communication and navigation tasks. Most importantly, it provides the integration in and optimization of all these tasks under the special constraints set by flight. So under the newly introduced term 'bat avionics' we can place all sensory and communication aspects that are influenced by and adapted to the special requirements of powered bat flight. For the context of this talk, bat avionics will concern how active sensing is interlinked with movement ecology. We will explore the spatio-temporal sensory and movement ecology from a theoretical framework and from descriptive and comparative field observations leading to bio-inspired modelling of the sensory ecology of bat movements. This will include exploring several aspects of movement ecology including discrete spatial perception and ranging, collision avoidance and habitat use, echo overlap and stochastic navigation, discrete flow perception, optimal spatio-temporal searches, and movement-generated Doppler shifts and FM bats.

Plenary

Studying navigation in bats: a field based approach

HOLLAND RICHARD

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Bats are famous for their nocturnal lifestyle and their ability to navigate and hunt using echolocation. However, evidence shows that outside a relatively short range, echolocation alone is not enough to allow them to return to their home roost. The question is, what cues do bats use to return from the long distance foraging trips or migratory journeys that they make? Surprisingly, until recently, the answer was: we don't know. This was in part because of the challenge in studying their behaviour in the field. However, since 2006, research by myself and my colleagues has revealed that bats are able to call on other "sixth senses" to navigate outside of the range of echolocation, including the earth's magnetic field and cues from the sunset. In this presentation I will discuss the theoretical background to bat navigation, the evidence for how they are able to navigate, and what is still to be learned.

Plenary

Active sensing guided movement unravelled by on-board GPS and ultrasonic recordings

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Bats are extreme aviator and amazing navigators. Studying them in the wild however has always been challenging because of their small size and agile nature. In the past three years we have developed the ability to GPS-tag small bats, thus opening a new window to study their movement. We equipped our miniature GPS tag with an ultrasonic microphone which allows monitoring the sonar and social communication of freely behaving wild bats. Because echolocating bats rely on sound emission to perceived their environment, recording audio on-board a bat enables us to tap into their sensory 'point of view' and infer their fundamental behaviours such as their foraging and their interactions with conspecifics. The task of inferring behaviour from movement is extremely difficult to do with non-echolocating wild animals and makes ideal models.
I will present results from three different studies demonstrate the power of GPS and audio monitoring: (1) I will discuss how a social bat species (*Rhinopoma microphyllum*) that searches for ephemeral prey benefits from a collective search. (2) I will compare two close (*Myotis*) bat species that exhibit very different foraging strategies, probably resulting from the nature of the prey they seek. (3) I will show a control-theory model which explains sensorimotor guidance in bat flight and will discuss its application in the field.
Finally I will present our current effort to include more on-board sensors for the study of bats' movement ecology including acceleration, EEG and more.

Plenary

The link between morphology, aerodynamics and movement ecology

SWARTZ SHARON

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Deep understanding of the links between morphology and motion has been surprisingly difficult to achieve. To connect anatomical structure to movement ecology will require an interdisciplinary effort of a kind that is only now evolving. This approach should aim to synthesize data from the level of cell and tissue level organization, through organ level structure and function, to the critical morphology and performance of whole organisms. Movement ecology can best make progress, then by effectively seeing to interpret an integrative view of organismal structure and specific locomotor performance and its ecological and phylogenetic context. I provide a case study of this approach by presenting a multi-level integrative view of intrinsic or intramembranous muscles of bat wings. First, I show that these muscles are distinctive among mammalian striated skeletal muscles: in all bat species we have examined to date, they lack spindles, connect to their attachment sites via tendons composed primarily of elastin surrounded by a collagen sleeve, and insert into their attachment sites in the dermal matrix by numerous fine collagen fibrils. At the whole organism level of organization, the plagiopatagiales proprii muscle groups varies in number of muscles and total muscle cross-sectional area among bats, independent of body mass. I show that over the phylogenetic diversification of bats, on average, the total cross-sectional area of this group of muscles has increased, and the number of muscles has increased notably in a few taxa. There have also been groups in which muscle size and/or number are reduced. Direct recordings of muscle electrical signals by electromyography (EMG) document the activity of these muscles during flight, and I show that the plagiopatagiales proprii display activity during the downstroke, which increases in magnitude with increasing forward speed. Additionally, multiple muscle bundles activate synchronously, suggesting that these muscle arrays function as a single distributed unit, and not as many small separate muscles activated independently by the bat motor control system. I demonstrate that activation of these muscles can modulate the stiffness of wing membrane skin, which, in turn, changes the aerodynamic characteristics of wings, such as lift/drag with respect to angle of attack. These aerodynamic traits, in turn, directly influence flight energetics, especially for animals that travel long distances or that employ very high speeds. Moving forward, improved understanding of the multi-scale functional architecture of bat wings can continue to enlighten understanding of the mechanistic basis of flight performance.

Plenary

Coordinated movements in bats: benefits and constraints

KERTH GERALD

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Coordinated movements are ubiquitous in nature because in most species group members benefit from coordinated actions. Examples include bacteria that coordinate their movement collectively, flocks of migrating birds that coordinate their locomotion, fish swarms that escape from predators, predators that hunt collectively, and bats that collectively move from roost to roost. I will introduce the benefits and constraints of collective movements using examples from different animal taxa, including bats. Because almost all bats live in groups for at least some part of their life cycle, they are particularly well suited for studying coordinated movements. Indeed, coordinated movements of bats have already been documented in several species, in particular during foraging and during roost-switching. I will report on our own work on collective movements, information transfer, and group decision-making about roosts in bats. In this context I will introduce the concept of fission-fusion dynamics and give an overview how social network analyses can be used to unravel the social structure in bat colonies and the movements of bats between roosts. I will conclude by outlining open questions and by presenting a few ideas on what kind of studies on coordinated movements in bats might be particularly rewarding in the future.

Plenary

Moving bats and diseases

FRICK WINIFRED, LANGWIG KATE, CHENG TINA, HOYT JOE, FOSTER JEFF, PARISE KATY, KILPATRICK MARM

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Disease ecology is tightly linked to movement ecology as movements of hosts and pathogens are important drivers of disease transmission and spread. Understanding movements of hosts and their pathogens at local and broad spatial scales is key to determining how disease is transmitted among individuals and spreads across landscapes. Bats are important hosts for a variety of pathogens, including many that cause high-profile zoonotic diseases as well as the fungal pathogen *Pseudogymnoascus destructans* that has killed millions of bats in North America in the past eight years. Studies on movements of bats, particularly movements that influence social contact rates and seasonal use of landscapes, provide excellent opportunities to understand how host movements influence disease transmission and spatial spread dynamics. In this talk, we show patterns of transmission and spread of *P. destructans*, the fungal pathogen that causes white-nose syndrome in hibernating bats. We show temporal progression and spatial variation in infection dynamics of this invading pathogen as it spread across half the North American continent. We also show how seasonality of bat movements and use of habitats is an important driver of disease dynamics. Integrating movement ecology into disease ecology will provide needed insights that will aid conservation decision-making for species impacted by this disease. For example, we still know relatively little about movements between summer maternity areas and winter hibernacula for many hibernating bat species. Determining the spatial scale of bat movements across landscapes and between seasons is needed to better estimate the impacts of disease mortality on regional populations. These lessons from white-nose syndrome address a bigger picture of how movement ecology is an integral part of understanding wildlife disease and its conservation implications.

Plenary

Bats and plants entangled in the web of life

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What consequence does the preference of *Carollia* bats for *Piper* fruits have for the mutualistic community formed by seed dispersers and plants in a rainforest? Questions like this one motivated my collaborators and I to investigate complex systems formed by bats and plants at different levels, from the individual to the community. We have been focusing on seed dispersal and pollination, and trying to integrate the network approach with naturalistic observation and experimentation. Our studies revealed hierarchical feeding preferences by phytophagous bats, which result in nested diets at the genus, species, and individual levels. Those hierarchical diets seem to have a profound effect on the effectiveness of bats as mutualists, and they seem also to affect the systems formed by bats and plants at the community level. Bat species of different genera show stronger interactions with their preferred food-plants, and they form modules within each local network. Despite those strong connections, even species with marked feeding preferences are connected to several secondary food-plants. Consequently, modules within bat-plant networks are sometimes bound to each other by ecologically specialized species that play the roles of either hubs or connectors. When analyzing mixed taxon networks, for instance with bats and birds together, we observed that modules composed of different taxa have different structure and dynamics. Nevertheless, despite those differences, the same prominent role of specialists was observed in different modules and across modules, which contradicts the current paradigm in network ecology. Dietary specialization showed to be more important than other ecological attributes. In a nutshell, ecological specialization at different hierarchical levels seems to be the main driving force structuring bat-plant networks, and the findings made so far suggest that most of their emergent properties remain yet to be unveiled.

ORAL PRESENTATIONS

SESSION I: MOVEMENT ECOLOGY OF BATS

Chairs: Stephanie Kramer-Schadt, Frieder Mayer

Airplane tracking of flight behavior of individual Brazilian free-tailed bats

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Bats have a well developed spatial memory. They remember feeding places or po The ~ 2 million Brazilian free-tailed bats that emerge and forage nightly from Frio Cave in Texas, USA, are known to have a nightly flight range of over 50 km and to feed at altitudes of at least 1200 m above ground level. Most information on the bats' dispersal, flight activity, and foraging behavior has relied on acoustic monitoring and radar observations of mass movements. Little is known of the movements and flight behavior of individual bats, and nothing of their response to winds or local meteorological conditions. The complete nightly flights of seven radio-tagged female Brazilian free-tailed bats were tracked from an aircraft on seven nights (1 bat/night) from emergence to return to roost. All bats emerged before dusk and flew continuously for 3 to 6+ hours. Radio-fixes of each bat's location were obtained approximately every 3 minutes throughout these flights. The net distances traveled by bats ranged from ~ 54 km to > 160 km. Bats adjusted flight speeds in response to prevailing winds by decreasing flight speed when flight direction is supported by winds, a strategy that optimizes energy use. Flight speeds increased in response to opposing winds. Motion variance analysis of flight trajectories indicates directional flight earlier and later in the flight period as the bats commute to and from the roost. During the mid-flight period directional flights are interspersed with apparent Brownian movements. These observations support the hypothesis that these bats move rapidly and graze within the aerosphere habitat to exploit patches of insects.

The air up there: reconstructing 3D foraging flights of the common noctule

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Bats are small and energetically limited, and many species are highly specialized in their ecological niche and corresponding morphology. Small-scale foraging movements of bats are difficult to follow and the radio-telemetry techniques that are typically used to study bats are limited to two-dimensional space. While this gives us information about home range size and habitat use, we have little idea of how bats use the full range of their three-dimensional spatial niche. We employed for the first time on bats newly developed radio transmitters whose signal encodes air temperature, air pressure (i.e., altitude), as well as wing beats. We equipped adult male common noctules (*Nyctalus noctula*), a narrow-winged species belonging to the guild of open-aerial foraging bats, and tracked them from the ground as well as with a Cessna 172 airplane between 3-5 nights each. We reconstruct altitudinal habitat selection, foraging and commuting, wing beat counts, and three dimensional flight paths. This allows us to come closer than ever before to sitting on the bat's shoulder and gain insight into the investment vs. return of a foraging flight in this most extreme guild in terms of investment into flight costs. Once established this method can be applied on other species as well as long-distance flights, such as migration – an urgently needed tool in the framework of contemporary discussions about windmills and bats.

Aerodynamics of manoeuvring flight in bats

HENNINGSSON PER, JAKOBSEN LASSE

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Research on animal aerodynamics to date has been largely focused on steady level forward flight. The reason for this is first of all simply because the level of complexity of wakes of flying animals is already under steady conditions challenging enough to analyse. In recent years the techniques used in aerodynamic research has been developed and the resolution of the aerodynamic tracks we are able to record and reconstruct has been greatly improved – both temporally and spatially. Today we are able to start dissecting the wakes behind flying animals to a degree where we can disentangle small wake features and examine their dynamics by capturing multiple instantaneous measurements within each wingbeat. Because of this it is now possible to analyse how animals generate manoeuvers through difference in timing and magnitude of forces generated by the two wings dynamically through the wingbeat.

In the daily life of any flying animal, manoeuvring is something that is ever present; predators pursuing prey, prey avoiding predator, coping with gusty winds, flying through cluttered environment, and so on. For bats catching insect prey on the wing, this is something that the animals perform constantly and therefore the way they create their manoeuvers and what it cost for them to do so, is of utmost importance to their biology and ecology.

Here we present the results from the first ever study to explicitly explore the aerodynamics of a manoeuvring flying animal. We performed a set of experiments on Brown long-eared bats (*Plecotus auritus*) flying in a wind tunnel and used time-resolved stereo particle image velocimetry (PIV) to capture the wake generated by the bats, both as they flew steadily at cruising speed and as they were performing lateral manoeuvres. To encourage the bats to perform the manoeuvers we laterally translated a thin metal sting holding a mealworm at the instant just before the bat approached its prey. This resulted in three different phases captured within each recording sequence; (i) initiation of the manoeuver, (ii) execution of the manoeuver, and finally (iii) termination of the manoeuver and stabilization. We discuss the results in the context of flight performance and the added cost of flight as a consequence of the manoeuvres.

Using acoustic flight path reconstruction to distinguish foraging and commuting behaviour, then predicting it a posteriori from call features

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Acoustic recording have been more and more widely used to assess bat ecology, especially their space use. However, almost all recordings are performed with single microphones, giving only local measures of activity and no information on flight position and path, thus limiting our possibilities to study bat movement ecology on a large scale. To circumvent this limitation, some call features have sometimes been used as a proxy of flight behaviour (commuting vs. foraging), but these models are simplistic (often based solely on bandwidth and rythm) and, to our knowledge, have never been validated on ground truth.
Here, we used several hundreds of bat flight paths of 4 species, reconstructed through 4-microphones array recordings to model flight behaviour. First, we classified these flight path in two clusters on the basis of measures of flight speed and sinuosity, since commuting flights were already known to be faster and more direct than foraging flights. Secondly, we used 116 call features measured on all flight paths to build a predictive model of bat flight behaviour that could be applied on common recordings made with single microphones. This kind of model have the advantages of (1) providing objective assessment of individual behaviour and (2) efficiently differentiating commuting flight from foraging flight. Since currently measured bat activities are dominated by foraging behaviour impeding the ability to study commuting behaviour and bat movements, we anticipate that the use of these models will give new insights on bat space use.

Seasonal variation in foraging movements determines seed dispersal distances by straw-coloured fruit bats (*Eidolon helvum*) in tropical African landscapes

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Fruit bats are increasingly recognized for their vital ecological and economic roles for seed dispersal and pollination services of a diversity of plants across varied ecosystems. Large colonies of straw-coloured fruit bats, *Eidolon helvum*, migrate great distances across Africa, likely in response to seasonal fluctuations in food availability. However, it is largely unknown how changes in food availability influence local bat foraging patterns and in turn influence seed dispersal distances in these seasonal landscapes. We used combined GPS- and accelerometer-loggers in conjunction with phenology and remote sensing data to quantify bat foraging patterns of *E. helvum* colonies located in urban and rural landscapes. We estimated seed dispersal distances for fruit trees whose seeds were either ingested (small seeds) or ejected (both small and large seeds) by combining food handling and gut passage times of bats with their foraging movements. For the first time, we show that foraging *E. helvum* roost alone in foraging areas away from colony day roosts, probably in response to low food availability. Food resources showed pronounced seasonal fluctuations and differences among landscapes, and probably influenced local foraging movement patterns of *E. helvum*. Further, like many other pteropodids, *E. helvum* appears to be a sequential specialist that tracks food species within and between seasonal landscapes. We postulate that foraging patterns and their resulting influence on seed dispersal distances are driven mostly by the fluctuations in food availability.

Variation of spatial activity of different populations of *Rousettus aegyptiacus* living at distribution range margins

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Western Palearctic populations of the Egyptian fruit bat (*Rousettus aegyptiacus*) represent the northernmost offshoot of pteropodid bats which otherwise occur in tropical regions of Old World. Given their obligate frugivory and inability to hibernate, they are active year-round and hence, a question arises about the effect of profound climatic seasonality on the pattern of their spatial activity. By using standard and automatic telemetry, we studied three populations of *R.aegyptiacus* living at species distributional limits and under different settings of environmental conditions: an isolated and decreasing island population on Cyprus, numerous and well prospering population in southern Turkey and an isolated population living in a large desert oasis (Dakhla, Western Desert, Egypt).
Based on radio-tracking of 184 individual fruit bats (Cyprus 43, Turkey 69, Egypt 72) of both sexes we compared summer and winter spatial activity (home-range size, core-feeding area size, number of feeding sites) and habitat use as related to food offer. We found no sex-mediated differences in spatial activity in any population. However, the studied populations markedly differed in the size of MCP and core feeding areas as well as in the seasonal pattern of spatial activity. Smallest home ranges and core feeding areas were found in bats from the desert oasis, intermediate in Turkish study population and largest ones had bats in Cyprus. No seasonal differences in the size of home range and core-feeding area existed in the desert population, but it changed between summer and winter in the two other study populations. While fruit bats in Cyprus markedly increased their home-range and core feeding area between summer and winter period, Turkish population showed right the opposite pattern. Further, there were inter-population and seasonal

differences in the number of feeding sites visited by individual bats. While Cypriot fruit bats visited very few feeding sites (≤2 on average, no seasonal differences), Turkish fruit bats visited many more (mean = 7) feeding sites in winter than in summer. In contrast, fruit bats in the desert visited fewer sites (mean = 1) in winter than in summer (mean = 3). In all three regions, bats visited sites with higher density and/or diversity of food than by random. Overall, major observed inter-population differences in space-use of *R.eagyptiacus* refer to regional specificities in spatio-temporal distribution of food resources. Last but not least, our data demonstrate extreme ecological plasticity and adaptability of *R.aegyptiacus* which probably enabled that species colonize regions with relatively harsh conditions for a tropical bat.

Elucidating animal foraging in heterogeneous landscapes: the importance of detailed quantification of resource distribution and movement, illustrated by the Egyptian fruit bat

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Resource distribution plays a key role in determining the movement and distribution of foraging animals in heterogeneous landscapes. Optimal foragers are expected to maximize their food intake in relation to the cost and risk of movement. We studied the foraging movements of the Egyptian fruit bat (*Rousettus aegyptiacus*) in relation to the spatially explicit distribution of its food resources in a heterogeneous landscape. More specifically, we examined the extent to which the foraging movement corresponds to simple predictions of optimal foraging and ideal free distribution theories. By using a spatially explicit empirical model, we also examined the mechanisms by which bats optimize their foraging movement.

Egyptian fruit bats captured when exiting their roosting cave after sunset were equipped with a GPS (N=22) or a radio telemetry (N=26) tracking device, released near their roost and tracked for up to 11 weeks. The GPS tags provided flight tracks of free-ranging wild bats in unprecedentedly high spatial and temporal resolutions, providing the means to compare their spatial foraging patterns to the corresponding distribution of over 6.3 million fruit trees mapped in the entire foraging landscape.

We found that bats exhibit a distinct foraging pattern of a long (12 – 25 km), fast (median speed, 9.28 m/s), high (median altitude a.g.l., 103.8 m) and straight (median straightness index, 0.92) flight path directly to a specific fruit tree, followed by local foraging nearby, and repeatedly return to the same favourite tree night after night. Such a foraging pattern was counterintuitive due to the presence of numerous alternative trees with similar ripe fruit closer to the roost. To address this puzzle, we compared foraging movements to the spatial variation of site attractiveness, a simple measure combining the basic gains (fruit trees) and costs (distance from the roost) of foraging at each 1 km^2 cell in the landscape. Bats selected sites that are highly attractive compared to random sites, and that are significantly more attractive than sites closest to the roost containing trees of the same species and ripeness. Furthermore, the spatial distribution of foraging sites was similar to the distribution of fruit trees in the landscape, in accordance to the null model predictions of the ideal free distribution theory. We conclude that accurate and detailed quantification of resource distribution and movement can explain seemingly counterintuitive foraging patterns, suggesting that fruit bats follow simple optimal foraging principles. Social and energetic factors may account for the favourite tree phenomenon.

