DTFF

Heidesee, Germany
12 -14 January 2018

Deutsches Treffen für Fledermausforschung

museum für
naturkunde
berlin

WELCOME!

Dear colleagues, dear guests,

it is our great pleasure to welcome you to this years'
Deutsches Treffen für Fledermausforschung, in Heidesee near Berlin.

DTFF Organizing Committee

ORGANIZING COMMITTEE

Museum für Naturkunde, Berlin
Simon Ripperger
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Emrah Coraman
Linus Günther

Freie Universität Berlin
Mirjam Knörnschild
Martina Nagy
Ahana Fernandez

Humboldt Universität zu Berlin
York Winter
Vladi Nachev

Juliane Schaer (Macquarie University, Sydney)
Simon J. Ghanem (K&S Umweltgutachten, Berlin)

January 12
Friday

14:00-16:00 Uhr	**ARRIVAL & REGISTRATION**	
16:00-16:15 Uhr	**WELCOME & INTRODUCTION**	
16:15-16:45 Uhr	***Gerry Carter***	Cooperative relationships in vampire bats: theory, controversy, and evidence
SESSION 1	**Virology, Physiology & Movement Ecology** chair: *Simon Ripperger*	
16:45-17:00 Uhr	*Bernd Köllner*	When a virus uses another entrance – Immune mechanisms involved in innate anti-Lyssaviruses immune response in nasal cavity of European bats
17:00-17:15 Uhr	*Stephanie Reher*	Extreme flexibility in torpor patterns in a tropical bat (*Hipposideros commersoni*)
17:15-17:30 Uhr	*Oliver Lindecke*	The magnetic sense of migrating bats – Its biophysical character and putative role in true navigation
17:30-17:45 Uhr	*Manuel Roeleke*	Lunarphilia in open-space foragers
17:45-18:00 Uhr	*Julia Scholl*	Movement ecology of noctule bats in an urban environment
18:00-19:30 Uhr	**DINNER**	
19:30 Uhr	**POSTER & DRINKS**	

January 13
Saturday

09:00-09:30 Uhr	***Holger Goerlitz***	Low-amplitude stealth echolocation - coevolution or preadaptation?
SESSION 2		**Sensory Ecology** chair: *Annette Denzinger*
09:30-09:45 Uhr	*Daniel Lewanzik*	Reaction towards con- and heterospecific feeding buzzes depends on food patch quality
09:45-10:00 Uhr	*Thejasvi Beleyur*	Sonar glimpses in the bat cocktail party nightmare
10:00-10:15 Uhr	*Jens Koblitz*	Foraging behavior of black mastiff bats (*Molossus rufus*)
10:15-10:30 Uhr	*Inga Geipel*	The effect of rain noise on roost emergence in two Neotropical bat species
10:30-11:00 Uhr	**COFFEE BREAK**	
11:00-11:30 Uhr	***Sabine Schmidt***	Emotional acoustic communication in a bat model (*Megaderma lyra*): concepts, pitfalls and perspectives
SESSION 3		**Communication** chair: *Mirjam Knörnschild*
11:30-11:45 Uhr	*Philipp Schmidbauer*	Social calls of *Myotis nattereri* during swarming
11:45-12:00 Uhr	*Ahana Fernandez*	Characterization of babbling behavior in the bat *Saccopteryx bilineata*
12:00-12:15 Uhr	*Lara Sophie Burchardt*	Rhythm analysis in three vocalization types of *Saccopteryx bilineata*
12:15-12:30 Uhr	*Meike Linnenschmidt*	Vocal development after acoustic deafening in juvenile bats (*Phyllostomus discolor*)
12:30-12:45 Uhr	*Sonja Vernes*	Vocal learning in bats: from genes to behavior
12:45-14:00 Uhr	**LUNCH**	
14:00-14:30 Uhr	***Marco Tschapka***	Flower bats, bat flowers and more...