Using multiple methods to investigate movements of Nathusius' pipistrelle in the UK

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Migration patterns of Nathusius' pipistrelle (*Pipistrellus nathusii*) are relatively well studied in mainland Europe but the movements of bats in and out of the UK, their migration routes and origins are not known. This lack of knowledge means that we are currently unable to assess the conservation impacts of development such as onshore and offshore wind energy generation on this species. We ran a pilot citizen science project in 2014 to trial methods using highly trained volunteers to assess the status and migratory activity of Nathusius' pipistrelle from spring to autumn at inland water bodies across England. Animals were captured using harp traps in conjunction with an acoustic lure, their breeding status was assessed, and samples of dorsal fur were obtained. We compared the stable isotope profiles from samples obtained at different times of year, and also compared the Nathusius' pipistrelle profiles with those obtained from fur samples of other pipistrelle species presumed to be sedentary in the UK. Finally, we installed bat detectors on two ferries operating on routes between South West England, France, Spain and Ireland in 2013 and 2014. The bat detectors produced the first known recordings of Nathusius' pipistrelle in the English Channel and, together with the recovery of a banded bat from England in The Netherlands, provide definitive evidence of the migratory status of this species in the UK. The results of this pilot will help to improve our knowledge of and threats to populations of this species and to develop a protocol for a national citizen science study of the status and migratory patterns of Nathusius' pipistrelle.

SESSION II: GPS-BASED TRACKING OF BAT MOVEMENTS

Chairs: Ran Nathan Israel, Dina Dechmann

GPS-tracking of Lyle's flying fox (*Pteropus lylei*; Pteropodidae) in an anthropogenic landscape in central Thailand

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The significant ecological role of flying foxes as seed dispersers and pollinators is increasingly recognized by the global research and conservation community, as are threats to their populations from human activities. Basic aspects of their movement ecology are yet unknown, but crucial to develop effective conservation strategies and appropriate landscape management. Our study investigates movement and foraging patterns of Lyle's flying fox (*Pteropus lylei*) in an anthropogenic landscape in Thailand, using high-resolution GPS loggers. We obtained detailed spatio-temporal data on the movements of 19 individuals of Lyle's flying fox foraging in a landscape dominated by human land use. We assessed foraging habitats and diet for individuals captured at two roost sites in temples during two different seasons. Individuals commuted between day roosts and foraging areas each night, followed by small-scale movements in foraging areas. Site-fidelity was high during the study period. Tracked bats mostly foraged in farmland, plantations and gardens, but small mangrove remnants constituted important habitat components for Lyle's flying fox. We documented a highly diverse diet of 34 food plant species, comprised of exotic crops and native plants. Our results suggest that remaining native trees and natural vegetation in the study area represent important resources for Lyle's flying fox, and that their preservation might reduce human-wildlife conflicts in relation to perceived crop-raiding by bats. Given the potential role of flying foxes in the transmission of zoonotic diseases, our data can inform epidemiologists about contact points between humans and flying foxes. Our findings can further assist public information campaigns targeting the benefits of flying foxes as disperser of useful plants and the human health risk associated with hunting and consumption of these bats.

Loyal rural bats vs. adventurous city bats - a GPS study of foraging of city and rural fruit bat colonies

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The on-going massive growth of urban areas has resulted in the replacement of original natural habitats and in colonizing of cities by wild animals. When animals colonize cities they often have to adapt their physiology and behaviour to the novel environment. Songbirds for example sing louder or use higher frequencies in cities in comparison to their conspecifics in forests. Little is known on how urbanization affects animals' foraging and almost nothing is known on how it affects the foraging behaviour of bats.
We equipped Egyptian fruit-bats (*Rousettus aegyptiacus*) from both urban and rural colonies with on board miniature GPS units and recorded their 3D position over many nights. Flight trajectories of bats in the city and bats from the rural village revealed very different foraging patterns.
We found that in contrast to rural bats that spend the entire night at one distant foraging site, urban bats visited many foraging sites along the same night. We also found that urban bats often switch their foraging sites, visiting different sites on consecutive nights while rural bats are extremely loyal to the same foraging site flying to it night after night for long periods. Current work aims to reveal the reasons for these differences which might be related to food availability or to difference in sociality.

How foraging bats deal with wind - a GPS study

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The movement of flying animals is highly influenced by the airflow around them. Almost all previous studies investigated the influence of wind on migrating birds, examining wind and movement over wide spatial scales and in relatively large animal models. Recent technological advancements now allow measuring the effects of wind on increasingly smaller animals, and in smaller movement scales such as during daily commute flights or foraging behaviour. Currently, little is known about how wind affects foraging and commuting in birds, and its effects on bat movement is almost unknown.
Using a novel system, which combines a miniature GPS device and a synchronized ultrasonic microphone, we investigated the influence of wind on daily commute flights and foraging in two bat species: *Rhinopoma microphyllum*, an insectivorous species which forages over ground in Northern Israel and *Myotis vivesi*, a fish-eating bat, that forages in the sea in Baja California of NW Mexico. Wind data was simulated using the RAMS model, providing wind information with high spatial and temporal resolution (250 m^2 every 5 minutes).
We found that both species compensate for an increase in wind speed by increasing their air speed. Compensation in both species increased as the wind's angle in relation to heading increased. We show that bats respond differently to wind when commuting to their foraging sites or when foraging. We also found that bats actively prefer to forage in areas with low wind speed. The similar response of both species (one of which flies over sea and cannot rely on visual cues) suggests an internal mechanism to sense and respond to airflow.

GPS tracking reveals the potential importance of fruit bats for forest regeneration in Madagascar

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Seed dispersal plays significant role in the regeneration and maintenance of forests. Among vertebrate dispersers, fruit bats are often cited as effective long-distance seed dispersers due to their large home ranges and ability to disperse seeds when flying. Although a number of earlier studies have investigated the fate of bat-dispersed seeds, our understanding of the subject is limited. This study integrates several aspects of *P. rufus* behaviour to evaluate the role of this bat species in the maintenance and regeneration of Madagascar's forests. We tested germination success of over 18,000 sterilized and unsterilized seeds of *Ficus polita* and *F. grevei* extracted from bat faeces and ripe fruits under progressively more natural conditions. Additionally, through captive feeding trials and GPS tracking, seed shadow maps were created to visualize seed dispersal patterns that arise from the movement patterns of the bats. We found that *P. rufus* increase germination success of ingested seeds. When feeding in captivity, they have short gut retention times (GRTs) (estimated at 12 min) but are sometimes able to retain seeds for over 24 h. They produced extensive seed shadow webs when feeding on figs within their large forging areas. They dispersed fig seeds in a variety of habitats and over large distances from the feeding tree (up to 20 km). Because figs are important pioneer species, *P. rufus* is an important dispersal vector that potentially makes important contributions to the regeneration and maintenance of highly fragmented forest patches in Madagascar.

The ATLAS system and its potential contribution for studying movement ecology of bats

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The study of animal movement demands an ability to track the journeys of free-ranging animals in the wild, yet practical difficulties have long made movement ecology a data-poor discipline. Global satellite navigation systems (especially GPS) have dramatically increased the availability and accuracy of wildlife movement data over the last decade, but inherent physical and technological barriers still limit GPS (and other) tracking techniques to relatively low volume datasets. Today, GPS tracking is feasible only for relatively large-bodied species, whereas the vast majority of animal species are too small to be tracked by GPS devices. This general state of affairs is well pronounced for flying vertebrates, and especially for bats.

Reverse GPS is a promising wildlife-tracking technology that can complement GPS tracking and deliver very large amounts of tracking data on many animal species including rather small bats. We developed such system, called Advanced Tracking and Localization of Animal in real-life Systems (ATLAS), which allows for accurate tracking in high sampling frequency at the regional/landscape scale (a few to tens of kilometres) within which many animals spend substantial parts of their life. The system uses lightweight (≥1.0 g) tags, much lighter than equivalent GPS tags, and multiple animals can simultaneously be tracked. As such, ATLAS offers unique opportunities to explore key data-limited topics such as various interactions – inter- and intra-specific, social, familial and genetic ones, collective movements and animal-environment relationships – at the fine spatial and temporal resolution needed to divulge these interactions.

In this talk, we will present the ATLAS system and illustrate its potential to advance movement ecology research on bats and birds. We have established the first prototype of this system at the Hula Valley (northern Israel), a relatively flat and open landscape surrounded by highlands, hence favourable for localization by reverse GPS. The Valley holds the only wetland in Israel and one of very few in the Middle East, with two protected areas (Hula Nature Reserve and Agamon Hula), and rich wildlife diversity providing ample opportunities for ecological research. We have already obtained large datasets for a few bird species, and plan to explore foraging patterns and social interactions among Egyptian Fruit Bats (*Rousettus aegyptiacus*) in the near future. In the longer term, we plan to track small insectivorous bats such as *Rhinopoma microphyllum*, to study collective movement as these bats swarm out of their caves and commute to their foraging sites within the ATLAS coverage area.

SESSION III: MORPHOLOGICAL, SENSORICAL AND PHYSIOLOGICAL CONSTRAINTS OF BAT MOVEMENTS

Chairs: Holger Goerlitz, Marc Holderied

Movement as a part of the sensing strategy for maximising foraging efficiency

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The most obvious function of predator movement is prey capture. Equally important for foraging success, but poorly understood, is the role of movement in prey search. During prey search, movement is a part of the strategy to sample the environment. Foraging efficiency measured as net energy intake rate and consequently animal fitness depend on this strategy. Here I use a theoretical approach to test whether echolocation pattern and flight speed of aerial-hawking bats are adapted to maximise the foraging efficiency. By computing search volume for flying bats and metabolic costs of flight and vocalisation, I expressed the net energy intake rate as a function of five parameters: flight speed, maximum detection angle, maximum detection distance, pulse duration and interpulse interval. I then used mathematical optimisation to find the combinations of these parameters that maximise foraging efficiency in different prey densities. The results show that under low prey densities typically experienced by bats in the open space, it is optimal to use high flight speed and maximum detection distance, as well as long pulse duration and interpulse interval. This matches the strategy of bats that forage in such habitats. Currently we do not know how broad detection beams bats use. My model predicts that it is optimal to use a very wide angle in the open space, around 180°, irrespective of the prey density. I conclude that economy of foraging is an accurate novel explanation for echolocation and movement patterns of bats.

Sympatric horseshoe bats differ in flight performance in confined space

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In south Eastern Europe all five European horseshoe bat species occur sympatrically, and are presumed to compete for insects during periods of low insect abundance. They are known to forage within or close to vegetation within woodlands. In this habitat, manoeuvrable flight is essential for effective prey pursuit and avoiding collisions with vegetation. We hypothesized that resource partitioning in these species is affected by differences in their morphology and ability to manoeuvre within dense vegetation and tested 2 - 6 individuals of each species in an obstacle course simulating vegetation of different density. Then we related the manoeuvrability performance with measurements and ratios of body size and wing morphology.
The five species differed mainly in their overall size, although there was overlap among the intermediate-sized species for some variables (armwing area, the tail length, tail area, body length and body area). Smaller species performed better than the larger species in the obstacle experiment, with the exception of *Rhinolophus blasii*. Although *R. blasii* is the second smallest bat it performed only as well as the second largest bat *Rhinolophus mehelyi*. The manoeuvrability performance of all species improved throughout the experiment, but not within consecutive trials. When relating the manoeuvrability performance with morphometric measurements we found that body length seemed to play a major role. When comparing the intermediate species only, the wing tip length ratio and aspect ratio seemed to play a more important role.
We conclude that in regard to manoeuvrability the smallest species *R. hipposideros* and the middle-sized species *R. euryale* are best adapted to forage within dense vegetation. The species *R. blasii*, *R. mehelyi* and *R.ferrumequinum* seem less well adapted to forage in dense vegetation. However the differences found between the five species are small and compared to other species all are very well adapted to forage within vegetation. In a similar experiment with greater and lesser mouse-eared bats, both species performed poorer than all five horseshoe bat species. Furthermore the importance of the body length for the manoeuvrability performance seems to be a more general phenomenon, since similar results were found in the study on mouse-eared bats.

The aerodynamic cost of echolocation – flying with big ears.

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Comparisons between bat and bird aerodynamics have found birds to be more efficient flyers. One possible explanation for this is the fact that the bodies of flying bats contribute to lift production to a lesser degree than those of birds. Bat bodies are less streamlined than those of birds, and especially the heads of bats appear to be less than ideally shaped with regards to aerodynamics. Bats have relatively larger heads compared to birds. Additionally, bats are endowed with external ears and nose leafs protruding from the head and intercepting air flow likely adding significantly to the parasite drag of the animal as well as limiting its ability to efficiently generate aerodynamic lift. We performed tomographic particle image measurements of freely flying *Plecotus auritus* in the Lund University low-turbulence windtunnel. Here we present quantitative data for the aerodynamic consequences of flying with large ears in *Plecotus auritus*, as well as the wake structure resulting from the ears. The ears of *P. auritus* were found to produce significant aerodynamic drag distinguishable from the rest of the body drag. Ear and tail morphology has been found to correlate with foraging style and flight style in bats. *P. auritus* is a gleaning bat, meaning it feeds by flying slowly or hovering while picking insects from foliage. Commuting bats, in contrast, feed by flying between patches of food such as nectar flowers, and in general have much smaller ears than gleaning bats. Comparing the measurements of *P. auritus* with similar measurements performed on a commuting bat with significantly smaller ears than *P. auritus* show the commuting bat to produce less ear drag, indistinguishable from the rest of the body. Our results thus indicate an aerodynamic cost related to the size of ears in bats.

Ear movements for dynamic sonar processing in orienting fruit bats

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The common belief is that Egyptian fruit-bats (*Rousettus aegyptiacus*) rely on (lingual) echolocation only in caves and use vision when navigating outside. To test this, we equipped wild bats with on board miniature GPS and ultrasonic microphones and found that these bats regularly use echolocation when flying near trees even in relatively high light levels. The accurate ranging information provided by echolocation is probably important for these bats when landing on branches even when they can use vision.
Pervious research on echolocation mostly focused on different aspects of its transmission such as the echolocation signal design. Bats' receivers (the ears) have received less attention despite their crucial role in sonar-based sensing. Many bats, including Egyptian fruit-bats are known to move their ears while flying, but there is no clear understanding of the function of these movements.
In the laboratory we used a highly advanced tracking system which includes 16 high speed tracking cameras allowing 0.1mm tracking accuracy together with synchronized audio recordings. We studied pinnae movements of fruit-bats during flight sessions toward a landing platform under different ambient noise levels. Our system enabled accurate reconstruction of the bats' ear posture on the exact moment of the arrival of the echo.
Using 3D printing, we reconstructed the bats' head related transfer function (HRTF) which enabled us to explain the ear posture during the approach under different noise levels. This proved that Egyptian fruit-bats optimize SNR via ear movements and adjust their movements according to ambient noise.

SESSION IV: MIGRATION OF BATS

Chairs: Liam McGuire, Anders Hedenström

Aggregation of migratory bats to the coastline of the Northern Baltic Sea

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In Northern Europe the coastline of the Baltic Sea is the most important pathway for migratory bats. During the early 21st century regular observations of many long-distance migrants have also been made along the Finnish coastline in the Northern Baltic Sea. In Finland quite a few studies on migratory bats have so far been made, why rather little is still known about their overall distribution and relative abundance on areas further away from the Baltic Sea coastline. In this study we compared the acoustic activity of the Nathusius' pipistrelle (*Pipistrellus nathusii*) between the coastal and inland sites in Satakunta region (SW Finland, 61.5−61.9 °N). In the three-year project (2012−2014) data was collected from 38 sites, which were located either along the coastline of the Baltic Sea (n=16) and to the shallow lakes 4−35 kilometres inland (n=22). In each site the acoustic activity of bats was monitored from early May to the end of September using automated ultrasonic detectors (SM2/Anabat). Significantly higher activity of *P. nathusii* was observed in the sites located on the coastline of the Baltic Sea. The difference between the coastal and inland sites gives support for the hypotheses that migratory bats aggregate to the coastal zone also in the Northern Baltic Sea. However, in SW Finland the distribution of *P. nathusii* is not limited only to the coastal zone, but the species was regularly found as far as 35 kilometres away from the coastline. Further inland the observations were, however, more scattered and no aggregations typical for the coastal sites were found.

Massive bat migration across the Alps: implications for wind energy development

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For the last two decades, the installation of wind parks in Europe has been accelerated to reach the ambitious targets of the energy turnaround and to combat climate change. Especially hill tops, ridges and alpine passes are benefited from continuous winds. Therefore, remote sites throughout the European Alps are increasingly suggested for wind parks in order to harbour the extensive winds and to concurrently avoid conflicts near human settlements and restricted protected areas in the lowlands. It is well known that myriads of migrating birds regularly cross the Alps in spring and autumn. Many discoveries of marked bats point to the fact that they cross Europe, but the phenology and flight routes of migrating bats are still obscure. In this study, within the framework of an international cooperation throughout the European Alps, we aimed to undertake long-term observations of bats to better understand the seasonal occurrence of local and migrating bat species.

We conducted continuous acoustic monitoring using broadband ultrasound recorders on towers, in the nacelle of wind turbines and on the ground from spring to autumn. A dozen recording sites were distributed across the Alps in Austria, Germany and Switzerland, including control sites in the lowlands.

We found a regular presence of bats at sites up to 2500 m ASL, surprisingly high bat species richness at many alpine sites, including both, local and migratory species. While there was a high variability between the sites, we recorded peaks with massive migration especially during a few weeks in autumn. At some valleys and passes in the Alps hundreds of bat sequences were recorded in single nights,

indicating that many thousands of bats were crossing the perimeter of a wind park in the course of the season.
Our results clearly demonstrate that the Alps are regularly used for foraging by local bats and as seasonal routes through Europe by migrating bats. We strongly recommend to carefully monitor planned wind energy sites in the Alps, including those in valleys and on alpine passes, and to implement appropriate mitigation measures to protect the threatened bat species.

Stable isotope analysis reveals flexible breeding and migratory strategies in Iberian populations of the bat *Nyctalus leisleri*

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Nyctalus leisleri is one of the few bat species in Europe for which long-distance migrations of over 1000 km in one direction have been reported. Anecdotic information on recaptured banded bats has shown that the Iberian Peninsula is a wintering site of migrant *N. leisleri* breeding in Central Europe. However, the region also hosts sedentary populations of the species, with sexual segregation at regional or local scales likely occurring at some sites. We used stable hydrogen isotope analysis to test hypotheses on site-specific and sex-biased migratory strategies of *N. leisleri* populations across the Iberian Peninsula. We corroborated previous findings based on seasonal occurrence data that different breeding and migratory strategies coexist in the Iberian Peninsula, with female-biased long-distance migration in northeastern Spain (Catalonia and Navarra), and sedentary populations with regional or local segregation of males and females, and possibly migrations in elevation, in northern, central and southern Spain. Migratory behavior seems to be flexible, with marked individual differences occurring within populations. Our results on the breeding origins of Iberian *N. leisleri* populations have important conservation implications, since the species is victim to high numbers of fatalities at wind energy facilities, and an alarming number of turbines are located in the vicinity of the bat populations studied, possibly interjecting migratory pathways.

Using carbon and nitrogen stable isotope signatures in bat fur to make inferences on regional migration

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Migratory patterns of bats are not well understood and traditional methods to study these, like mark-recapture, often do not provide enough detail. Stable isotope profiles of many animal species have been studied to make inferences on migration. *Myotis lucifugus* and *M. septentrionalis* migrate every year from summering roosts to swarming sites in the fall, but how bats move between these sites is not well understood. In this study, carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes of 305 *M. lucifugus* and 200 *M. septentrionalis* fur samples were analyzed to make inferences on migration patterns between summering and swarming sites in Nova Scotia, Canada. We expected that there would be greater variability in $\delta^{13}C$ and $\delta^{15}N$ among individuals at swarming sites because it was believed that these sites are used by individuals originating from many summering sites. There was extensive overlap in the standard ellipse area (SEA_c) of bats at swarming sites, whereas there was much less overlap in SEA_c among summering sites. For *M. lucifugus*, swarming sites had larger SEA_c than summering sites and discriminant analysis assigned swarming bats to several summering sites. *Myotis septentrionalis'* SEA_c was much smaller than *M. lucifugus* indicating a more narrow dietary niche breadth. Isotopic profiles of *M. lucifugus* varied among summering sites and the data support the contention that swarming sites are catchment areas for bats from multiple summering sites. These data suggest that $\delta^{13}C$ and $\delta^{15}N$ profiling of bat fur offer potential to make inference on regional migration in bats.