January 13
Saturday

SESSION 4		**Ecology 1** chair: *Vladi Nachev*
14:30-14:45 Uhr	*Stefan Brändel*	From bat communities to microbial communities: The effect of a changing habitat
14:45-15:00 Uhr	*Thomas Hiller*	The influence of habitat loss on a bat ectoparasite community in Panama
15:00-15:15 Uhr	*Tanja Halczok*	Species-specific responses of Neotropical bats to human-induced habitat modifications
15:15-15:30 Uhr	*Anna Vogeler*	Habitat use of pteropodid bats and their importance as seed dispersers, compared to birds, on the slopes of Mt. Kilimanjaro, Tanzania
15:30-15:45 Uhr	*Patrick Cvecko*	Implications of differences in availability and abundance of roost resources for leaf-nosed bats (Phyllostomidae) across a lowland rainforest island system in Panamá
15:45-16:15 Uhr	**COFFEE BREAK**	
16:15-16:45 Uhr	***Uwe Firzlaff***	Neural processing in the bat brain: from biosonar to vocal learning
SESSION 5		**Neurobiology** chair: *Kalle Esser*
16:45-17:00 Uhr	*Jerome Beetz*	Acoustic orientation in the dark: About how the brain processes naturalistic echolocation sequences in the fruit-eating bat *Carollia perspicillata*
17:00-17:15 Uhr	*Jan Pastyrik*	Duration tuning in the IC of *Carollia perspicillata*
17:15-17:30 Uhr	*Stephen Hörpel*	Processing of fast temporal modulations in bat auditory cortex specifically matches communication call specific sound features
17:30-17:45Uhr	*Francisco Garcia Rosales*	Spiking activity in the auditory cortex is synchronized to local beta-band oscillations
17:45-18:00Uhr	***Holger Goerlitz***	**Information:** Tabachka Research Station
18:00-19:30 Uhr	**DINNER**	
19:30-20:30 Uhr	***Christian Voigt***	Movements of bats across anthropogenic landscapes: from processes to patterns to conservation
20:30 Uhr	**CHILL-OUT WITH BONFIRE**	

January 14
Sunday

09:00-10:00 Uhr	***Gerald Kerth***	The value of long-term field studies in bat research
SESSION 6		**Ecology & Behaviour** chair*: Martina Nagy*
10:00-10:15 Uhr	*Sophia Beer*	Auswirkungen der Dichte künstlicher Baumhöhlen-Ersatzquartiere auf die Populationsentwicklung waldbewohnender Fledermäuse im Untersuchungsgebiet ehemaliger Forstbetrieb Schnaittenbach in der Oberpfalz
10:15-10:30 Uhr	*Yann Gager*	New insights on the ecology of the Giant noctule (*Nyctalus lasiopterus*) from a population of the middle of Southern France
10:30-10:45 Uhr	*Vladislav Nachev*	Ladies' Night Out: Sex-dependent resource defense in *Glossophaga soricina*
10:45-11:00 Uhr	*Nicolas Fasel*	Revelations about the mysterious intimacy of bats
11:00-11:30 Uhr	**COFFEE BREAK**	
SESSION 7		**Conservation & Miscellaneous** chair: *Frieder Mayer*
11:30-11:45 Uhr	*Jochen Moll*	FMCW Radar System at Millimeter-wave frequencies for the detection of bats at wind turbine installations: initial results from a field study
11:45-12:00 Uhr	*Sascha Klose*	Molecular phylogeny of African epauletted fruit bats
12:00-12:15 Uhr	*Karl Kugelschafter*	Lassen sich Fledermausgesellschaften umsiedeln?
12:15-12:30 Uhr	*Renate Rabenstein*	Paläobiologie der fossilen Fledermäuse aus Messel
12:30-12:45 Uhr	**CLOSING MEETING**	
13:00-14:00 Uhr	**LUNCH**	

Posters I

#	Topic	Presenter	Affiliation	Title
01	Behavior	*Jan Philipp Bechler*	Universität Ulm	Assessing foraging strategies in nectar-feeding bats with a wireless sensor network
02	Behavior	*Sophia Louise Gérard*	Tierärztliche Hochschule Hannover	Roosting patterns in a captive colony of *Carollia perspicillata*
03	Behavior	*Shambhavi Chidambaram*	HU Berlin	Irrational choice and suboptimal decision-making in nectar-drinking bats
04	Behavior	*Lara Marggraf*	Leibniz Institute for Zoo and Wildlife Research	Bats prefer to migrate in silence: playbacks of con-and heterospecific calls reduce migratory bat abundance at activity-spots
05	Behavior	*Darija Josic*	HU Berlin	How well does roosting proximity and kinship predict social grooming in common vampire bats?
06	Behavior	*Andreas Rose*	Universität Ulm	Exploring social learning during ontogeny: Do juvenile flower-visiting bats follow their mothers on first foraging flights?
07	Behavior	*Simon Ripperger*	Museum für Naturkunde Berlin	Miniaturized wireless sensors provide novel insights into the social life of bats
08	Communication	*Tania Bosia*	Stiftung Tierärztliche Hochschule Hannover	Social behavior and social call repertoire of *Carollia castanea* from the wild, in a flight cage
09	Communication	*Lutz Wiegrebe*	LMU München	Vocal production learning through imitation of frequency-shifted sounds by bats?
10	Communication	*Stephanie M Shields*	LMU München	Vocal repertoire of phyllostomid bats, *P. discolor*
11	Communication	*Vanessa Kratzer*	LMU München	Fundamental frequency discrimination in *Phyllostomus discolor*
12	Conservation	*Daniela Fleischmann*	Stiftung Fledermaus	Monumental bats - Historic buildings as a biodiverse habitat and an object of monument preservation
13	Ecology	*Jennifer Pöll*	Universität Gießen	Activity of bats around streetlights
14	Ecology	*Ebenezer Kofi Badu*	Universität Ulm	Intraspecific variation in the food habit of Noack's round leaf bat (*Hipposideros* cf. *ruber*) from Ghana
15	Ecology	*Kseniia Kravchenko*	Ukrainian Independent Ecology Institute (UIEI)	Changes in migratory status of bats revealed by stable isotopes
16	Ecology	*Carola Viktoria Behle*	Universität Gießen	Migratory pathways of bats in the Gießener Lahntal and adjoining mountain landscapes
17	Ecology	*Nina I. Becker*	Universität Gießen	Automatic location monitoring in wind farm planning process
18	Ecology	*Jorge A. Encarnação*	Universität Gießen	Semi-natural bat roosts as continuous ecological functionality-measures (CEF)
19	Ecology	*Frauke Meier*	Büro Echolot GbR	How to spend the winter: Species and sex specific hibernation phenology of two sympatric European bat species