Trans-boundary origin of noctule bats killed at wind turbines in Germany

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The rapid expansion of wind energy in many European and North American countries is widely recognized as an environmentally friendly alternative to conventional energy production, but may come at high costs for bats dying at wind turbines. Here we studied the geographical origin of noctule bats (*Nyctalus noctula*) killed at wind turbines in eastern Germany to illuminate the spatial range at which populations of endangered bat species might be affected by operating wind turbines. Therefore, we investigated carcasses of noctule bats (n=136) found below wind turbines applying a three-step approach that combined 1) the measurement of stable isotope ratios of non-exchangeable hydrogen in fur keratin of bat carcasses to categorize individuals as migratory or sedentary, 2) a linear mixed-effects model to identify temporal, spatial and biological factors explaining the variance in the measured stable hydrogen ratios and 3) isoscape origin models to determine the geographical breeding provenance of the migratory individuals. We found that the majority of the casualties were of local or regional origin, while 28% were identified as long-distance migrants, hence documenting that bat fatalities at wind turbines in Germany may affect local as well as distant populations. Furthermore, we recorded a relatively high proportion of females among the migratory specimen and observed more juveniles than adults among the local individuals indicating that the vulnerability towards lethal accidents at wind turbines is sex and age-specific. Migratory *N. noctula* were found to originate from distant populations in the Northern and Northeastern parts of Europe. Here, sex specific differences in the breeding provenance were detected, with the geographical range projected for the origin of female bats extending further to the North and Northeast than for males. The large numbers of endangered bats killed annually at European wind energy facilities call for immediate action to reduce detrimental effects on local as well as distant source populations. This study highlights the importance of implementing effective mitigation measures as well as developing species and scale-specific conservation approaches on an international level. The efficacy of local compensatory measures such as the installation of artificial roost boxes appears doubtful, at least for migratory noctule bats, considering the large geographical catchment areas of German wind turbines for this species.

Stopover ecology of spring migrating silver-haired bats

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Recent research has have begun to provide important insights into the origins and destinations of migratory bats, but fewer studies have examined how bats budget their time and energy en-route. Previous work in our lab found that during fall migration silver-haired bats (*Lasionycteris noctivagans*) use a torpor assisted migration strategy, which dramatically reduces daytime thermoregulatory costs, increases net refueling rate, and facilitates very brief stopovers. Spring and fall migration pose different challenges. The concurrence of migration and pregnancy in the spring creates a conflict for female bats. Daily torpor use will spare energy stores for migratory flight, but may delay fetal development. Thus, sex may substantially affect the energy and time management of spring migrants in ways that wouldn't occur during the fall. Here we investigate sex differences in several aspects of spring migration ecology: arrival date phenology, body composition, stopover duration, and torpor expression.

Lasionycteris noctivagans were captured between in April and May 2012-2014 at Long Point, Ontario, Canada. We assessed bats fat and lean mass of all bats using quantitative magnetic resonance. In 2012 we used automated radio-telemetry to quantify stopover duration. In 2014 we monitored torpor bout depth and duration of free-ranging bats with temperature-sensitive radio-transmitters. Bats were tracked to their day roost and skin temperature and roost temperature were measured continuously throughout the day.

Although most bats stopover briefly during their spring migration, some individuals required longer periods of 1-2 weeks. Female bats had significantly longer stopovers males. This was unexpected because males had smaller fat-stores, approximately half that of female bats. Furthermore, female bats that stopped over for several days had lower body fat percentages than those that resumed migration the following evening. This suggests that the cause of extended stopover in females was to refuel, and was not driven by weather conditions. Both male and female bats entered deep at the stopover site. Our findings indicate that sex does affect the energy management decisions of bats during spring migration.

East by Northeast – the onset of spring migration in female noctule bats

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In mid-spring (April/May) of 2013 and 2014 we conducted radio-tracking studies at the border between Switzerland and Germany (Lower Aare Valley, Canton of Aargau/CH and Upper Rhine Valley near Waldshut/DE). We tagged 24 female *Nyctalus noctula* (2013: 16, 2014: 8) captured from a building roost at an industrial site and from bat boxes in a nearby beech forest during evening emergence, tracking them on the ground during the night and from the air during daylight search.
We documented the day of departure from the study area for 19 females, additionally observing the direction and time for 8 individuals. Furthermore we succeeded in following two noctules from the ground for several hours almost continuously, confirming the onset of spring migration for these two bats. For the first part of their first night of migration we were able to reconstruct their flight paths with high probability. Neither animal flew a straight line between the Aare Valley and the location of last contact, but took many detours and loops, almost doubling the direct distance covered. An individual's total migratory flight path therefore is likely considerably longer than the straight line between the start and end points of migration. The loops were presumably due to foraging bouts and food availability, enabling the bat to move on for many hours.
Between 2013 and 2014 there were striking differences regarding the weather in the weeks and days preceding migration, possibly causing a different migratory behaviour. Whereas in 2013 temperatures fluctuated moderately and the tagged animals departed over a period of 6 weeks almost on a one-by-one basis, in 2014 most of the bats tracked started migration on the same day and within 15 minutes after a period of unseasonally low temperatures. We are also considering other weather data,and the hypothesis that bats might leave their hibernation area prior to an approaching unfavourable weather system. Furthermore, noctules appeared to leave the area in different directions in the two study years. Both animals tracked in 2013 used an almost identical route towards the entrance to the Upper Danube Valley in the Northeast. In contrast, in 2014 the bats headed in a more easterly direction towards Lake Constance. This raises questions about the final destination of the hibernating and stop-over bat populations from Northern Switzerland, which we also approached by conducting isotope analyses.
This study is part of a R&D project on bat migratory routes, funded by the German Agency for Nature Conservation.

Using automated telemetry arrays to study the movement ecology of migrating bats: more than just connecting the dots

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The study of movement ecology in migrating bats has been severely limited by their elusive nature, and the cost and size limitation of available technologies for following their movements. Recent technological advancements now make it possible to track large numbers of bats over great distances with automated telemetry networks, and ask a variety of questions that were previously impractical or impossible to address. I will describe recently developed open-source radiotelemetry receivers (www.sensorgnome.org), how they have enabled large-scale collaborative automated telemetry networks, and the types of studies we are currently conducting. As part of a growing network in North America (www.motus-wts.org), there are currently > 250 telemetry towers deployed with detection range (under ideal conditions) exceeding 20 km. This network makes it possible to track migrating bats (and birds) as they migrate hundreds of kilometres. However, automated telemetry networks provide the opportunity to address many aspects of movement ecology other than simply connecting the dots, where an animal starts and finishes. With current and planned studies, we are addressing questions of migration phenology, colony dynamics, migration routes and rates, broad front migration and migratory corridors, the influence of landscape features, the influence of ecological barriers, and the intrinsic and extrinsic factors that affect migration.

SESSION V: SOCIALITY AND MOVEMENT ECOLOGY

Chairs: Sebastien Puechmaille, Mirjam Knörnschild

Ecological determinants of body mass: insights from the group foraging bat *Molossus molossus*

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The use of public information has been proposed as an important driving force in social evolution, including in bats. Information transfer about food patches appears as a promoter of group living in male groups from the temperate zones as well as mixed groups in tropical species. By acquiring social information about food, individuals can both reduce foraging time and increase their energy intake. Over the long- term, an improved foraging efficiency can ultimately enhance fitness and promote group hunting.
Group foraging and eavesdropping has been recently observed by a telemetry study in the Neotropical bat *Molossus molossus*. Members of a social group fly within hearing distance to find and share patches of ephemeral insects. Our objective was to characterize the ecological parameters (sex, group size and climatic variables) influencing body mass variation as a proxy for foraging efficiency in these groups. We predicted that an optimal, but fairly small group size, should allow for most efficient information transfer and thus linked to mass gain. To test this, we monitored individually marked bats with an automated recorder – integrating a PIT-tag reader and a scale –installed at the entrance of five roosts to record activity and mass of individuals.
Analysis with GAMM models showed that bats were active predominantly just after sunset and this was linked to a significant increase in mass. Rain had a negative effect on individual mass variation while group size had a positive effect, indicating that access to information from more foraging partners increases efficiency. Our study is the first one to show a direct link between mass variation and group size in a social foraging bat, emphasizing the importance of investigating alternative explanations in order to understand the evolution of sociality.

Acoustically mediated natal dispersal in the polygynous bat *Saccopteryx bilineata*

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Offspring dispersal is an important factor in shaping the social structure of a given species. While the causes and consequences of offspring dispersal have been studied in detail for some species, the actual mechanisms facilitating natal dispersal events have received less attention in the past. Female greater sac-winged bats (*Saccopteryx bilineata*) disperse after weaning from their natal colonies which is crucial to avoid father-daughter inbreeding. How young females find new colonies suitable for dispersal was unclear so far. We provide experimental evidence that dispersal females eavesdrop on male territorial songs to locate new colonies. Territorial songs are low-frequency vocalizations that are produced by territorial males at dusk and dawn to defend their territories against male competitors. When broadcasting territorial songs at dawn from potentially suitable day-roosts that were currently uninhabited, we attracted dispersal females and, in rare cases, adult females, and we were able to catch the bats with mist-nets when they were trying to land in the vicinity of the speaker. During silent control trials, no bats were caught. Using a formula originally developed to calculate maximum detection distances in echolocating bats, we estimated the minimum and maximum detection distances of male territorial songs for flying dispersal females. Our results indicate that the dawn chorus of singing male *S. bilineata* constitutes an acoustic beacon in the landscape that can help dispersal females to locate new colonies. Such an acoustically mediated natal dispersal has, to the best of our knowledge, not been experimentally shown in bats so far.

What happens when bats don't move - landscape heterogeneity, fore-arm length, and population dynamics

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Flight enables bats to move easily and efficiently which would permit communities to optimise their choices of foraging and roosting sites across landscapes of heterogeneous quality to ensure maximal productivity and survival. This should result in little variation in the growth, condition or fate of individuals and / or the performance of their populations. However, females of many temperate species are known to be strongly philopatric to their natal site, and many landscapes so heavily managed that their value to bats is very heterogeneous. These may interact to produce spatial variation in individual growth or population performance; a phenomenon common with other terrestrial mammals. Some consequences of this include the creation of meta-population dynamics and complexities in studying and managing bat populations. To start to understand these issues we have collated and analysed Serotine (*Eptesicus serotinus*) records from a number of studies across their range in England. We find statistically significant variation in the adult fore-arm lengths (AFL) of comparable bats (i.e. mature females). In addition, at two sites with distinct AFLs we have observed annual variation in cohort growth and been able to build models to predict community population dynamics, describing differences in their population performance. An initial analysis has explored the relative contribution of landscape scale drivers (geographic, climatic, genotypic as well as habitat composition and configuration) and a random roost specific effect in explaining the variation in AFL we observe. Our preliminary findings could be explained by a hypothesis that considers the environmental constraints that may be imposed upon the energy budget of a developing pup, either from limitations driven by the roost context (i.e. its supporting landscape) or the intrinsic properties or roosts (e.g. thermal behaviour). We note that bats develop rapidly, with 95% of their skeletal growth occurring before their first flight (20-30 days of age) whilst completely dependent upon their mother, and growth is probably completed whilst still associated with their natal site (first 50 days). Their ability to realise their genotypic AFL is potentially constrained during this period by both landscape scale factors (affecting maternal foraging and/or energy budget) and those associated with the natal roost (i.e. the proportion of the pup's energy budget used for maintenance rather than growth). We extend our speculation to suggest that sites sufficiently poor that they constrain pup growth may also produce less favourable population dynamics.

BATS: sensor technology for unraveling social networks in bats

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Recent technological advances allow for automatized recording of social networks in free ranging animals. However, this technical revolution is still kept outside the group of small vertebrates like bats due to the considerable weight of transmitters in combination with the small body size of most chiropterans. Since direct observations on flying bats are almost impossible due to their nocturnal activity and high mobility, most studies on social interactions focus on observations within colonies. Therefore, we know little on social interactions among bats once they left their roosts since sophisticated tracking technology in the required weight class is missing. In order to overcome this issue a dynamically adaptive sensor network based monitoring system is developed by the BATS-research unit. The system will allow for localization of bats at high spatial and temporal resolution and the simultaneous documentation of encounters among tagged bats. The light-weight sensor tags will give new perspectives on bat sociobiological research and finally allow for linking data on bat interactions in flight to mobility patterns during the nightly activity phase. We present the BATS system architecture, first results from pilot studies in the field and give an outlook on future directions of research on social behavior of bats based on sensor technology.

SESSION VI: MOVING BATS AND DISEASES

Organizers: Raina Plowright, Daniel Streicker, Gudrun Wibbelt

Features of bat virus spillover

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We outline the ecological dynamics of bat virus spillover from the within host processes that drive virus excretion to land-use changes that increase interaction among species. We show that a number of processes must come together for bat viruses to filter through ecological systems to cause disease in humans. We focus on Hendra virus in Australia, but also show how filoviruses, coronaviruses, and other henipaviruses share similar spillover characteristics.

Migratory bats linking communities in world-wide migratory networks

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Every year, billions of migratory animals cross the planet in pursuit of increased foraging opportunities, improved safety, and higher reproductive output. In so doing, these migrants transport nutrients, energy, and other organisms between disparate locations. Migrants also forage and are preyed upon throughout their journeys, thereby establishing transport and trophic interactions with resident communities. Migratory animals thus couple ecological communities across the globe and may mediate their diversity and stability. However, as yet, the influence of migrants and their services within ecoloical communities is often overlooked. Migratory bats are likely to be a particularly important group as they have been identified as important pollinators, valuable predators of insects, and are the reservoir hosts for a wide range of pathogens, including several emerging zoonoses. We will present a synthesis of the role of migratory bats in the structure and dynamics of the ecological communities these animals connect throughout their migratory movements. In particular, we will demonstrate the importance of migratory timing (synchrony and phenology) in the spread of infectious diseases in a migratory network. Given that animal migrations are threatened worldwide, we show that understanding the consequences of global changes for both migratory movements and their contribution to ecosystem structure and function is a pressing issue, particularly in bats.

African fruit bat species differences in health and immunity as a function of habitat disturbance and movement ecology – implications for emerging infectious disease from South Sudan studies.

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, health

Anthropogenic pressures resulting in habitat loss and landcover changes are leading drivers of biodiversity loss worldwide and such loss is strongly associated with the emergence of infectious diseases in a variety of taxa. Fruit bats vary by species in their response to habitat loss, which is likely mediated by overall species composition, behavioral differences, and differences in movement ecology. We have calculated theoretical fruit bat species richness maps (biodiversity hotspots) in South Sudan using DIVA-GIS to stack IUCN species distribution maps and adding point location data from past surveys compiled by the 2013 African Chiroptera Report and from our own surveys. Given that South Sudan has undergone nearly six decades of conflict, significant landscape changes have occurred. We have quantified landcover changes over time in the Game Reserves in which we work and other areas using Landsat remotely sensed satellite imagery. Applying analysis of habitat-level changes to species richness maps can aid in the estimation of how biodiversity may have been affected by habitat changes over time, and what the implications are for bats and for bat borne disease in South Sudan. Bats are known and suspected carriers of a variety of pathogens, including viruses. The ability of bats to host, maintain and transmit these pathogens is likely related to their health status, which itself likely varies by sex, age, reproductive condition and a variety of social factors, including the formation of multi-species assemblages. Building upon our spatial analyses, we will present data on health and immune status in several species of commonly captured fruit bats (*Epomophorus labiatus, E. gambianus, Epomops franqueti,* and *Micropteropus pusillus*) in relation to differences in their distributions and in their use of encroached habitats. Beginning to understand these differences in fruit bat species as a function of habitat loss and behavioral differences will enable our further study of disease ecology in this critical group.

Epomophorus gambianus role in the maintenance of filoviruses among sympatric fruit bats in Ghana.

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In the recent years, bats have been shown to serve as reservoirs for a multitude of infectious agents (Calisher, Childs et al. 2006), such as: Lyssaviruses (Banyard, Hayman et al. 2011), Coronaviruses (Li, Shi et al, 2005), Henipaviruses (Hayman, Suu-Ire et al. 2008), and Filoviruses (Leroy, Kumulungui et al. 2005). As surveillance and research on infectious diseases increases, so does the number of emerging viruses found in bat species (Weiss, Witkowski et al, 2012; Baker, Leggett et al, 2013; Tong, Zhu et al, 2013; Drexler, Geipel et al, 2013). *R. aegyptiacus* is the main reservoir species for Marburg virus (Towner, Pourrut et al, 2007) and several other species have been found to harbor Ebola, among them the Gambian epauletted fruit bat (Hayman, Yu et al. 2012). The aim of this study is to assess the role of *E. gambianus* as a reservoir of filoviruses and the transmission dynamics driving the mantainance of these viruses between sympatric fruit bats. *E. gambianus* is widely spread throughout Ghana, co-roosting with several other species, among them *E. helvum* and *R. aegyptiacus*. This study focus on 4 colonies of *E. gambianus* scattered across regions of the country, with up to 400 km of distance between them, and different composition and diversity of sympatric bat species. Serosurveillance of the species mentioned above was performed 4 times yearly. By-catch fruit bats were also sampled oportunistically. Seroprevalence analysis of Ebola and Marburg viruses was performed with a Luminex multiplexing assay. Samples from *E. gambianus* have contained specific antibodies against Ebola virus in all the colonies studied. To understand the underlying viral transmission within this species, perhaps responsible for viral persistance, a genetic approach will be taken (Peel, Sargan et al, 2013). In doing so, mtDNA and microsatellite markers will be selected from high-throughput sequencing readings from an Ilumina platform (Castoe, Poole et al, 2012). Both the seroprevalence context and gene flow analysis, characterizing either panmixia, isolation by distance or population structuring, will help demonstrate connectivity of *E. gambianus* across colonies and regions of Ghana.

High fidelity of bats to specific hibernacula – does it mean low potential for spread of WNS?

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Bats may benefit from fidelity to roosts that are well-suited for reproduction or hibernation. If such behavior is adaptive, costs should be balanced by benefits associated with staying (e.g. greater site familiarity, maintenance of social relationship, lower dispersal of pathogens or parasites). Selection of a suitable hibernation site is crucial for overwinter survival, and caves and mines are the most common type of hibernacula in temperate zone. Presence of White Nose Syndrome was confirmed in Europe and it has been identified at many localities from France to Turkey. In contrast with sites in North America, WNS in Europe does not appear to be associated with dramatic bat mortalities.
Our objective was to analyze re-capture data from nettings realized during two three-years periods (1992-1994 and 2012-2014) at entrances of eight caves situated in the Moravian Karst. We predicted that bat species with higher WNS prevalence will exhibit lower site fidelity. The recapture rate was generally low, and species and site dependent, respectively. Specimens were recaptured mostly once and repeated recaptures were exceptional. More than 90% of recaptures was realized at the locality of ringing and during the same part of season. Relatively high number of specimens recaptured spring was ringed during previous autumn swarming. The species with the highest prevalence of WNS (*Myotis myotis*) had one of the lowest recapture rates and lesser horseshoe bat (*Rhinolophus hipposideros*) vice versa.
This study was supported by the grant of GACR No. 506/12/1064.

Investigation into the transmission and spread of *Pseudogymnoascus destructans*, the etiologic agent of White Nose Disease

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Describing the population structure of animal hosts and their pathogens can provide critical information about the processes by which the pathogens are transmitted and spread. If the host is the major disperser of the pathogen, both species (host and pathogen) would be expected to show similar population structure patterns. On the other hand, if both species population patterns are drastically different, the host is unlikely to play a major role in the pathogen dispersal. We used the model system of bats (particularly *Myotis* species) and their fungal pathogen *Pseudogymnoascus destructans* to characterise the host and pathogen population structure and investigate if bats are dispersing the fungus across the landscape. We studied population structure in *Myotis* species and *Pseudogymoascus destructans* using genetic methods. The population structure patterns observed were then compared to ringing studies (for bats) and patterns of dispersal of the fungus in North America as observed since the outbreak of the White Nose Disease in 2006 in New York.

Small differences in host and parasite life history can strongly affect parasite population genetic structure: lessons from two bat hosts and three ectoparasites

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Host movement and social interactions not only affects disease spread directly, but also interacts with host and parasite life history to shape parasite population genetic structure. Host movement and interactions are especially relevant for parasites that are unable to disperse independently of their hosts such as many direct and obligate parasites. However, how individual host and parasite life history variables interact to shape parasite genetic population structure is poorly understood. In order to disentangle the effects of host and parasite life history, we compared the population genetic structure of two ectoparasites infecting a single host (the mite, *Spinturnix bechsteini* and the bat fly, *Basilia nana* on *Myotis bechsteinii*). In addition, we also compared the population genetic structure of two very similar parasites across hosts (*Spinturnix myoti* on *Myotis myotis* and the aforementioned *Spinturnix bechsteini* on *Myotis bechsteinii*). Both parasite genera investigated are highly specialized permanent ectoparasites of bats, but differ in several key life history traits including their mode of reproduction and generation time. Similarly, the bats investigated have a broadly similar life history (eg. follow temperate cycle), but differ in several features of social organization including colony size and degree of movement and social interaction outside of the maternity period. Within a single host, we found divergent population genetic structures in its two ectoparasites. The mite (*S. bechsteini*) was highly differentiated between demographically isolated host maternity colonies, whereas the fly (*B. nana*) was panmictic across the same host colonies. Across hosts, we also found differing population genetic structures within their mite species (*S. becshteini* and *S. myoti*). Here, *S. myoti* showed very little differentiation across host colonies, which contrasted sharply with the highly differentiated population genetic structure of *S. bechsteini*. In conclusion, we show that facets of both host and parasite life history can strongly influence parasite population genetic structure. Such differences in genetic population structure have substantial implications for the evolutionary potential of the parasites, thereby also affecting the risk and evolutionary pressure exerted by each parasite on its host.

Molecular evolutionary signatures reveal male-biased dispersal of vampire bat rabies

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Identifying key groups associated with the spatial spread of pathogens improves prospects for disease control but is commonly limited by scarce data on movements of infected individuals across landscapes. Using three datasets representing nuclear, mitochondrial and viral genomes from nearly 500 common vampire bats (*Desmodus rotundus*) and their associated rabies viruses (RV), we present a comparative framework to identify sex-biased pathogen dispersal. Striking correspondence between the population structure of biparentally inherited host and horizontally transmitted viral genomes, but discordance of either to extreme population structure implied by mitochondrial DNA indicates that males disseminate RV between genetically isolated female populations. This ecological process, in turn, triggers lethal outbreaks in humans and livestock and delimits the landscape distribution viral lineages. Female philopatry and male dispersal is the most common life history strategy in wild mammals. Our study provides a simple and generalizable genetic snapshot approach to assess how such heterogeneities influence the spatial spread of pathogens that could be used to refine interventions in a variety of wildlife disease systems.

SESSION VII: CONSERVATION AND MOVEMENT ECOLOGY OF BATS

Organizers: Christian Voigt, Tigga Kingston

Two lakes, three countries and thousand of bats: movement and conservation of bats in the Prespa Lakes area

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Since 2004, expeditions on bats have been done in the area of Prespa Lakes, mainly in Greek side. Following these expeditions, collaboration between Greek, Macedonian and Albanian experts has been established, and an action plan has been finalized in 2011. In the frame of this action plan, and in order to increase the knowledge on bats in the Albanian sides of the lakes, a PhD started in 2012 at the University of Tirana and we are presenting here the main results of this study, concerning three species: *Rhinolophus euryale*, *Miniopterus schreibersii* and *Myotis capaccinii*.
During this PhD, the first monitoring for the Albanian side has been setup and data have been collected between September 2012 to February 2015. Visit of caves and former military buildings have been realised during the four seasons in order to identify the main movement of bats within the area. The number of stations known as used by bats in the Albanian side, increases from 8 to 45. New important maternity colonies and hibernacula sites have been discovered and monitored.
Moreover, in collaboration with Greek and Macedonian experts, the movements of species during the year at the lakes scale have been better understood, helping the managers of the different protected areas of the region, which are also concerned by a UNESCO transboundary biosphere reserve.

LED light impacts urban bat communities less than commonly used mercury street lights

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Artificial light at night has deleterious effects on wildlife across taxa. All over the world, light pollution is increasing at unprecedented rates, thus posing a serious threat to biodiversity. Yet, light qualities probably differ in their effect on behaviours and physiology.
Since light emitting diodes (LEDs) are expected to become predominant in outdoor lighting applications within the next few years we were interested in how the replacement of commonly used mercury vapour (MV) street lights by LED light affects urban bat communities. We acoustically monitored bat activity at 46 municipal street lights across Germany for six nights each both before and after lamps were converted from MV to LED light.
Species known to forage on insects at street lights such as the common pipistrelle (*Pipistrellus pipistrellus*) and other pipistrelle species as well as bats of the *Nyctalus-Eptesicus-Vespertilio* group were all less active at LED as compared to MV street lights. Only the generally light averse mouse-eared bats (*Myotis spp.*) increased activity in proximity to LED lights. These findings indicate that light tolerant species are probably less attracted to LED light due to lower insect densities as compared to MV lights, while light sensitive species are less repelled by LED than by MV light in urban habitats. Thus, the anticipated wide-spread transition from MV to LED street lighting might reduce the anthropogenic impact of artificial light on urban bat communities and could help establishing a more natural level of competition between light tolerant and photo sensitive species in urban areas around the world. Ultimately, an altered competition between bats is likely to have far reaching consequences for biodiversity and ecosystem functioning through cascading effects via the food web, since insects constitute food for many taxa and provide key ecosystem services.

Population structure of hoary bats and silver-haired bats across Canada

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The most common types of bats killed by wind turbines are the migratory tree-bats. In North America, hoary bats (*Lasiurus cinereus*) make up 38% of all bat fatalities and silver-haired bats (*Lasionycteris noctivagans*) make up 18%. While recent cumulative fatality estimates of 840,486 to 1,690,696 from 2000-2012 are disturbing, we have little knowledge of the population structure of these species and how wind turbine-related fatalities may be impacting populations. We used a highly polymorphic portion (HVII) of the mitochondrial DNA control region (D-loop) to investigate the population structures of 151 hoary bats and 215 silver-haired bats from several mist-netting localities and wind energy sites across four Canadian provinces. To address our questions, we used an analysis of molecular variance (AMOVA), a spatial analysis of molecular variance (SAMOVA), and Mantel tests. The AMOVA of silver-haired bats suggests population structuring among groups across Canada and among populations within provinces and the SAMOVA analysis suggested 3 groups across Canada. The Mantel test shows that this population structure is influenced by geographical distance. The AMOVA of hoary bats also indicated structure among groups across Canada, albeit at lower levels than the silver-haired bat. The SAMOVA analysis suggested 5 groups across Canada but this structure was not influenced by geographic distance, as determined by a Mantel test. Additional analyses using microsatellites will help to further elucidate population structure and movement and help guide conservation strategies.

Acoustical flight path tracking for bat conservation: assessment of road collision risks before construction, and mitigation measures propositions

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Death by traffic collision is estimated to count among the most impacting human activities for bat populations. In order to obtain legal agreements for road constructions crossing identified bat corridors, road developers are asked to find mitigation measures to minimise their impact on wildlife. Very often, the efficiency of those measures is not proven, or even tested. In this task, automated acoustic flight path tracking is a practical tool and can be used to record bat behaviour over several whole nights. Results allow a thin estimation of collision risks species by species.

A road construction project in North-Eastern France plans to cross over a bridge a river with high riparian vegetation. On this site, a high species diversity with high activity levels was identified. A behavioural diagnosis was conducted in order to define collision risks.

10 different bat species of Pipistrellus, Myotis, Nyctalus, Barbastellus, Plecotus and Eptesicus groups have been contacted. The results show in the first instance that the riparian structure is very highly used as a corridor for most species. Second, the greatest majority of bats coming from high tree surroundings and flying into the open space, where the bridge will be erected, drops altitude in a significant way. This observation confirms the assumption that bats' flight height is highly dependent of vegetation height. However, the mean altitude decrease for most species is not significant enough to avoid the collision zone entirely, unless for *Pipistrellus kuhlii*. It might be that individuals need a greater distance from the border of the riparian high vegetation to lose enough altitude. Vegetation cues could also be needed to guide bats along the current wide open space.

Two mitigation measures were proposed. The first consists in the installation of bridge parapets, high enough to exceed the tallest vehicles. The second proposal is the enlargement of the open space surrounding the bridge and the plantation of trees at decreasing heights from the border of the original trees toward the side of the bridge. This plant slide is thought to guide bats along the river from high trees through the under-road passageway. A study after the construction of the road will be needed to confirm the efficiency of this landscaping.

POSTER PRESENTATIONS

SESSION I: MOVEMENT ECOLOGY OF BATS

Poster 1: Time and spatial activity of Rousettus aegyptiacus: a novel perspective in study of spatial behaviour

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Isolated population of *Rousettus aegyptiacus* has been intensively studied in the Dakhla oasis in Egypt. Newly designed radiotracking system, BAARA (Biological AutomAted RAdiotracking), was deployed during three field trips (winter 2010, spring and summer 2011), where we consecutively tagged 131 fruit bats (*Rousettus aegyptiacus*) in 10 × 10 km study area covered by five stations, took bearings every 2–10 min, based on the number of simultaneously followed bats (more than 85 000 fixies). The multiple records of simultaneous continuous positioning of a large number of individuals provided by automated radiotracking opens a different perspective beyond a level of individual behaviour. Here we illustrate it with a simple comparison of seasonal differences in activity pattern of the fruit bat population inferred directly from the primary instrumental data. The values of the basic statistical characteristics of individual spatial activity (as mean difference in successive positionings and in feeding and searching activity) show (i) absence of the difference between males and females, and (ii) high diversity between conditions in summer and winter, i.e. the concentration of spatial activity of the colony on the few high-quality resources in summer and wide dispersion with individual specific use of diffuse sources during the winter.

Poster 2: Activity and dispersal of the Leisler's bat, *Nyctalus leisleri* (Kuhl, 1818) during the pre-hibernal and hibernal period in Ireland

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The activity of bat species during the pre-hibernal and hibernal period in Ireland is largely unknown, and few hibernation sites have been recorded. The Leisler's bat (*Nyctalus leisleri*) is the largest species to occur in Ireland and is known to be a long distance migrant across parts of its European range. In an effort to determine the activity and dispersal patterns of this species during this period and assess whether Irish populations are migratory, we used temperature sensitive VHF radio tags to track bats from three sites in Northern Ireland, over two consecutive years. Data indicated that bats entered torpor throughout the study period but remained in torpor for longer periods when ambient temperatures dropped below 6˚C, entering hibernation around the beginning of November. We observed dispersal to mating and hibernation roosts, yet found no evidence that Leisler's bats in Ireland undergo long distance migrations as they do in some areas of continental Europe, possibly because conditions in Ireland in winter are favourable for hibernation. A seasonal shift in roost use was observed, with bats utilising cracks in buildings, splits and holes in trees, as well as bat boxes during the pre-hibernal period (August to October), while deciduous trees were used more frequently after November.

Poster 3: Effects of different linear features on the level of bat activity in agricultural landscapes in Serbia

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Linear features in agricultural landscapes have been recognized as extremely important elements for bat conservation. Field studies and observations in Europe during the last decades indicate that most bat species show preferences for using linear landscape elements such as hedgerows, woodland edges, tree lines and/or streams when compared to flying over open areas. It is argued that linear landscape elements are of crucial importance for bats as they protect them against wind and potential predators, and also provide foraging habitats as prey densities are higher than in open areas. In this study we analyzed the effects of different linear features surrounding 64 sampling points distributed in a lowland agricultural landscape along the Sava and Danube rivers in Serbia. We sampled during the period August-September 2013 using SM2Bat+ bat detectors, programmed to start recording half an hour before sunset until half an hour after sunrise. Sampling was done during nights with temperature higher than 10°C, with no rain and low wind speed. Recorded bat calls were analysed to species level or to the level of bat species group (e.g. *Myotis* sp.) using BatSound 4.1.2c. We used GIS (QGIS 2.2) to quantify the length of different linear features within a radius of 500m around the sampling points. A Generalized Linear Model (GLM) was used to evaluate the effects of length of different linear features (woodland edge, road, hedgerow, water edge) on the level of activity of different bat species/groups. Our analysis showed that the total level of bat activity was positively correlated with the temperature. The total level of bat activity, as well as activity of *Pipistrellus pygmaeus*, *Pipistrellus kuhlii/nathusii* and *Eptesicus serotinus/Nyctalus noctula* were significantly positively affected by the presence of water edge habitats (canals, streams and rivers found in the landscape), while woodland edge significantly affected in a positive way the level of activity of *Rhinolophus ferrumequinum*. The results of this study confirm that careful maintenance, conservation and enhancement of woodland and water areas could greatly increase the value of linear habitats for Serbian bat species, especially in agricultural landscapes.

Poster 4: Accelerating movement patterns – a modelling approach to connect populations of the endangered Greater horseshoe bat (*Rhinolophus ferrumequinum*)

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Greater horseshoe bat (*Rhinolophus ferrumequinum*) has undergone a serious population decline in Central Europe caused by habitat deterioration and habitat loss resulting in a decrease of carrying capacity and fragmentation. We examined the spatial ecology, habitat use and key landscape features in a vital maternity colony of *R. ferrumequinum* in the northern part of their current European distribution in Luxembourg. In total, 3,559 fixes from 26 radiotracked individuals were calculated. Results from radio-tracking were used to establish conservation measures in the landscape around the maternity roost. The tracked individuals showed commuting flights along hedgerows, streams and small-forested patches. *R. ferrumequinum* preferred semi-open, but richly structured traditional farmland habitats such as orchards, pastures and parkland habitats. The landscape configuration around the buffered radio fixes was characterised by higher habitat diversity than in the surrounding region.

In the ongoing process we calculated the habitat connectivity to influence the spatial distribution within the home-range of the maternity colony and also in the direction of the next populations settling in northern France. For this we applied a cost-distance analysis to identify habitat connectivity at different landscape levels. This modelling approach identifies both cost paths between recent colonies (e.g. between Luxembourg and Northern-France) also as cost paths to landscapes with historic populations (e.g. in western parts of Germany).

Our results indicate conservation efforts on areas where habitat potential connectivity and landscape texture together should be taken into account to preserve both endangered bat species along with the local biodiversity.

Poster 5: Bat3Data, the automated detection of the trajectography of bats in 3D in the field using acoustics

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The current ultrasonic bat call identification solutions provide only basic information on presence / absence and limited assistance for species identification.
The Bat3Data monitoring package, designed to map in 3D the flight paths of bats is a significant improvement towards understanding both the behaviour of bats and the efficiency of wildlife corridor mitigation measures for infrastructure projects.
Tested on new bat bridges and flight paths in France, Egis Environnement has developed a non-intrusive monitoring package Bat3Data consisting of a network of 4 antennas placed I a tetrad, linked to a sound card and a bat call detection algorithm in addition to the computerized treatment of common bat species allowing the accurate 3D plotting of each call. The bat sound signals can be located through a 3D Geographic Information System and blended with a client's infrastructure design, allowing the study of bat flight behaviour when disrupted by a new project.

Poster 6: "When September Comes": bat community changes with autumn in a Argentinian town revealed by acoustic survey

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When the summer decline bats community can show important change related to migration or movements to hibernation roosts. Few information are available for the southern hemisphere and here we present a first bioacustic approach to changes in the faunistical composition with the change of the season. Using a Petterson D240x bat detector, recording were performed from the roof a 10 meters tall building in the center of La Plata (750,000 inhabitants, Atlantic coast of Argentina).
Here we display the results achieved over 4 nights approaching autumn (night 1: 16 March, night 2: 1 May, night 3: 22 May, night 4: 13 June) analyzing 38 recording of 10 minutes each, collected every 40 minutes, from 20 minutes after the sunset to 1 o'clock in the night. As is not possible actually to assign the different sound to clearly identifiable species due to the lack of knowledge and reference sound libraries for Argentinian bats, we attributed the sound recorded to 6 typical sonotypes by Batsound software taking in account the parameters Fpeak, Fmax, Fmin, Fstart, Fend, BW, Cd and IP. The sonotypes were named by letters A, B, C, E, F and G. Activity peaks differ in the nights 1-3 from the night 4. In the first case were recorded an higher number of passages (0.4 to 2.9 per minute) from 20 minutes to 140 minutes after sunset and a second peak (0.1 to 3.6 per minute) from 210 to 290 minutes after sunset. In autumn, during night 4, the peak (0.5 to 0.8 per minute) was only between 40 to 210 minutes after sunset. Temperature at night 1 and 2 was over 15° and lower in night 3 and 4. During night 1 a total of 111 passages were recorded and all the 6 sonotypes were recognized. In night 2 we had the maximum activity with 250 passages and 5 sonotype (G type not recorded). In night 3, 74 passages were recorded and 4 sonotypes (G and E types not recorded). During the last night, 4, a total of only 34 passages were recorded with just sonotypes A, C and F. In conclusion with the autumn approaching and the decrease of temperature and elongation of dark period, the composition of the community decrease to half the diversity and also activity tends to concentrate in the central

Poster 7: The movement ecology of a predator-prey-community: neural representation of bat predation risk in moths

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In many predator-prey-interactions, the prey animal tries to escape the predator with unpredictable movements. The predator-prey-interactions of echolocating bats and eared moths include complex flight manoeuvres in three dimensional space. Echolocating bats possess a complex auditory system, a high degree of sensory-motor integration, and flexible behavioural strategies for attacking prey. In contrast, the ears of noctuid moths contain only two auditory receptor cells (A1 and A2) that are tuned to the ultrasonic call frequencies of predatory bats. Here we investigated how the escape flights of moths is adapted to the search flight of echolocating bats. Particularly, we tested the hypothesis that the frequency-dependent A-cell thresholds allow moths to detect bat species calling at different frequencies at distances at which they pose a similar threat. First, we show that bat call frequencies are tightly correlated with four bat characteristics that are related to the danger that these echolocating bats pose to moths. Second, we measured auditory receptor thresholds in 12 moth species for the echolocation calls of 13 sympatric bat species in the lab and compared them with data collected for several species in the field. Third, we modelled call-by-call the flight of bats and the corresponding evasive flight of moths for all combinations of bats and moths, determining temporal and spatial safety margins before detection by the bat for moths initiating directional flight at A1 threshold. In general, moths detect bats long before bats can detect the moth. For moths almost directly in front of an approaching bat, A1 activity translated into similar temporal safety margins across all bat species. At greater angles away from the bat, the safety margins varied greatly, often resulting in unnecessary directional flight. This suggests that the A1 cell has adapted to the worst-case scenario for the moth, with A1 activity allowing the moth to escape just in time from the worst case. In contrast, the less sensitive A2-cell starts to fire at approximately the same time as the bat detects the moth for bat species calling at 30 kHz and greater. This suggests that A2 activity informs moths that they have been detected by a bat and triggering erratic movements to escape from the attacking bat.