Posters II

#	Topic	Presenter	Affiliation	Title
20	Ecology	*Lena Grosche*	Universität Greifswald	Bat hibernacula are more than only winter places: species and sex specific activity patterns show the year-round importance for bats
21	Ecology	*Patricia Bulang*	ForGen Hamburg & Noctalis	Auf den Spuren von Batmans Familie.. Was uns der genetische Fingerabdruck über die Fledermaus verrät
22	Ecology	*Tanja Straka*	Leibniz Institute for Zoo and Wildlife Research	Berlin's nightlife: studying urban bats with citizen scientists
23	Ecology	*Hanna Wieser*	Museum für Naturkunde Berlin	Holes or boxes – Where to roost in an urban forest?
24	Immunology	*Marcus Fritze*	Leibniz Institute for Zoo and Wildlife Research	Resilience or Resistance – How do European bats cope with White-Nose infections?
25	Immunology	*Ihor Tovstukha*	Ukrainian Independent Ecology Institute (UIEI)	White blood cells as an indicator of immunological status of bats
26	Neurobiology	*Dennis Röhrig*	Goethe Universität Frankfurt am Main	Lamniar activity in the auditory cortex of vocalizing bats
27	Neurobiology	*Francisco Garcia Rosales*	Goethe Universität Frankfurt am Main	Neuronal response patterns and coherence dynamics in response to distress vocalization sequences
28	Neurobiology	*Uwe Firzlaff*	TU München	The neuro-molecular basis of vocal learning in bats
29	Neurobiology	*Ine Alvarez van Tussenbroek*	Max-Planck-Institute for Psycholinguistics	Investigating the neurogenetic mechanisms of vocal learning using a bat model
30	Physiology	*Michael Speidel*	Universität Ulm	Physiological traits in phyllostomid bat species related to roosting temperature
31	Sensory Ecology	*Kristin-Jasmin Stelzer*	LMU München	Detection of biosonar target changes in FM bats
32	Sensory Ecology	*Theresa Hügel*	Max-Planck-Institut für Ornithologie	Escaping a bat: Behavioral variability as anti-predator adaptations in moths
33	Sensory Ecology	*Antoniya Hubancheva*	Max-Planck-Institut für Ornithologie	Acoustic response of European bushcrickets to bat echolocation calls
34	Sensory Ecology	*Kathrin Kugler*	LMU München	Bat flight in conflicting sensory flow fields
35	Sensory Ecology	*Leonie Baier*	LMU München	What makes the ripples risky? Surface wave perception with echolocation
36	Sensory Ecology	*Verena Reininger*	Max-Planck-Institut für Ornithologie	Do temperate bats keep their detection distances constant by adjusting call parameters to daily weather fluctuations?
37	Sensory Ecology	*Tania Gonzalez-Terrazas*	Universität Ulm	More than a big nose-leaf: echolocation behavior of the phyllostomid insectivorous bat *Lonchorhina aurita*
38	Sensory Ecology	*Diana Schöppler*	Universität Tübingen	Precise Doppler shift compensation in the hipposiderid bat, *Hipposideros armiger*: resting and reference frequencies are coupled but variable
39	Sensory Ecology	*Myrna Eble*	Universität Tübingen	The alternating low and high frequency echolocation signals of *Saccopteryx bilineata* may have different functions

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DTFF

Plenary Talks

Cooperative relationships in vampire bats: theory, controversy, and evidence

Gerry Carter

MPI for Ornithology, Radolfzell, Germany

Low-amplitude stealth echolocation – coevolution or preadaptation?

Holger R. Goerlitz

Acoustic and Functional Ecology, MPI for Ornithology, Seewiesen, Germany

Bat-moth-interactions are regularly portrayed as a text-book example of coevolution: the evolution of echolocation in bats caused the evolution of hearing and of anti-bat behaviours in moths, causing the evolution of – well, of what actually in bats? Clear evidence for a coevolutionary response of bats to the defence strategies of eared moths and other eared insects is missing. The best-supported example to date is stealth echolocation, i.e., low-amplitude echolocation calls that are inaudible to eared prey. While the functional benefits of low-amplitude echolocation are well supported, the history of its evolution is not. In this talk, I will highlight some of the potential selection pressures acting on active sensory system like echolocation, including the need to avoid detection by prey animals as well as the need to reduce unwanted echo information. Considering additionally the phylogeny of known low-amplitude bats, a potential alternative hypothesis for the evolution of low-amplitude echolocation emerges. While low-amplitude echolocation appears ill-suited for flying in open space, it is likely beneficial in cluttered space. Low-amplitude echolocation thus might have evolved as adaptation to dense habitats, allowing some pre-adapted bats to secondarily successfully hunt eared moths.

Emotional acoustic communication in a bat model (*Megaderma lyra*): concepts, pitfalls and perspectives

Sabine Schmidt

Institut für Zoologie, Tierärztliche Hochschule Hannover, Germany

Flower bats, bat flowers and more...

Marco Tschapka

Institute of Evolutionary Ecology and Conservation Genomics, University of Ulm, Germany; Smithsonian Tropical Research Institute, Balboa, Panama

Neotropical nectar-feeding bats (Phyllostomidae: Glossophaginae, Lonchophyllinae) are specialized flower visitors that pollinate plants from a large taxonomical range. They occur in all major neotropical habitats, ranging from rain forests to dry forests, deserts and mountain ranges. Adaptations to nectarivory include elongated snouts that permit storing of a long tongue used in extracting nectar from flowers, reduced dentition, a pronounced capability of hovering flight and a well-developed spatial memory. As these bats obtain their nectar food mostly in rather small quantities through numerous flower visits they have a very high energy turnover, which in turn selected for a high degree of behavioral opportunism in foraging. Bat flowers are generally quite large and grow well exposed, and address the bats' senses through specific scents, and often also through structures reflecting echolocation calls very efficiently. In order to attract their relatively large pollinators, bat flowers produce rather high quantities of nectar with a moderate sugar concentration of 15-20 %.