Poster 8: Seasonal and daily movements of *Lasiurus blossevillii* in California

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We modelled the seasonal distribution by sex of the western red bat (*Lasiurus blossevilli*) to infer seasonal movements using GIS-based ArcView 9 and 527 western red bat location records from the California Natural Diversity Data Base, museum records, and capture and acoustic data from E. Pierson, W. Rainey, C. Corben, D. Johnston, D. Stokes, S. Whitford, and S. Remington and various reports. Land cover attributes, political boundaries, and records were combined into a single table. GAP polygons that showed only the primary wildlife habitat relationship (WHR) vegetation community were used to generate the GIS-based range maps. The breeding (summer female and young) range comprised valley foothill woodland habitats in the Central and Salinas Valleys, and in coastal areas of Southern California. The male summer range included the Sierra Nevada and other mountainous regions adjacent to the female – young summer range. The winter range for both sexes was mostly limited to the San Francisco Bay Area, the Delta, the central portion of the Central Valley, and coastal areas with valley foothill riparian habitat. These range maps suggest males disperse from coastal and Delta wintering areas into a wide range of forested areas up to a several hundred kilometres away and up to 2427 metres above sea level during summer months whereas females migrate shorter distances as a group from coastal wintering areas to raise young at low altitudes along the main stems of rivers and creeks in the Central Valley and inner coastal areas of Southern California. At Sutter Buttes located in the Central Valley, radio-tracking of a combined 20 nights of foraging by 3 females and 1 male suggested relatively long commute distances from roosts to foraging areas n = 20, Mean 7.94 km, SE 1.52 km. Maternity roosting sites were located in undisturbed hilly areas with native vegetation and without non-native predators. Foraging areas comprised agricultural and anthropogenic habitats with non-native predators (e.g., *Rattus rattus*). Although both areas appeared to provide appropriate vegetation structure to support maternity roosts, females raising young may prefer locating maternity roosts in areas without non-native predators, even with commute distances of 10 km.

Poster 9: Habitat use of a bat community in northern Bavaria, Germany

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Our goal was to determine how different bat species that live in sympatry partition a complex habitat mosaic. This study was carried out in northern Bavaria, Germany around the town of Forchheim during May and June 2014. The Natura 2000 area "Oertlbergweiher mit Oertlberg" consists of old forest stands and more than 500 years old ponds and is embedded in a mosaic of urban area, garden plots, agricultural land and meadows. The forest itself includes both coniferous monocultures and broadleaved parts, but mostly it is dominated by broadleaved forest consisting of old oaks and hornbeam. We captured bats using mist nets within a limited area close to the forest edge. Only males, 15 individuals representing nine species were then fitted with transmitters and were radio tracked using both a car antenna and H antennas. We tracked the bats for 3 to 8 whole nights and collected between 27 and 89 fixes for each individual. We assigned individual bat locations to 10 land cover categories. We looked for differences within and among species and among gleaners and non-gleaners. Utilization of the 4 most important habitat categories differed significantly among gleaners and non-gleaners. Broadleaved forest without ground-vegetation was used by all the species. While the group of gleaners (M. bechstenii, M. naterreri and Pl. auritus) mostly focused on that category other habitat categories were used in much smaller amount. The group of non-gleaners (*P. pygmaeus, P. pipistrellus, M. daubentonii, M. alcathoe, M. brandtii, B. barbastellus*) used extra forest sites to a larger extent for foraging e.g. ponds and houses and foraged more evenly over a wider range of habitat categories.

Poster 10: Object memory vs. spatial memory in trawling bats, *Myotis daubentonii*

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Bats have a well developed spatial memory. They remember feeding places or position of obstacles in their flight ways. They also make use of landmarks for orientation and navigation and remember object attributes [1]. Results have shown the nectar feeding bats rely mostly on position [2], whereas gleaning bats use object memory to find food reward [3], indicating that importance of object vs. spatial memory may rely on hunting strategy.
We trained nine trawling vespertilionid bat *Myotis daubentonii* to a fly to a food reward presented at one of two very distinct shapes functioning as feedingplatforms. We tracked their flight behavior by infrared videorecording. We recorded their echolocation calls by an array of seven ¼" precision microphones and we determined their sonar beam aim by an array of 64 microphones behind the shapes, connected directly to diodes.
After having learned to fly to the rewarded place and shape with > 90% success we switched the position of the two shapes. In the first trial after the move seven of the nine bats flew to the trained position and only two flew to the shape. The sonar beam was directed toward the trained position. When the whole scene was moved (shapes and surrounding objects) the bats flew to the trained *relative* position.
The results show trawling *Myotis daubentonii* presented with conflicting sensory information rely more on spatial memory than on object recognition. Gleaning bats may rely more on shape to recognize their prey in different locations, whereas nectar feeding bats may need to remember the position of food plants. Thus the results call for more data to show if prominence of memory can be predicted by hunting strategy in bats.

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Poster 11: Which environmental factors affect the commuting and foraging activity of bats in an anthropogenic landscape?

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ıntensively used agricultural land is widely considered to be a low quality habitat for bats. Nevertheless, 13 out of 25 bat species occur in an intensively used agricultural region located in the North of the federal district of Brandenburg, Germany. Here, bats experienced fragmentation and loss of habitats, decrease in food availability and now face novel threats such as the increase in wind turbine density associated with bat fatalities. For conservation reasons and in order to elucidate the interaction of bat species with the agricultural landscape, it is crucial to gain information about which environmental factors affect bat species activity patterns on arable fields.

In this study, we are aiming at answering two questions:

1. Which major environmental factors influence bat species activity over open arable fields?
2. Is bat species activity on arable fields near vegetation edges influenced by the distance from the field to the edge?

The study was conducted in the Uckermark region in Northeast Brandenburg, Germany. We used a stationary passive acoustic monitoring approach to record commuting and foraging activity of bats during the summer months of 2012 and 2013. We analysed all recordings manually using the software Avisoft SASLab Pro referencing published literature on bat species echolocation calls and their identification.

Our preliminary results suggest a spatiotemporal dynamic use of open arable fields. We also found a negative relationship between the intensity of habitat use and the distance from the vegetation edge into the open field, meaning that activity for most bat species concentrates at the vegetation edge and decreases with increasing distance to the edge. However, the quality of the above mentioned relationship appears to be species specific as some species (e.g. *Pipistrellus nathusii*, *P. pipistrellus*) showed a negative relationship while another species (*Nyctalus noctula*) showed an evenly distributed activity pattern irrespective of distance to the forest or hedgerow structure.

Our results highlight and confirm the importance of edge habitats for bat species movement in agricultural areas. As a consequence, the extant of insect population

control by bats may be highest near vegetation and decrease with increasing distance to the vegetation edge. In this context our study provides further insight into the relationship between important landscape elements, bats movement ecology and the link to potential ecosystem services provided by bats.

Poster 12: Patterns of spatial activity of *Rousettus aegyptiacus* colonies in the Mediterranean Region in the light of multiple comparisons: individual variation vs. social synchronisation

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An intensive study of spatial activity in three model colonies of *Rousettus aegyptiacus* in Cyprus, S-Anatolia (Turkey) and Dakhla oasis (Egypt) provided an enormously large dataset: 138,662 fixies of 223 individuals (1657 bat nights). Besides analyses of between-season and between-regions effects and relations between patterns of spatial activity and food supply (Bartonička et al., Lučan et al., this volume) it enabled to compare aspects of information provided by different techniques of study and revealed the details of spatial behaviour of a colony not obvious with smaller datasets.

The largest part of the dataset was obtained from Dakhla oasis (winter 2010, spring and summer 2011: 87,609 fixies of 111 bats, 927 batnights) with aid of simultaneous application of GPS receivers (n=42/26: 58 nights, 4498 fixies), standard radiotracking and a newly designed radiotracking system, BAARA (Biological AutomAted RAdiotracking). Comparison of their outputs confirmed that all three methods provide consistent picture of colony dispersal and individual foraging patterns. Notwithstanding considerable between-season differences (comp. Bartonicka et al.) it indicates a conservative pattern of foraging activity indexed by a repeated exploitation of few individually specific feeding grounds close to colony roost. GPS record further revealed that some individuals may begin their night activity with a different behaviour: three males made a long-distance search flights (50-80 km), later in night followed by regular foraging in their feeding grounds close to colony roost.

Along with triangulated positioning of individual records we examined a possibility to retrieve certain behavioural information from the rough BAARA instrumental output data. We found that some basic statistics (std, skeweness, kurtosis etc.) of uncorrected azimuth data seem to provide significant quantitative characteristics of dispersal patterns of colony during a night and enable also to assess the aspects of between individual variation and common features in spatial activity. It seems that in time of an increased food availability the dispersal activity of colony, both in Dakhla and Turkey, was significantly enlarged at first half of

night and the pattern of activity showed aspects of social synchronisation.

Poster 13: From sensory limitations to roost finding strategies in bats

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Based on a series of conducted experiments and literature review, in a simple theoretical model we explore the benefits of tree selection, memory, and eavesdropping on searches for tree cavities by bats with short and long perception range. Our model suggests that correct identification of trees with cavities and memory are basic strategies decreasing the cost of roost finding, whereas perceptual range plays a minor role in this process. Eavesdropping constitutes a buffer that reduces the costs of finding new resources (such as roosts), especially when they occur in low density. We conclude that natural selection may promote different strategies of roost finding in relation to habitat conditions and cognitive skills of animals.

Poster 14: Seasonal movement of bats in big city area (Kharkiv, NE Ukraine)

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The role of big cities as the elements of landscape during bat seasonal movements is not clear. We studied seasonal changes in bat assemblage in Kharkiv city (NE Ukraine) in 2010-2014. Kharkiv has 1.5 million population and area 350 km^2. Data was collected in following ways: 1) monitoring and gathering of bats inside buildings; 2) collecting bats found by people (communication through the call-center of Bat Rehabilitation Center of Feldman Ecopark); 3) mistnetting of bats in the city center and forest on the outskirts; 4) acoustic monitoring.

It was noted seasonal difference in bat assemblage in Kharkiv city. The city is most full of bats during the winter. Dominant noted species was *N. noctula* (over 90%), subdominant were *E. serotinus* and *P. kuhlii*, rare were *V. murinus* and *P. auritus*. The winter bat population of non rare species was represented by all sex-age groups. In the last days of March most of *N. noctula* left city. Results of mistnetting in the city center showed presence of males and underproductive females of *E. serotinus*, males and few reproductive females of *P. kuhlii* during breeding time. At the same time results of mistnetting in oak forest located on the outskirts (5-10 km from city center) showed presence of 7 species (*M. daubentonii, M. dasycneme, N. noctula, E. serotinus, P. pygmaeus, P. nathusii, P. auritus*), represented by subadult individuals and lactated females.

Further bat invasion happened in the first days of August. 9 species were captured in the outskirts forest (already noted + *N. leisleri* and *V. murinus*), 5 in the city center (*N. noctula, N. leisleri, E. serotinus, P. nathusii, P. kuhlii*) and 3 recorded in buildings (*N. noctula, E. serotinus, V. murinus*). Bat assemblage of mass species was represented by all sex-age groups; among *N. noctula* prevail young individuals.

From the 10th of September to beginning of November followed “period of silence”.

In November-December the number of finding bats, species composition (exclude *P. auritus*), sex-age structure were the same as in January-March.

On the example of Kharkiv city we see that bats use urban area primarily for wintering and swarming.

Poster 15: Relationships between spatial activity, ecomorphology and ecology in Chiroptera

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Despite the increasing number of studies on spatial activity of bats, no cross-species relationships between spatial activity of bats and different aspects of their morphology and ecology have been available so far. Using an extensive dataset compiled from published scientific literature (incl. 163 papers and 100 species) we are presenting a preliminary results of multiple analyses of relationships between the home-range size and distances traveled to foraging sites and various aspects of bat's ecomorphology (size, wing shape, echolocation mode), ecology (dietary specialization, colony size) and environment they occupy (geographical location, net primary productivity).

Poster 16: Testing the intensity compensation hypothesis in foraging barbastelle bats, *Barbastella barbastellus*, in the wild

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The everlasting arms race between insectivorous bats and their insect prey lead to the convergent evolution of ultrasonic sensitive ears in several insect taxa. Eared moths perform evasive flight manoeuvres when they hear bat echolocation calls, thereby significantly decreasing their risk of predation. Despite moth hearing, however, the barbastelle bat is able to almost exclusively prey on eared moths. How do barbastelles circumvent being detected by moths? Recently, it has been shown that barbastelle bats emit low-intensity search calls that are not audible to moths at distances at which the bats are able to hear moth echoes. However, while bats move towards their prey, the intensity of their calls at the moth's position will increase, eventually becoming audible and potentially eliciting evasive flight. Yet, it had been hypothesized that barbastelle bats may continue to lower call intensity while closing in on the moth, causing the intensity at the moth's ear to remain below the moth's hearing threshold. Consequently, the moth would not detect the approaching bat and fail to elicit the life-saving evasive flight manoeuvre.
We tested the intensity compensation hypothesis in the wild by offering tethered tympanate moths to free-flying barbastelle bats. We used a four-microphone array to compute the bats' three-dimensional flight paths based on time-of-arrival differences of the echolocation calls at the four microphones. An additional omnidirectional miniature microphone at the tethered moth allowed us to calculate the source intensity of echolocation calls at the bat's mouth as well as the received intensity at the moth's position. Further, we conducted synchronized video recordings to evaluate the moth's behaviour in response to approaching bats.
If the intensity compensation hypothesis was true, barbastelle bats would have combined a probably already existing mechanism for intensity control with a novel low-intensity echolocation strategy to counter moth hearing until the final capture of the moth. Thereby, they might have obtained exclusive access to a formerly unavailable food source, thus altering competition between sympatric bat species. In turn, selection pressure for eared moths might have increased, potentially fostering new anti-bat traits to evolve.

Poster 17: Where, when and why? Spatio-temporal use of habitat in boreal forest-dwelling bats

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Two of the three regularly found Finnish species of the genus *Myotis*, *M. brandtii* and *M. mystacinus* use forests predominantly for feeding, breeding or roosting. However, the significance of forests to bats is not well known in the boreal zone. Although approximately 70% of the total land area of Finland is covered by forest, only varying proportions of the forests may be available to bats, because of extensive forestry.
The present study investigates the spatio-temporal habitat selection of *Myotis* bats in Finland by the use of an intensive network acoustic survey method during two field seasons, 2013 and 2014. The study was conducted at a recently protected forest with a gradient of forest types from recently harvested seed-tree clear cuts to near old-growth forests. The results reflect the importance of moist old growth forests as feeding grounds of especially the species *M. brandtii* and *M. mystacinus*. However, the importance of different environmental variables varies within a season, even within a night. The results add a considerable amount of information to the knowledge on the habitat selection and movement of boreal bats within their summer ranges. The research produces guidelines for conservation planning and forestry in a boreal landscape.

Poster 18: Move under light or shade: habitat use and lightings in different Mediterranean bat species

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One of the main risk for bat conservation is habitat human change. Lighting of different landscape, from urban to forests, seems to be particularly concerning many different life forms. Light pollution is known to cause roost sites abandonment and significantly affecting habitat use. Movements of the bats can be affected in term of loss of connectivity or to make certain areas undesirable. Also biomass and diversity of preys can be strongly affected by lightings.
To evaluate the effect on some Mediterranean bat species of lights in hunting grounds we recorded files lasting 10 minutes each, with standardized acoustic methods, in random points of various North and Central Italy sites. An arbitrary scale from 0 (no light) to 5 (center town lights) was assigned to the intensity of artificial light measured by luximeter. Ecological parameter and light intensity were later correlated to the faunistic composition by multivariate analysis with SPSS software.
The different light conditions, both lower and higher ranks, are statistically correlated to variation in bat community structure. *Pipistrellus kuhlii* and *Hypsugo savii* are clearly attracted by light both in suburbans and countryside sites where they largely forage on small insect under lights. *Rhinolophus* spp. appeared to avoid the presence of light, according to literature data showing that light has negative impact on commuting flight routes. Distribution of sampling in different time moments over the night is also important to define the faunistic composition in different environments**.**
Behavioral differences in term of feeding, connection flights and social interaction were also recorded differently among species and under light conditions.
The different species feel positively or negatively the effect of lights in the foraging grounds and these effects have to be considered in the management and planning of the territory for conservation.

Poster 19: Revaluation of the range expansion of *Pipistrellus kuhlii* sensu lato in central Europe

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Since the recent review (2006) of the range expansion of *P. kuhlii* s. l. in central and eastern Europe, new data have confirmed its continuous and rapid spread. The species has colonized new areas in Ukraine, Romania and expanded to Slovakia and Czech Republic. According to the latest genetic studies, *P. kuhlii* s. l. comprises two species in central Europe: *P. kuhlii* in the south and *P.* cf. *lepidus* in the east (Poland, Ukraine). Although the first individual of *P.* cf. *lepidus* was recorded in Poland in 2005, first evidences of breeding population have been obtained in 2012 and 2013. In 2013 and 2014, we conducted field work focusing on this bat species in the south-eastern Poland. We recorded the species to be already established and locally widespread in anthropogenic habitats. Data from central Europe support the hypothesis, that the species colonizes new areas in jumps with subsequent saturation of suitable habitats. Monitoring of *P. kuhlii* s. l. expansion in Poland and research on its ecology are ongoing.

Sachanowicz, K., Wower A., Bashta A-T. 2006. Further range extension of *Pipistrellus kuhlii* (Kuhl, 1817) in central and eastern Europe. *Acta Chiropterologica* 8:543–548.

Poster 20: Do bats hunt preferentially over certain crop fields in agricultural landscapes?

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Over the past century, an increased intensity of agricultural land use caused a decline in the heterogeneity of landscape structures. This loss of diversity in habitats may affect the biodiversity of plants and animals. Bats are know to be highly sensitive to habitat fragmentation, lower availability of food, an other anthropogenic landscape changes, such as increase establishment of wind turbines. Considering the adverse nature of intense agricultural landscapes for bats, we asked if crop types may influence the movement of bats, specifically, we tested if bats were more active and if bat species diversity increased at flowering rapeseed fields compared to other crop types and/or to other flowering stages of rapeseed fields. In our project, we focused on four main crop types, namely rapeseed, wheat, sugar beet and corn, which are the predominant crop types at our study sites in the Uckermark region in the Northeastern Germany. We use stationary automated "Batcorder" (EcoObs) to monitor the echolocation calls of foraging bats before, during and after flowering of rapeseed between March and June 2014. Afterwards, we used Avisoft SASLab (Avisoft Bioacustics) to check the species identification of recordings. This study sheds light on the interaction of bats with local landscape factors such as local crop types and gives information about the preferences of bats to different crop types and the changes throughout time according to flowering stages.

Poster 21: Flight metabolism in relation to speed in migratory *Nyctalus noctula*

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Flight is an energetically expensive form of animal locomotion; flight metabolism of bats, in particular is at least double the metabolism of running in mammals of comparable size. Aerodynamic theory states that the relationship between metabolism and flight speed can be described as a U-shaped curve: more energy is required at slow and fast speeds than at intermediate speeds. It has been suggested that flying bats should migrate at maximum range speed (the speed at which a bat travels the longest distance expending the least amount of energy) under optimal conditions. Usually maximum range speed is higher than minimum power flight speed, which is the speed at which bats should forage. However, empirical findings regarding flight metabolism in bats, and especially migratory bats, are currently lacking.

In an ongoing study we are measuring the relationship between flight metabolism and speed in the common noctule bat (*Nyctalus noctula*). These insectivorous bats migrate each autumn, covering distances of up to 1,000 km one way. We are testing flight metabolism at different speeds in wind tunnel experiments using the 13C-labelled Na-bicarbonate method. We will then compare these experimental findings with optimal flight speeds based on aerodynamic models. This new data will improve knowledge on flight energetics and will help advance our understanding of the ecology of migratory bats. By measuring the relationship between flight metabolism and speed in migratory bats we can determine whether free-ranging bats fly at maximum range speed or whether foraging during flight (aerial refueling) reduces the realized flight speed.

Poster 22: CSI methods applied to biology: Indirect evidence of bat movements on a small scale

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Molecular analysis of faecal pellets has proven to be of great value to many areas of bat research. However, usually only the most abundant prey species receive all the attention. Here, we show that by concentrating at the rarest prey species instead of the most common ones, it is possible to pinpoint the foraging locations of individual bats or individually collected faecal pellets.
To accomplish our task, we analysed the dietary spectrum of several Daubenton's bat (Vespertilionidae: *Myotis daubentonii*) individuals and several faecal pellets. We focused to the most rare prey objects, those that were found only once from each pellet. We utilized the visualization and analysis methods used widely in food web research. By drawing a predator-prey food web connecting all the samples to prey species we were able to unambiguously differentiate all the sampled faecal pellets and collecting sites.
This is the first time that this kind of approach has been applied to bat ecology. As our method makes use of non-invasive sampling, this finding offers valuable tool for both ecological research and conservation of endangered species.

SESSION II: GPS-BASED TRACKING OF BAT MOVEMENTS

Poster 23: Habitat use of noctule bats (*Nyctalus noctula*) unraveled by high-resolution miniaturized GPS receivers

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High quality movement data is pivotal for understanding the ecology of species, particularly their ecological requirements in anthropogenic landscapes. Until very recently, GPS positioning was only available for medium or large mammals, since GPS units and batteries weighed too much. Accordingly, information on habitat use in bats is mainly based on stationary acoustic monitoring or time-consuming and sketchy VHF telemetry. We tested a novel approach by using miniaturized GPS units in 9 greater noctule bats (*Nyctalus noctula*), asking which habitats noctule bats would use in a landscape dominated by intense agriculture, lakes, isolated forest fragments, and highly abundant wind turbines. We recorded the spatiotemporal behavior of our study animals in 30 second interval during continuous nights. GPS units weighed about 3.5 grams and thus exceeded the 5% limit recommended in the literature. Yet, we could not see any adverse effects related to the relatively large mass of GPS units. To increase the likelihood of retrieving GPS units attached to bats, we studied a population of greater noctule bats roosting in artificial bat boxes in an isolated forest patch. We retrieved 9 out of 21 units, resulting in data for one to four days from six males and three females between early and late summer. We estimated foraging excursion areas by calculating minimum convex polygons (MCP) and tested for habitat preferences by comparing simulated trajectories using correlated random walk to the flight trajectories. To identify habitats suitable for intensive foraging, we separated the movement data into directional flights towards foraging habitat and area restricted search (ARS) based on categories of flight speed and turning angle. Females conducted long distance travels during single nights in late summer (mean distance covered 26.12 km ± 7.11 SD), exhibiting relatively constant flight speeds and rarely ARS periods. In contrast, males monitored in early summer flew directly to areas close to the roosting site (mean maximum distance to roosting site 4.23 km ± 1.75 SD, mean distance covered 14.77 km ± 5.72 SD). These foraging areas were often associated with water bodies, where they performed intensive foraging. Both sexes exhibited a second short foraging trip shortly before sunset. Occasionally, flight trajectories crossed wind farms, leading to the assumption that there was no active avoidance of such facilities. Our data suggests that noctule bats use large

areas for foraging, with preferences for water bodies, particularly in male bats in early summer. Yet, we also observed a large variance in movement patterns.

SESSION III: MORPHOLOGICAL, SENSORICAL AND PHYSIOLOGICAL CONSTRAINTS OF BAT MOVEMENTS

Poster 24: Visual detection threshold in echolocating bats

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Bats use echolocation to hunt and navigate. Most bat species have developed complex laryngeal echolocation and due to the effectiveness in terms of perceptual detail that is available to bats through echolocation, their use of vision has largely been ignored (but see Childs & Buchler 1981 and Manske & Schmidt 1976 for example). In fact, all species of bats possess eyes, which presumably are of adaptive value to bats, since eyes that are of no use have been shown to disappear in other vertebrate species (e.g. *Astyanax mexicanus*). Few experiments exits, but a few species of echolocating bats seem to be able to use vision in dim light as a navigational cue or even, in rare cases, as a hunting cue (Eklöf & Jones 2003; Eklöf et al. 2002).
Our study aim to shed light on this still fairly unknown field of bats' ecology, we started by assessing vision in echolocating bats (*Myotis daubentonii* and *Nyctalus nyctalus*). We chose to use psychophysiological and behavioral methods in order to evaluate the intensity threshold in these bats. The bats were clicker-trained and tested while crawling on a Y-shaped platform in a psycophysical 2AFC paradigm with a staircase method (one down/three up). The first results suggest that this bat is able to see green light (~540 nm) at intensities as low as moonless starlight (i.e. 0,03 lux). This experiment will be repeated with different wavelengths and backed up by physiological and anatomical data.

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Poster 25: Bat flight: aerodynamics, kinematics and flight morphology

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Bats have evolved the ability of powered flight during more than 50 million years. The modern bat is an efficient flyer and recent research on bat flight has revealed many intriguing facts. By using Particle Image Velocimetry to visualize wake vortices, both the magnitude and time-history of aerodynamic forces can be estimated. At most speeds the downstroke generates both lift and thrust, while the function of the upstroke changes with forward flight speed. At slow speed and hovering bats use a leading edge vortex to enhance the lift beyond that allowed by steady aerodynamics and an inverted wing during the upstroke to further aid weight support. The bat wing and its skeleton exhibit many features and control mechanisms that can be understood as improving flight performance. Yet, bats appear aerodynamically less efficient than birds when it comes to cruising flight, while bats have the edge over birds when it comes to manoeuvring. There is a direct relation between the kinematics and the aerodynamic performance, but there is still a lack of knowledge about how bats control the movements and shape (planform and camber) of the wing. Considering the relatively few bat species whose aerodynamic tracks have been characterized, there is scope for new discoveries and a need to study species representing more extreme positions in the bat morphospace.

Poster 26: Stereotypic flight paths: a way to focus attention while foraging?

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The big brown bat, *Eptesicus fuscus*, uses echolocation for orientation and foraging. *E. fuscus* scans its surroundings by aiming its sonar beam at relevant objects.The bat receives stroboscopic updates whenever it echolocates and changes its pulse repetition rate and number of sonar sound groups depending on clutter density and target movements. However, in a foraging situation, the bat's attention must necessarily be divided between navigating its surroundings and catching prey. Catching moving evasive prey, while keeping a lookout for obstacles could conceivably be a difficult task. By using stereotypic flight paths in known areas, bats may be able to reduce the amount of attention needed for orientation and therefore focus more on foraging. A previous experiment has shown that *E. fuscus* do adopt to stereotypic flight patterns when navigating obstacles under laboratory conditions.
Here we investigated whether *E. fuscus* flying freely in the wild uses stereotypical flight paths when foraging in a semi-open field.
A ¼" G.R.A.S. multi-microphone array arranged in a cross shape was placed in a foraging area close to Lake Artemesia, MD, USA. The area was a rectangular open space (approximately 20 m x 45 m) flanked by a high fence and a deserted road at either end, and a thicket of trees and a small creek along the two opposites sides. We computed the bats' 3D position at each sonar call emission based on arrival time differences at the nine microphones in the array determined by cross-correlation and triangulation. Subsequently we estimated flight paths based on the sound emission times. Each flight path was displayed to visualize any overlap and thus determine if flight paths were fixed and stereotyped to reveal if bats preferred to patrol the area along stable unchanging trajectories.
Although the foraging area was a semi-open field with no clear obstacles other than the field boundaries, the bat flew in a stereotypic flight path while hunting for prey. These flight paths may aid the bat in focusing its attention and limited perceptual "bandwidth" on catching prey.

Poster 27: Echolocation and flight behaviour in the brown long-eared bat (*Plecotus auritus*)

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The tremendous evolutionary success of bats has been attributed to two main properties, flight and echolocation. Together they enable bats to forage in the night sky, a niche thought to have been relatively underexploited before the emergence of bats. Our knowledge of the flight behaviour of bats and their echolocation system is steadily growing, but most research has focused on the two properties separately. Hence, little is known about the interdependence and integration of the two.

To study the sensory motor integration of echolocation and flight in bats, we flew four brown long-eared bats (*Plecotus auritus*) in the low turbulence wind tunnel at Lund University over a wide range of flight-speeds. We recorded their echolocation emission using a nine-microphone array and their flight behaviour using high-speed cameras. This setup enables us to monitor changes and adaptations in the bats flight behaviour and in the temporal and spectral properties of their echolocation emission as well as changes in their echolocation beam aim and beam shape. Preliminary analysis indicates that when faced with contradicting sensory-motor information, flying at high speeds in confined space, sensory information dominates i.e. the bats emit short, high frequency calls at low intensities irrespective of flight-speed.

Poster 28: How anthropogenic noise affects bat foraging

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Anthropogenic noise is becoming a priority concern for nature conservation. In many animal species noise impairs foraging, consequently reducing survival and reproductive success. However, the mechanisms of noise disturbance are poorly understood. Here we developed a diagnostic framework to simultaneously test three hypotheses. We then implemented it in behavioural experiments with Daubenton's bats, which find insect prey by echolocation. During the playback of traffic noise most bats suffered a reduced foraging success, even if the noise did not spectrally overlap the echoes of prey. Neither overlapping nor non-overlapping noise influenced the search effort required for a successful prey capture. These results show that noise did not interfere with detection of prey by masking its echoes, nor did it reduce the attention available for foraging. Instead, foraging success was reduced because bats actively avoided both noise types and searched for prey less often than in the silence treatment. Noise acted as an aversive stimulus that caused avoidance or potentially even a stress response, although it did not interfere with prey perception or overload attention. Conservation policies may seriously underestimate numbers of species affected and the additive impact of diverse effects on animal fitness, by not considering the mechanisms of disturbance.

Poster 29: Buzz II vary in duration accordingly to the level of difficulty when catching prey, in the bat *Myotis daubentonii*

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Myotis daubentonii is an echolocating vespertilionid bat that prefers to hunt over water by trawling, but occasionally hawk for prey in open areas. The hunting behavior of *M. daubentonii* consists of four stages; namely the search phase, approach phase and a terminal phase divided into a buzz I and buzz II. During the buzz the repetition rate increases rapidly up to around 200 Hz and the call frequency decreases by approximately an octave to terminate around 20 kHz. The duration of this buzz II phase is very flexible and can vary considerably.
We tested the hypothesis that the duration of the buzz II would change according to the degree of difficulty in the task, assuming that a moving prey is more difficult than a stationary prey, and that catching prey from mid-air is more difficult for *M. daubentonii* than catching prey from the water surface.
In the lab, three *M. daubentonii* were trained to take prey from the water surface in a small pond, and also from a string hung from the ceiling. The prey could be still or it could be rotated in a steady pace – either on the water surface or in midair. The bats' acoustic behavior was recorded with a multi-microphone array with 4 ¼'' G.R.A.S. microphones, and the sound files analyzed afterwards.
We found that the length of the buzz II phase did indeed vary considerately between tasks ranging from 31,2ms to 370,1ms. The shortest buzzes were for stationary prey on the water, whereas moving prey in air resulted in the longest average buzz-duration. Evasive prey is harder to catch than still prey, and must presumably be pursued more closely for a longer period of time. Based on our results we propose that buzz duration could be a proxy for the degree of difficulty for a given task. If so, catching prey on a water surface, even when moving, is easier for the bats than catching still prey in mid-air. The easiest task was to catch still prey on the water surface, whereas the hardest task was catching moving prey in mid-air.

Poster 30: Directionality of sonar calls emitted by *Macrophyllum macrophyllum* in open and cluttered habitats

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Echolocating bats dynamically adjust acoustic features of their calls to the situation and behavioral context. Recent results show that they adjust not only temporal and spectral characteristics, but also directionality of the sonar beam, which in mouth emitting bats is adjusted by a combination of frequency and mouth opening. The trawling vespertilionid *Myotis daubentonii* opens the mouth wider to decrease beam width to only 20° half amplitude angle (HAM) in the field vs. 40° in the lab [1]. The nose-emitting neo-tropical bat *Macrophyllum macrophyllum* is the only trawling phyllostomid bat. It is unknown if it also adjusts the directionality of the beam to the context. A closely related phyllostomid bat, *Carollia perspicillata* emitted a narrow beam with little variation in different lab-situations [2]. We recorded wild *M. macrophyllum* in its natural habitat over open water and in a flight room in Panama. We determined directionality for the whole call and also for each harmony separately to reveal any morphological adjustment. The horizontal directionality of *M. macrophyllum* had HAM of 21° in the open and HAM of 26° in cluttered space, i.e. slightly broader. The main energy of the calls was shifted to higher harmonics in clutter. The slight increase in beam width and the energy shift to higher harmonies may indicate some adaptive changes in sound beam directionality in *M. macrophyllum* but the effect is only small and the biological relevance is not obvious. The general acoustical behavior of *M. macrophyllum* probably reflects both phylogenetic and ecological niche specific constraints. It is a rare example of a trawling bat that forages successfully both highly cluttered and fully open environments making it a unique species within its family and within the whole order of Chiroptera

[1] Surlykke, A., S. B. Pedersen and L. Jakobsen (2009). "Echolocating bats emit a highly directional sonar sound beam in the field." Proceedings of the Royal Society B: Biological Sciences 276(1658): 853-860.
[2] Brinkløv, S., L. Jakobsen, J. M. Ratcliffe, E. K. Kalko and A. Surlykke (2011). "Echolocation call intensity and directionality in flying short-tailed fruit bats, Carollia perspicillata (Phyllostomidae) a)." The Journal of the Acoustical Society of America 129(1): 427-435.

Poster 31: Sexual size dimorphism in wing morphology in European bat species – preliminary results

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Sexual size dimorphism (SSD) occurs in all groups of vertebrates and presents an important manifestation of certain ecological mechanisms in populations. The SSD in some species may be missing, atypical female-biased or typical male-biased. In bats, females are usually larger than males, and these differences apply to both body mass, cranial elements and wing morphology. Several hypotheses have been suggested to explain this phenomenon: it may be the result of sexual selection, the effect of nursery time, or the size of the species' foraging area. Each factor may have a different influence on the species' aerodynamic capabilities.
We analyzed the wing measurements of five bat species: two closely-related species: *Myotis myotis* and *M. blythii*, two ecologically similar species: *M. daubentonii* and *M. capaccinii*, and a long-distance migratory species: *Miniopterus schreibersii*. Pronounced SSD was observed in three out of the five species studied, and the parameter in which the species showed greatest sex differenciation was the forearm length. Females of *M. myotis* and *M. blythii* moreover have consistently longer fingers: significant differences in the first two phalanges of each finger were found in *M. myotis*, while in *M. blythii* significant differences were found in the first phalange of each finger. Among the “trawling” bat species, only *M. capaccinii* exhibited a slight SSD, while in *M. daubentonii* sex dimorphism did not occur. Similarly, no difference in wings morphology between the sexes was found in *M. schreibersii*. Moreover, significant differences between females and males were found in aspect ratio index and area index for *M. myotis*, tip index and area index for *M. blythii*, and area index for *M. capaccinii*.
Preliminary results showed that the SSD in the wings of bats is not uniform, and is more likely to depend on several factors rather than one main single factor. It is hoped that further research including other bat species and parallel analysis of both wing morphology and cranial elements will foster better understanding of which factors are responsible for SSD in bats.

Poster 32: Bat species comparisons based on external morphology: a test of traditional versus geometric morphometric approaches

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External morphology is commonly used to identify bats as well as to investigate flight and foraging behavior, typically relying on simple length and area measures or ratios. However, geometric morphometrics are increasingly used in the biological sciences to analyze variation in shape and discriminate among species and populations.
Here we compare the ability of traditional versus geometric morphometric methods in discriminating between closely related bat species, in this case European horseshoe bats (Rhinolophidae, Chiroptera) based on morphology of the wing, body and tail. In addition to comparing morphometric methods, we used geometric morphometrics to detect interspecies differences as shape changes.
Geometric morphometrics yielded improved species discrimination relative to traditional methods. The predicted shape for the variation along the between group principal components revealed that the largest differences between species lay in the extent to which the wing reaches in the direction of the head. This strong trend in interspecific shape variation is associated with size, which we interpret to be a consequence of evolutionary allometry.

Poster 33: Echo-acoustic adaptions in a bat-pitcher plant-mutualism

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The Bornean woolly bat *Kerivoula hardwickii hardwickii* is symbiotic with the carnivorous pitcher plant *Nepenthes hemsleyana*. This plant captures less arthropods than closely related *Nepenthes* species. However, it compensates this nutrient deficiency by harbouring bats that fertilize the plants with their faeces while roosting in the plants' pitchers. However, the bats and the pitcher plants are rare and occur in highly cluttered peat swamp forests. To maintain their symbiosis, both partners are thus faced with the problem to find each other regularly. We hypothesized that the plants show similar echo-reflecting adaptations as Neotropical bat-pollinated plants. Therefore, we measured the echo impulse responses of *N. hemsleyana* pitchers and compared them to those of a closely related pitcher plant species, which does not serve as a bat roost. We found that a parabolic structure at the back of *N. hemsleyana*'s upper pitcher wall reflects a strong and conspicuous echo. In fact, our behavioural experiments showed that this structure is important for the bats to find and select pitchers. Our study demonstrates that bat-dependent plants in the Neotropics and in the Paleotropics have evolved convergent structures, albeit for completely different reasons.

Poster 34: Phenotypes of newly generated cells in the adults' brains of some species of the Rhinolophidae bats

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In the brain of adult mammals neurogenesis continues in two regions: the dentate gyrus (DG) and subventricular zone of the lateral ventricles (SVZ). Here we present data concerning neurogenesis in brains of *Rhinolophus* (Rh) *ferrumequinum*, *Rh euryale*, *Rh mehely* and *Rh hipposideros*. These bats were captured on permission of the Ministry of Environment of Armenia. After capture all bats were injected with bromodeoxyuridine (BrdU, 300 mg/kg). Seven to nine days later animals were perfused transcardially with 4% paraformaldehyde in narcosis. We used immunohistochemical double-labeling to characterize the phenotype of newly generated cells. Colocalization of BrdU with NeuN (marker of mature neurons), glial fibrillary acidic protein (GFAP, astrocytic marker) and 2`,3`cyclic nucleotide phosphatase (CNP, oligodendrocytic marker) was examined using confocal microscope. We found that in both neurogenic regions the rate of neurogenesis was highest in *Rhinolophus ferrumequinum* and lowest in *Rh mehely*. Double-immunolabeling showed that in all neurogenic regions of the bats' brain the neuronal phenotype dominated among newly generated cells, while proportion of astrocytes was low. BrdU colocalized with CNP in only a few cells in the SVZ of *Rh ferrumequinum*. We conclude, that bats show typical mammalian adult neurogenesis, though at rather low level and suggest that the rate of neurogenesis in different species may depend on the bats' ecology.

SESSION IV: MIGRATION OF BATS

Poster 35: Male mating strategies and reproductive success in a bat with an exceptional mammalian dispersal pattern

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Leaving the natal group prior to reproduction (i.e. natal dispersal) is an important life history trait, affecting the demography and genetic structure as well as the evolution of social behaviour. The mating system is discussed to be one of the major factors shaping natal dispersal patterns of birds and mammals. Although bats form the second largest mammalian order, the mating system of only 7% of all known bat species has been studied so far. Polygyny appears to dominate group-living bats and female defence supposedly leads to male-biased natal dispersal. However, which and how factors (e.g. avoidance of inbreeding, local mate and resource competition and kin cooperation) shape dispersal patterns is still discussed controversially. Studying exceptions to general patterns of natal dispersal in mammals, for example, female-biased dispersal in the proboscis bat (*Rhynchonycteris naso*), provides a valuable opportunity to test the validity of proposed evolutionary pressures. While female dispersal in the Proboscis bat can be explained by avoidance of father-daughter inbreeding, since their age at first conception falls below the tenure of males, a former study suggested a female-defence mating strategy of male Proboscis bats. The latter is hypothesized to lead to male-biased dispersal due to severe local mate competition between male kin. Based on exhaustive long-term behavioural observations on individually banded Proboscis bats and genetic data on male reproductive success, we assess these seemingly contrary findings and specify the complex mating strategy of male proboscis bats, which appear to have more common traits with the closely related Greater Sac-winged bat (*Saccopteryx bilineata*) than previously thought.

Poster 36: Do opposites attract? Disassortative grouping in harems of Nathusius' bats during autumn migration

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Migratory bats are a prominent example for often weak population structures close to panmixia and large breeding populations which make it difficult to track back spatial origins of reproductively active individuals (e.g. Petit & Mayer, 1999). Traditional techniques like banding-recapture are limited, plus any mating strategies are still cryptic due to observational hurdles. In this study in Eastern Germany, we examined how spatial origins vary within and among mating groups at stopover sites, so called harems ($n \geq 1$ female). If mating in *Pipistrellus nathusii* would be influenced by this, distinct groups among conspecifics should be observable during stopovers. We studied harems of *P. nathusii* at two sites in Saxony-Anhalt, Germany. Phenology of migration and formation of social units were recorded via presence-absence quantification in bat boxes ($n = 217$) from July to October 2012. Reproductive readiness of territorial males was systematically controlled and the migratory background of both sexes was determined applying stable hydrogen isotope analysis of fur keratin (δ^2H_f). To gain insight into grouping patterns we post hoc compared stable hydrogen based origin information among harem members. First of all the range of δ^2H_f in *P. nathusii* was three times larger when compared to sedentary species, indicating that *P. nathusii* crossing stopover sites in Eastern Germany originate from multiple isoclines. Secondly, harems exhibited a significant negative correlation between δ^2H_f of female members and the corresponding dominant and reproductively active male ($r = -0.54$; $p = 0.004$; $n = 26$ harems). It became obvious that non-random grouping behaviour can occur in territorial males and females of *P. nathusii* during migration. The observed disassortative grouping in *P. nathusii* represents a precursor of selective mate choice which is in line with previous findings of a high level of gene flow among populations of ecological similar species. Numerous studies demonstrating males' advertisement songs along with courtship flights support selective mate choice. But, however, if this is driven by males or females can not be said and remains a puzzling aspect. Our results highlight a rarely observed mammalian social behaviour and an important function of mixing of individuals at conservational significant stopover mating sites.

Petit E., Mayer F. (1999) Male dispersal in the noctule bat (*Nyctalus noctula*): where are the limits? Proc. R. Soc. B 266: 1717–1722.

Poster 37: Are the spatial dynamics of bats in summer the foundation stone for the successful management of European bats?

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In Europe the successful management of bat/human conflict requires the maintenance of the disturbed bat populations. This principle is prescribed in international and national legislation using the concept of 'Favourable Conservation Status' (FCS); a poorly defined administrative tool essentially describing the maintenance of a viable population for the affected species. However, the application of FCS and especially the requirement to predict its maintenance is likely to become more complicated given climate change and the spread of land-uses known to disrupt populations (e.g. roads, wind power). Further, for the mitigation of conflict to be proportionate, it may be necessary to recognise that heterogeneous landscapes will lead to a variation in the importance of specific roosts and require spatially specific predictions.

The quantitative assessment and prediction of FCS using agreed methodologies and robust data would help in informing decision-making in this complex context. Underpinning any quantitative approach is a functionally appropriate description of the unit of space, and by extension, of population at which to model and predict population dynamics. Separately and simultaneously, we are looking to resolve two of the more robust but contradictory generalisations about boreal vespertilionids, their apparent philopatry to their natal sites, and the consistent and well demonstrated spatial dynamism of individuals across a number of roosts.

Both requirements are well met by considering a summer population comprised of a collection of neighbouring communities, each consisting of a constrained network of roosts across which a bat community continually re-sorts itself. The network consists of roosts varying in their eco-physical properties (e.g. thermal behaviour, size) which individual bats exploit in response to their changing physiological demands, weather, or the season. A number of projects have begun to illustrate aspects of such community/social networks (e.g. their geography), though complete descriptions are absent and robust descriptions of the communities that live across them are lacking.

Our goal is to describe both the geography of resource use (roosts and foraging sites) and the composition and behaviour of a community of Natterer's bats (*Myotis nattereri*) in Northern England in an exclusively natural setting, to both form the foundation of predictive models (population and epidemiological) and to help inform novel management solutions in complex conflict situations. Our work reinforces the concept of a social community of bats re-sorting itself across a constrained network of roosts and suggests an interesting contrast between natural settings and previous studies based on anthropogenic roost sites.

Poster 38: Revaluation of the range expansion of *Pipistrellus kuhlii* sensu lato in central Europe

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Since the recent review (2006) of the range expansion of *P. kuhlii* s. l. in central and eastern Europe, new data have confirmed its continuous and rapid spread. The species has colonized new areas in Ukraine, Romania and expanded to Slovakia and Czech Republic. According to the latest genetic studies, *P. kuhlii* s. l. comprises two species in central Europe: *P. kuhlii* in the south and *P.* cf. *lepidus* in the east (Poland, Ukraine). Although the first individual of *P.* cf. *lepidus* was recorded in Poland in 2005, first evidences of breeding population have been obtained in 2012 and 2013. In 2013 and 2014, we conducted field work focusing on this bat species in the south-eastern Poland. We recorded the species to be already established and locally widespread in anthropogenic habitats. Data from central Europe support the hypothesis, that the species colonizes new areas in jumps with subsequent saturation of suitable habitats. Monitoring of *P. kuhlii* s. l. expansion in Poland and research on its ecology are ongoing.

Sachanowicz, K., Wower A., Bashta A-T. 2006. Further range extension of *Pipistrellus kuhlii* (Kuhl, 1817) in central and eastern Europe. *Acta Chiropterologica* 8:543–548.

Poster 39: Male occurrence as a function of female density and habitat quality in Bechstein's bats (*Myotis bechsteinii*)

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During their reproductive period many bat species of temperate climate zones show segregation and differences in space use between sexes. Pregnant and lactating females have a higher energy demand that leads to a concentration of reproductive females in areas with high prey availability. As males exhibit lower energy demand during this period they can cope with less profitable areas. This may lead to a segregation of sexes that often is confirmed on a regional scale. In this study we investigate if even a less mobile bat species as the Bechstein's bat (*Myotis bechsteinii*) exhibits sexual segregation – this segregation is expected to happen on a very local scale. To test this, we developed a habitat suitability model based on radio-tracking data of 43 individuals to analyze the habitat requirements of Bechstein's bats in the study area. We then analyzed the capture rate of males according to habitat quality and presence of females at 293 trapping sites. These analyses show that with increasing numbers of females in an area, males significantly more often occur in habitats with lower quality; an effect that is to be observed on a scale of 100 m. This indicates that males use habitats with lower quality to avoid intraspecific competition on a very small scale.

SESSION V: SOCIALITY AND MOVEMENT ECOLOGY

Poster 40: Movement and sociality of *Rhinolophus ferrumequinum* in October at a nursery roost and a hibernaculum in the U.K.

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R. ferrumequinum were located at a nursery roost and a hibernaculum during October, when these bats mate in the U.K. At Stackpole, West Wales, *R. ferrumequinum* flying in and out of the nursery roost, were detected by infrared beam arrays mounted in the entrance/exit hole, together with automated computer systems installed nearby. Social behaviour inside the nursery roost was monitored using simultaneous infrared video and ultrasound recordings. Outside the nursery roost bat social behaviour was monitored with low light/infrared video records. Simultaneous ultrasound recordings, stored in a Sony ICD-MSI voice recorder, were coupled with the input from a speaking clock. Social behaviour was monitored in a cave at Chudleigh, Devon, which is a hibernaculum occupied predominantly by mature male *R. ferrumequinum* in October. Roosting bats were counted at midday at the beginning of 24 h automated ultrasound-recording sessions when the same ultrasound equipment was used as above. Ultrasound calls (x 32 time expansion) recorded with Tranquillity detectors (Courtpan) were analysed using BatSound (Pettersson), with a Hanning window and a FFT size of 512, and the ultrasound social calls were identified according to categories described by Andrews and Andrews (2003). The CF-FM-CF *R. ferrumequinum* echolocation calls (calls/h) were used to record the level of activity. Ultrasound social calls with fundamental frequencies in the range 11-39 kHz were identified at each location but complex frequency modulated oscillatory trill calls, with 5-7 components, were evident inside the cave in Devon (categories FM VII t, FM XIII t and FM XIV t). Inside the nursery roost less complex trills calls were identified with 2-4 components (categories FM IV t, FM V t, FM VI t) as well as the trill calls with 5-7 components. The ratio of 2-4:5-7 component calls inside the roost was 3.8:1. Outside the roost only the less complex 2-4 component trill calls were recorded. The predominance of the more complex 5-7 component trill calls in the cave in male *R. ferrumequinum* territory indicates that these bats make calls that have sufficient variety to identify individuals at a distance. However, the oscillatory trill calls inside the nursery roost suggest that some mating activity also occurs in predominantly female *R. ferrumequinum* territory and that social behaviour outside the nursery roost in October is not ‘light sampling’ but has a

specific purpose related to mating.

Andrews, M. M. & Andrews, P. T. (2003). *Acta Chir.*, 5 (2): 221-234.

SESSION VI: MOVING BATS AND DISEASES

Poster 41: Monitoring bat populations in Ghana

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Bats are receiving increasing attention as reservoirs and potential natural host of infectious agents and zoonotic diseases (Calisher *et al* 2006, Luis *et al* 2013, Clayton *et al* 2013, Hayman *et al* 2013). Ghana is reported to have at least 89 species of Fruit bats; all 11 genera of fruit bats (pteropodidae) known to occur in West Africa are found in Ghana (ACR 2013, Rosevear 1965, Yeboah 2007). There is evidence for viruses in these bats and potential spillover into domestic animals in Ghana has been reported (Wright *et al* 2010, Hayman *et al*, 2011). This highlights risk of potential spillover into humans as there exists high human-bat interactions such as hunting bats for bushmeat, contact with faeces and urine under roosts in close proximity to humans (Mickleburgh *et al* 2009, Kamins *et al* 2011). Very little is known about the ecology of most of these bats (Richter and Cumming 2008, Limperte *et al* 2007) and there is a general lack of long term population and demographic data, poor quantification of distribution and movements for most of these species (Wood *et al* 2010). Such data are essential for understanding how disease dynamics change with time and life history, identify potential interactions and possible spillover routes of pathogens between bats and other animals and humans, and connectivity between roost or populations. These factors are known to influence disease occurrence and dynamics (Hayman *et al* 2013). This study seeks to provide demographic information and monitor trends of bats species populations in primarily three study sites using capture-recapture methods. The study also uses a citizen science approach to identify other bat roost sites in Ghana and GPS telemetry to track bat movements to help identify bat-human contact areas and possible spillover routes. Preliminary results show several roosts are reported for the first time suggesting that bat populations in Ghana are higher than previously estimated. The population monitoring shows seasonal variation in occurrence at the different roost sites and for different species and sympatric species at roost sites. Current marking methods have resulted in very low recapture rates of 2.9% of 1741 marked individuals and two attempts of GPS telemetry tracking have proved ineffective. Future steps would be to try more effective GPS tracking methods and capture-mark methods like radio-tracking.

Poster 42: Impact of guano mining on insectivorous bat colonies and guano miners in Turkey

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To date, 39 bat species have been found in Turkey. The most commonly encountered bat species belong to the families Vespertilionidae and Rhinolophidae. Both families generally form maternity and hibernation colonies in caves. Today, bat populations are seriously declining in Turkey as is the case worldwide because of anthropogenic disturbance and destruction of their roosts. Major threats to bats and cave ecosystems in Turkey include increasing urbanization, habitat loss, environmental pollution, illegal killing of bats, and deterioration of cave ecosystems due to guano mining. Attention should be drawn immediately to the regulations for the protection of cave ecosystems for the sustainability of biological diversity in various caves.

In recent years, bat guano has often been used as a natural organic fertilizer by farmers because of its rich content and yield. However, in addition to the benefits of guano, it may also possess pathogenic organisms such as the thermodimorphic fungus *Histoplasma capsulatum* var *capsulatum* and this fungus is the agent of the systemic disease histoplasmosis, which is not extensively known and has not yet been studied in detail in Turkey. Various guano companies have been legally marketing bat guanos from 30 caves in 12 provinces. However, illegal mining is frequently detected during our field research. Harvesting is being conducted all year round, especially in regions like the Mediterranean and the Aegean, where the climate is warm and appropriate for mining. Improper guano harvesting may devastate bats in caves, especially those containing roosting colonies including maternity/nursery colonies and hibernacula of bats. In this study *Myotis myotis / blythii* and *Miniopterus schreibersii* colonies are examined from Central and Aegean regions to determine the negative effects of guano mining on bats and people.

Poster 43: Movement activity of bats inside the cave during hibernation

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Many species of small, temperate zone mammals spend much of the winter in hibernation, minimizing their energy expenditure when there is little or no food, and when ambient temperatures are generally low. Hibernation is interrupted by periods of arousal, which requires costly thermogenesis and may occur for a number of behavioral and physiological reasons which are not mutually exclusive. They may depend largely on the ecology of a given species, its distribution and the local environment.
Movement activity of bats was studied in a limestone cave during two winter seasons 1992/93 and 2011/12. We used the visual census method (biweekly period) without any handling and marking of animals, as one of the main requirements of our research was to avoid any disturbance of the hibernating bats. The exact position of a hibernating bat was registered with information whether it was a new finding or the same specimen/cluster again during the subsequent visit. During the second season bat movements through the hole in the gate were monitored continuously by a custom-made IR barrier.
The findings of *Myotis myotis* and *Rhinolophus hipposideros* accounted for a major part of the data obtained. Bat activity reaches its lowest levels during mid-winter when the proportion of time spent in torpor is greatest. Nevertheless, pattern of activity is species specific and the hibernation period of *R. hipposideros* could be divided into three different parts. The level of *M. myotis* movement activity was relatively high during all season this species clusters more by the end of hibernation. The consequences for WNS spread are also discussed. This study was supported by the grant of GACR No. 506/12/1064 and institutional support RVO:68081766.

Poster 44: Ticks (Acari: Ixodidae) parasitizing bats in Montenegro

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Ticks are identified as important vectors of pathogens parasitizing large number of mammalian host species, including bats. In comparison to other tick hosts, bats are largely understudied, especially in the central part of the Balkan Peninsula. The ability to fly and cross different geographic barriers makes bats important study organisms from the aspect of distribution of ticks specific to bats and potential pathogens which can be carried and transmitted by them. Identification of host-parasite relationship, infective agent and its arthropod vector is necessary to understand the tick-borne diseases which can represent important public health and conservation issue. The present study represents new findings and records of tick species collected from bats in Montenegro. Data were collected at seven localities in Montenegro. Bats were caught using mist net placed at cave entrances, identified to species level, measured forearm, weighted, sexed, and released at the same site where caught. The whole body of the bat was carefully examined and using tweezers all ticks were collected, pooled per bat individual, placed in tubes with 70% ethyl alcohol, and labelled appropriately. Determination of taxonomic status of tick species was done using both morphological and molecular approach using cytochrome oxidase subunit I (COI) gene. For amplification of COI gene universal primers LCO1490 and HCO2198 were used. We examined 149 bats of nine different bat species: *Rhinolophus euryale*, *R. ferrumequinum*, *R. hipposideros*, *Miniopterus schreibersii*, *Myotis blythii*, *M. capaccinii*, *M. daubentonii*, *M. myotis* and *M. nattereri*. A total of 14 ticks belonging to two species were collected from six different bat species (*Rhinolophus euryale*, *R. ferrumequinum*, *R. hipposideros*, *Miniopterus schreibersii*, *Myotis blythii* and *M. myotis*). *Ixodes vespertilionis* was the most abundant and widespread tick. To the best of our knowledge, the study presents first published records of *I. simplex* and *I. vespertilionis* in Montenegro. The only specimen of *I. simplex* was collected from one individual of *Rhinolophus euryale*, which we identify as new possible host/parasite association.

Poster 45: Investigating ecological factors and the presence of *Pseudogymnoascus destructans* on bats and in their hibernation sites

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With the growing interest towards understanding emerging infectious diseases and how they are transmitted and spread, research on white-nose syndrome (WNS) affecting North American bats has become an important scientific topic with important implications for conservation. First documented in 2006, over six million hibernating North American bats have been estimated to have died from this emerging disease affecting caused by the cold-loving fungus *Pseudogymnoascus destructans (Pd).*

Investigations suggest that *Pd* is a novel pathogen in North America but native to Europe where there is no reported mass mortality associated with the fungus. Little is known about the prevalence of *Pd* in bat hibernation sites in Europe, the mechanisms of infection, the ecological predictors for its presence and the spatial distribution across the continent.

In this study, bat swabs and environmental samples from hibernacula across Europe and especially Germany were collected and investigated for the presence of *Pd*. A new method has been developed for the genetic screening of *Pd* presence in sediment samples. Cultures from environment samples were also carried out to give information on the amount of viable *Pd* in the environment, information not available from genetic screening methods. In agreement with field observations, modelling showed that this fungus is highly associated with *Myotis myotis*, the species most often seen with fungal growth, suggesting a host-dependent presence and possibly propagation. Relative humidity and temperature within the sites are the main abiotic factors predicting the presence of *Pd.* All together, our results provide evidence that *Myotis myotis* plays an important role in the life-cycle of the fungus and as the host is a highly mobile species, we hypothesize that the species is a key element in the transmission and spread routes of the fungus. Our study is the first to characterize factors affecting *Pd* presence, leading to a better understanding of the host-pathogen interaction and pathogen ecological requirements.

Poster 46: First specific data on the occurrence of EBLV in bats from Ukraine

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So far, two of the five fatal cases in Europe of rabies in humans due to bat bites took place in Ukraine in respectively 1977 and 2002. One more case occurred in an adjacent region of Russia in 1985. However, until recently, no systematic bat rabies surveillance has been carried out and the current system of data collection (no species identification, no initial details on circumstances of bat finding, no typing of positive cases) does not provide a clear picture of the occurrence of rabies in bats in Ukraine. We analysed brain samples taken from dead bats or those which had to be euthanased because of serious injuries (n=106 individuals). Among them, there were 21 specimens of the Common Noctule Bat, Nyctalus noctula, (years of collection: 2007 and 2010 in two cities) and 85 specimens of the Serotine Bat, Eptesicus serotinus (years: 2009–2014 in five cities). All details on tested bats were recorded. For testing we applied the method of RNA extraction, and RT-PCR. RNA extraction was performed using a protocol developed by the CVI. Total nucleic acid was isolated using the MagnaPureLC isolation robot (Roche-Diagnostics©) according to the manufacturer's instructions. PCR was performed with an in-house EBLV-1 specific real-time RT-PCR on a Roche LightCycler2.0. No positive cases were revealed among the analysed N. noctula. Six samples from E. serotinus were shown to be positive for EBLV-1: three from Kiev (1 – in 2010 and 2 – in 2011) and three from Kharkiv (2013). The absence of positive cases among the analysed Common Noctule Bats corresponds to the results from other European regions. The incidence of EBLV-1 in E. serotinus is relatively low (6%) in comparison with results of passive surveillance of bat rabies in some other countries (e. g. the Netherlands, Germany and France).

SESSION VII: CONSERVATION AND MOVEMENT ECOLOGY OF BATS

Poster 47: Bats at Risk! How informative are results from high-altitude surveys of bat activity at wind turbines? Practical applications

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Here we present results of standardized high-altitude surveys of bat activity at wind turbines, conducted by the Büro für Faunistik und Landschaftsökologie (Bingen am Rhein, Germany). In addition to a bioacoustical monitoring designed to detect bat activities at high altitudes (i.e., at rotor height ranging from 65 to 145 m), systematic ground searches for collision fatalities were conducted. The presented results include data from in total 31 wind farms (including 98 wind turbines) in Rhineland-Palatinate, Saarland, Hesse, Baden-Wuerttemberg and (northern) Bavaria, covering the years from 2010-2013. Surveys were conducted yearly April-October, and bat activity was recorded from 3 pm until 9 am each day.

We only present results from studies that were conducted with exactly identical ultrasound recording devices. The devices were mounted inside the wind turbine nacelles, placing the microphones on the outside of the nacelle walls. Exact locations depended on the wind turbine type. In addition, recent surveys often included a ground-level reference point, as well as additional recording devices at intermediate heights to account for methodological differences in microphone recording range. It remains to be seen if this approach will yield crucial results that will be relevant in practice.

The data set comprises a total of 63,487 bat call sequences obtained from 189,322 recording hours. Nine species were recorded, and further records of *Myotis* and *Plecotus* (at genus level). We found clear evidence of species-specific yearly and diurnal activity patterns. Bat activity patterns were strongly influenced by nursery period, swarming and courtship behaviours (for non-migratory species), as well as migration events (for migratory species). Species of the genera *Myotis* and *Plecotus*, both comprising species hunting in cluttered habitats (i.e. near vegetation or ground), were under-represented at rotor height (i.e., higher altitudes), except for samples recorded at older wind turbines (i.e. at 65 to 139,5m rotor height).

Future work including further statistical analysis of the data will investigate the scientific reliability and conclusiveness of the data. Preliminary results indicate that the number of species-specific flight activities at high altitudes is driven by both biotic and abiotic factors. *Nyctalus noctula* showed a trend of decreased flight activity at increasing rotor height. *Pipistrellus nathusii* and *P. pipistrellus* showed a trend of increased wind tolerance in open landscapes compared to forested areas. It appears that these bats fly at lower wind speeds over forests.

Poster 48: Bats at Risk! Reality versus statistical model: Do systematic fatality searches yield a realistic picture of species-specific threats to bats from wind turbines?

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This study, conducted by the Büro für Faunistik und Landschaftsökologie (Bingen am Rhein, Germany), reports results from standardized monitoring programs used to detect the impacts of wind turbine operation on bats in southwestern Germany. In addition to a bioacoustical monitoring designed to detect bat activities at high altitudes (i.e., at rotor height ranging from 65 to 145m), systematic ground searches for collision fatalities were conducted. We here present results from fatality searches at 28 wind farms (73 wind turbines in total) in Rhineland-Palatinate, Saarland, Hesse, Baden-Wuerttemberg and (northern) Bavaria, covering the years from 2007-2013.We only present results from studies that were conducted with exactly monitoring schemes.

We conducted standardized, systematic monthly fatality searches from April-October of each year. Within each month, each turbine was searched daily for a period of ten consecutive days. All searchable areas within a 50m-radius of each wind turbine were examined. To ensure a realistic estimation of collision fatalities, methodological error must be taken into account. These errors were determined experimentally according to current technical specifications: percentage of searchable area, individual observer search efficiency, and rate of carcass removal by predators. We used the model-based estimation method developed by the Leibniz University of Hannover (http://www.kollisionsopfersuche.uni-hannover.de/index.php), which takes into account both the actual number of bat carcasses found and any methodological error, and also includes a correction factor for turbines with a rotor diameter of more than 70m (Behr & Rudolph 2013).

A total of 55 collision fatalities representing 5 species were found under 35 of the 73 searched wind turbines. The most common species found was *Pipistrellus pipistrellus*, which composed 51% of all discovered fatalities (n=28). The second most commonly found species was *Pipistrellus nathusii* (n=11), followed by *Nyctalus leisleri* (n=9), *Pipistrellus pygmaeus* (n=2) and *Vespertilio murinus* (n=2). Three individuals could not be identified to species level due to advanced decay of the carcasses. Among the animals where sex could be determined, the sex ratio was fairly balanced with 21 males and 23 females. We could not determine the sex of 11 individuals because the remains were skeletonized. Model estimates for the monitored wind farms indicate a collision rate ranging from 0 to 38 bats per turbine in a given year (with a confidence interval of 0-100 bats). The main factors affecting the collision rate estimate were the number of animals found and the proportion of searchable area at the turbine. When as few as one animal is found at a site with a low percentage of searchable area, this may lead to an inflated estimate of collision rate. Our results obtained from fatality searches also yielded

information on factors influencing the bat species occurring in the wind farms, such as seasonality (e.g., long-distance migratory species, or seasonal changes in height activity of resident species). In addition to seasonality, the location of the wind park (forest, open land, forest edge) and the type of turbine can also influence the turbine- and species specific-collision risk.

Poster 49: Invertebrate species richness of bat guano in Central Anatolia

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There are few studies on cave ecosystems in Turkey. However, bat guano is very significant for ecological studies due to its fauna. In a field research on autumn migration and hibernacula of bats, 3 male colonies of *Myotis myotis/blythii*, *Miniopterus schreibersii* and *Rhinolophus euryale* were examined in Central Anatolia. Relative humidity, with an average of 66% in limestone caves, was higher than in tunnels. The average temperature of caves was 16 °C. Fourteen *Myotis myotis /blythii* and 2 *Rhinolophus euryale* specimens were caught by hand net and examined for external parasites and then released. In addition, bat guano was collected from the localities. No ectoparasites were found on the cave specimens between September and November; however the parasitic fly, *Spinturnix myoti*, was found on the specimens in tunnels in September. In this study, dipters, nematodes, staphylinids, hemipters, mites, and other arthropods were found to be abundant in bat guano deposits from both caves and tunnels. In additon in one cave in Konya province, *Atheta triangulum* (Kraatz, 1856), was detected as a new record in this study.

Poster 50: BatLife Europe - a pan European bat conservation NGO

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BatLife Europe is an umbrella organisation of 33 NGOs, whose aim it is to promote the conservation of all wild bat species and their habitats throughout Europe. It does so by developing pan-European projects, assisting in capacity building, assisting national bodies in developing / implementing national conservation, lobbying at the EU or at national governments, co-ordinatig action in relation to special threats, giving international status to national NGOs and providing international support for national matters of concern. In this way, it provides a central European voice for bats.

Poster 51: Identifying key habitats in different scales provides a reliable basis for the conservation of forest dwelling Bechstein's bat

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Understanding key habitat requirements and distribution of a species is critical for its conservation as well as for prioritising and designing conservation measures. The almost most characteristic bat species that live in western Palaearctic forests is the tree-dwelling Bechstein's bat (*Myotis bechsteinii*). Both morphologically and bioacoustically, Bechstein´s bats are ideally adapted to using resources in woody areas. Due to their specific habitat requirements and their organisation in demographically independent small populations, Bechstein´s bats might be especially susceptible to habitat alteration or degradation. We radio-tracked 93 different reproductive females from 13 nursery colonies in different landscapes distributed in Germany and the Grand Duché of Luxembourg to identify key habitat requirements and habitat types preferred by Bechstein`s bats in a small scale area. Using Ecological Niche Factor Analysis (ENFA) leads to a good a priori knowledge of optimal habitat components and ecological niche parameters.
Based on the results from the small scale analyses we created habitat suitability maps with the help of a MaxEnt (Maximum Entropy Modeling) model to predict distribution and key habitats for Bechstein`s bat in a large scale area. MaxEnt utilises a statistical mechanics approach called maximum entropy to make predictions from incomplete information. It is crucial that MaxEnt only requires presence data, performed well and remained fairly stable at a set of different sample sizes in both prediction accuracy and the total area predicted. We selected a total of 32 environmental variables that were considered to directly or indirectly be relevant and hence affect distribution of *Myotis bechsteinii*. After examining all 32 variables only 8 variables were chosen for the final model. The other variables were stepwise removed from the model due to low contribution.
The results showed that the variable with highest gain when used in isolation is the amount (percent-) of oak trees, which therefore appears to have the most useful information by itself for modelling the bats distribution. The environmental variable that mostly decreases gain of the model when omitted is mixed broad-leafed forest.
Both radio-tracking studies as well as modeling habitat suitability maps indicate that Bechstein`s bats are largely dependent on old growth oak and beech forests. For the conservation of maternity colonies, it is vitally important to identify roosting sites that are well connected to foraging habitats providing high quality prey.

Poster 52: Guild-specific responses of bats to vegetation structure at different scales: implications for conservation

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Vegetation structure is one of the main factors affecting bat occurrence in forest habitats. Depending on their foraging strategy and eco-morphological traits, bats show different patterns of activity related to structural forest features. While many studies across the world have widely documented these relationships at the stand scale with field-based data, few investigations have explored relationships at larger scales. This lack of information is mainly due to field-based methods which may be costly and time consuming. Recent advances in remote sensing technologies such as Light detection and ranging (LiDAR) now provide high levels of habitat detail, allowing to study species-habitat relationships across a hierarchy of scales. In this study, the main objective was to identify key structural forest variables that influence bat activity at the guild level at both local and landscape scales. Because wing morphology and echolocation call type of bats define their spatial foraging niches, we expected to find structural key factors that influence bat presence in relation to the guild and the scale studied. We hypothesised that bats using long-range echolocation would be more affected by variables representing the degree of openess of the forest while variables describing the vertical vegetation structure would better explain activity of middle- and short-range echolocating bats. To test these hypotheses, we assessed bat activity in eight square kilometres dominated by forest habitats with the implementation of 96 forest sampling sites (12/km^2). A range of variables representing the structural heterogeneity of the forest were (i) collected in the field and (ii) extracted from the LiDAR data. Results from the analyses as well as the implications for bat conservation and forest management will be presented.

Poster 53: Seasonal bat activity near hedgerows in north-eastern Germany

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Bat activity is often concentrated near linear edge structures such as hedges, but detailed information is lacking about activity and movement patterns of different bat species near hedges. The understanding of habitat use and how bats move relative to specific landscape structures is important for modelling bat movement patterns and determining habitat suitability. We studied bat activity in relation to distance to hedges in an agricultural landscape of north-eastern Germany and recorded bat echolocation calls in 0, 50, 100 and 200 m from the hedges at five sites between April and October. Regression models revealed that bat activity in all species was highest near the hedges in spring. In autumn, activity increased significantly away from the hedges in the migratory species *Nyctalus noctula* and *Pipistrellus nathusii*, while for other species, such as those from the genus *Myotis* we did not find seasonal differences of spatial activity near hedges. The observed behaviour partly reflects the species' general foraging behaviour, but seasonally different movement patterns between species may likely be explained by migratory movements and the exploitation of seasonally different food items. Considering the rapid increase of wind energy development and concomitant bat conflicts, our study may help to improve landscape planning and it provides necessary information for defining distance thresholds for the operation of wind turbines near hedgerows to avoid bat conflicts.

Poster 54: A bat fatality risk model at wind farms in Dobrogea, Romania, using a GIS approach

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During the last 7 years, wind farms have powerfully developed in Dobrogea, Romania, due to low population density and favourable wind conditions. A total of 27 bat species were recorded in the area, which is also considered a migratory route, due to its proximity to the Black Sea. Environmental impact assessments, conceived in the preconstruction phases, were based solely on ultrasound detection and had a limited view on the seasonal changes in species diversity or key landscape features that may arouse interest for bats. This study compiles the information collected in 3 years of pre and post construction monitoring (2011-2014) of bat mortality at various wind facilities in the study area, in order to generate a regional GIS model of the potential mortality risk. The species which were considered more vulnerable are the ones that recorded mortality values in the mentioned period (*Pipistrellus nathusii*, *P. kuhlii*, *P. pipistrellus*, *P. pygmaeus*, *Vespertilio murinus*, *Nyctalus noctula*, *Eptesicus serotinus*, *E. nilsonii*). The elements of interest for bats were extracted from environmental datasets, based on their ultrasound activity recorded in the field (transit, hunting, social sounds). Literature observations were also taken into account in order to generate model

rules, such as the linear landscape favourability for certain species. Environmental variables were extracted from various datasets, such as the land use from Landsat Imagery, with field data collection and validation, digital elevation models from topographic maps together with the Copernicus dataset and climatic models from data logger monitoring, National Meteorological Administration data and wind farm data loggers.

Preliminary results show that wind turbines record the largest number of bat fatalities during the migration season. The turbines that record the highest mortality rate are located between or within key landscape features, such as forest edges, ridges, saddles or certain open spaces used as feeding grounds. Although carcass searches have not been performed using the same methodology, and data has not been corrected for searcher detection accuracy or scavenger removal trials within all the studies, the model can point out areas where bats are more likely to interact with turbines. If certain units would be shut down in the periods with high bat activity and low wind speed conditions, mortality could decrease by 40%, losing only 0.05% of energy productivity (e.g. Babadag Wind Farm). Applying the method for the entire wind farm block could significantly reduce bat mortality at a regional scale, while minimising energy productivity losses.

Poster 55: Using species distribution modelling to predict the risk to non-migrating bats at current and future wind energy facilities in Ireland

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Wind turbines have fatal consequences for bats with large numbers of fatalities recorded worldwide. Migration is thought to play a key role in the susceptibility of bats to wind turbines, with the largest fatalities consistently recorded during autumn migration. However, the impact of turbines on resident, non-migrating bat populations is less well-understood. Ireland has nine resident bat species. These species are migratory in mainland Europe but their Irish counterparts choose a more sedentary lifestyle and avoid migration in Ireland's mild climate. At least four of Ireland's bat species have shown considerable mortality at wind energy facilities in mainland Europe, suggesting they may be undergoing similar fatalities in Ireland. However, the presence of bats at wind energy facilities in Ireland is site specific and there is little information on how bats use, open, upland areas where wind turbines tend to be sited. This research constitutes the first step in investigating the impacts of wind turbines on bats in Ireland by identifying areas potentially sensitive for bats and suitable for wind energy development. Using wind speed as an indicator of current and future wind energy development, car based monitoring was used to gather bat presence data exclusively within areas of high wind. Eight-nine 50 km transects were carried out in 2013 and 2014. With this data, we tested an existing bat habitat suitability model constructed for Ireland and found it unsuitable for predicting bat presence in areas of high wind speeds. Using MaxEnt predictive modelling, bat habitat and landscape associations were modelled to predict patterns in bat distribution exclusively in areas with large wind resources. This research will inform future research on bat fatalities at wind turbines as well as appropriate wind farm planning.

Poster 56: Bats' use of aquatic habitats: a review emphasizing how anthropogenic impacts on water bodies affect bats

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Many bat species use aquatic habitats to feed (mainly on emerging insects) and drink water. Often aquatic bodies face eutrophication or other water quality issues that might affect bats and their survival or migratory routes, in case of migratory species that rely on aquatic resources. Understanding how the characteristics and quality of aquatic foraging habitats are influencing bat activity and richness might contribute to bat species conservation.
A review, based on the Web of Science, was conducted for bats' use of aquatic habitats. The focus was on how the anthropogenic impacts on water bodies affect bats. The characteristics of aquatic systems that affect their use by bats and gaps on current knowledge were also identified. Recommendations for future studies and conservation efforts are provided.
This review showed that the effects of water pollution and eutrophication on bats remain unclear. Different effects are reported for different species and different areas. Knowledge of bats' use of aquatic resources is available but very fragmented. More studies are needed for Africa, South America, and Asia, regions for which few data are available, as well as from arid regions where standing water is a limited resource. We also need more studies that examine multiple stressors in aquatic systems and bats, in particular for desert regions. Also, although some characteristics of aquatic systems, such as pond or river size, hydroperiod, insect availability, and habitat structure, have been found to be important, it remains difficult to make general conclusions about species or habitats.
Climate change may shift bat species distributions and may change aquatic insect emergence phenology. Conservationists might face new challenges and thus it is essential to understand how bats are utilizing aquatic resources.

Poster 57: Bats crossing the federal motorway A11 on the segment Finowfurt-Gramzow via different types and sizes of underpasses.

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The fragmentation of habitats and the functional elements between them cause by roads is particularly relevant for bats. Especially species commuting alongside linear landscape structures are affected (SMWA 2012). Essential references were found concerning the role of different road buildings as crossing aids for bats, that are not particularly build for wildlife. This study compares the permeability of 25 underpasses at the federal motorway A11 in northeastern Germany to find out, which size and type is currently used by bats and which surrounding parameters may be linked to acceptance or avoidance. The sites were classified in two dimensions: buildings smaller than 2 m² cross sectional area (CSA) and buildings larger than 2 m² CSA. Mist-netting enabled to capture species-specific crossings. Species range and a catching quota were compared to data of a two years lasting investigation on behalf of the biosphere reserve Schorfheide-Chorin. 238 individuals were caught all in all. All buildings smaller than 2 m² CSA could not be proved as permeable. With one exception all larger buildings were proved as permeable. Species range not only included species that are strongly tied to guiding landscape structures (Natterer´s bat, Daubenton´s bat, Brown long-eared bat) but also species that are less linked to these (Common pipistrelle, Soprano pipistrelle, Nathusius's pipistrelle, Greater mouse-eared bat and Barbastelle). Given to the small sample there is no significant meaning, but also single individuals of aerial hawking bats were caught (Nyctalus, Serotine). This result represents almost all species that are verified as numerously spread in this area. Catching quota was 21 times higher than in open space areas, which underlines the importance of these flying paths and shows the adaption of bats to one of the oldest motorways in Germany.

Poster 58: Bats feed pitcher plants with their faeces: Feeding experiments reveal the plant's benefits

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Mutualisms are key inventions in nature allowing the interacting species to utilize novel resources and settle in otherwise hostile habitats. However, the degree to which partner species benefit from each other is often unknown. The pitcher plant *Nepenthes hemsleyana* grows on nutrient poor soils and compensates the lack of nutrients with a threefold strategy: nutrient uptake 1st by the roots and 2nd by pitchers, which capture and digest arthropods. The 3rd and unique strategy of *N. hemsleyana* is that their pitchers are regularly used as roosts by bats (*Kerivoula hardwickii*) whose faeces, in turn, contribute more than 33% to the pitcher plants' nitrogen gain. Here we present a feeding experiment with *N. hemsleyana* plants to quantify the plants' benefits of harbouring bats. The pitcher plants were randomly allocated to four treatments: 1) not fed (i.e. nutrient uptake only by roots), fed with 2) arthropods, 3) bat faeces, and 4) both. By comparing growth and photosynthesis rates as well as the nitrogen, phosphorous and potassium content in new grown leaves we demonstrate that the plants significantly benefit at multiple levels whenever they are fed with bat faeces. This shows that *N. hemsleyana* is strongly depending on its bat interaction partner.

Poster 59: Effects of forest management and forest structure on bat species diversity and foraging activity in different forest types of Brandenburg

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Bats are essential to maintain the ecological balance in forests due to their ability to control insect pests. On the other hand, forests are important foraging and roosting habitats for most bat species. Therefore, the understanding of the interactions between forested habitats and bats is important to derive implications for effective forest management.
We investigated effects of forest stand type, stand age, forest composition, and understory vegetation on bat species activity and nocturnal insect prey in structurally distinct types of forests in Brandenburg, Germany. We chose sampling sites according to different management practices in a) pine forest, b) mixed forest and c) deciduous forest and subdivided into plots of different structural complexity. Bat activity was recorded between April and October in two subsequent years (2012 and 2013) using Batcorder devices (EcoObs, Germany). Results from automatic sound analysis (batIdent, bcAdmin; EcoObs, Germany) have been verified with BatSound (V4.1, Pettersson Electronics). To validate species identification from bat call analysis, ground-based and high mist-netting (8-10 m) was additionally conducted to inventory occurring bat species. Insect community was investigated using short-radius attracting 6W- blacklight-traps.
In total, we analyzed 23708 recordings from 130 nights of acoustic monitoring. It turned out that particularly stand type and understory vegetation are important parameters determining bat species composition and overall insect abundance. Species diversity and relative abundance were considerably higher in structurally more heterogeneous forest types. Forest composition and stand age also seem to affect bat species composition, however we recognized a greater effect of these two parameters on the relative species abundance and overall foraging activity. Especially gleaning bat species seem to benefit from the heterogeneity caused by multi-storied forest structure and a mix of local tree species of varying ages. For all plots bat activity was higher on forest paths compared to forest interior, further demonstrating the importance of connecting elements within the forest.
We conclude, that habitat heterogeneity in managed forests increases bat species richness by facilitating niche or resource partitioning among species. Furthermore, we emphasize the role of bats as ecological bioindicators towards land use-driven environmental conditions. A more profound understanding of the interactions between forestry and bats would certainly contribute to improving integrative land use planning and management.

Poster 60: Ringing the changes: Establishing a set of guidelines and centralised database for bat ringing in the UK

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Bat ringing (or banding) has been a long established technique associated with bat research and monitoring in the UK. For a many years this was carried out by a very small number of bat specialists. However, in recent years it has become a more widely used research technique as a growing number of volunteer bat workers and a small number of ecological consultants have become involved in long-term research projects.

Despite this increase in use and the requirement of centralised recording systems in accordance with EUROBATS Resolution No. 4.6 in 2003 (Guidelines for the Issue of Permits for the Capture and Study of Captured Wild Bats), there is no central database for ringing records in the UK (only ring sales) and no specific nationwide guidelines on ringing.

A range of different techniques are used when applying bat rings and guidelines would promote sharing of expertise and agreed best practice. A national database would enable reporting on critical information that is currently unavailable, such as total numbers of bats ringed, ringing injuries, recapture rates and species longevity.

In this presentation, we give an overview of bat ringing in the UK and the efforts that are being undertaken to develop guidance and a centralised database. We wish to initiate a discussion with international colleagues to learn from approaches in other countries on the issues of guidance, ringing methods and centralised recording.

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