Current projects on nectarivorous bats focus on species living in very seasonal and in agricultural landscapes, as well as on spatial aspects of floral resource use. The talk will introduce flower-visiting bats and review selected aspects of their ecology, and will briefly present the current projects of the workgroup in Ulm.

Neural processing in the bat brain: From biosonar to vocal learning

Uwe Firzlaff

Lehrstuhl für Zoologie, TU München, Germany

Auditory perception in bats involves both active biosonar and passive hearing. In my talk I will highlight the extraordinary ability of the bat auditory cortex to process dynamic biosonar information as well as vocal communication sounds. I will show how the cortical map of target range adopts to the special requirements of echo analysis in complex environments and how special acoustic features of communication sounds are represented in the auditory cortex. Neural processing of communication sounds is also discussed in the context of vocal learning and expression patterns of vocal-behavior related genes such as FoxP2 in bats.

Movements of bats across anthropogenic landscapes: from processes to patterns to conservation

Christian C. Voigt

Leibniz Institute for Zoo and Wildlife Research, Berlin, Germany

The value of long-term field studies in bat research

Gerald Kerth

Angewandte Zoologie und Naturschutz, Universität Greifswald, Germany

In many bat species, individuals can live for more than 20 years, and even their median lifespans exceed typical DFG or PhD project lengths of 3 years by far. Consequently, answering topical questions in bat research such as: the adaptive value of different behavioural traits or social organizations, the causes for the unusual longevity of bats, or their responses to changing environments and other conservation relevant questions often require long-term data sets. Unfortunately, long-term field studies (>20 years) working with individualized (ringed and/or RFID-tagged) bat populations are very rare. Worldwide, probably less than 10 of such studies that allow to assess life-time reproductive success of individual bats and other important parameters for answering relevant questions in bat research are currently running. In my talk, I will summarize results from my own long-term research on bats of the temperate zone with the aim to outline the importance and the challenges of long-term field studies of individually marked bat populations.

Talks

Auswirkungen der Dichte künstlicher Baumhöhlen-Ersatzquartiere auf die Populationsentwicklung waldbewohnender Fledermäuse im Untersuchungsgebiet ehemaliger Forstbetrieb Schnaittenbach in der Oberpfalz.

Sophia Beer

Technische Universität München

Die für die Bachelorarbeit nötigen Kartierarbeiten sind von Juni bis September dieses Jahres ihm Rahmen eines großen Monitoring Projektes im Auftrag des LfU zur Erfassung nistkastenbewohnender Fledermäuse in der Oberpfalz erfolgt. Leiter des Projektes ist Rudolf Leitl. Insgesamt wurden ca. 15000 Kästen in der Oberpfalz kontrolliert und kartiert. Vom ehemaligen Forstbetrieb Schnaittenbach liegen mehrere umfangreiche Vergleichsdaten aus den Jahren 1995, 1997, 2007 und 2009 vor. Diese Daten, ebenso wie die von 2017, verwende ich für meine Bachelorarbeit. (An der Auswertung der Daten arbeite ich derzeit, die Arbeit wird in den nächsten drei Monaten fertig gestellt). Durch den Vergleich der Zahlen der Fledermausfunde soll Aufschluss über den Stand der Population der waldbewohnenden Fledermäuse im Untersuchungsgebiet gewonnen werden. Das Hauptziel meiner Bachelorarbeit ist es festzustellen, ob die schwankende Anzahl bzw. Dichte künstlicher Quartiere im Laufe der letzten 22 Jahre einen signifikanten Einfluss auf die Belegungsrate und die Populationsentwicklung der waldbewohnenden Fledermausarten im Untersuchungsgebiet hat. Es soll dadurch beurteilt werden, inwieweit künstliche Fledermausquartiere in Wirtschaftswäldern dem Populationserhalt der Arten dienen und nötig sind. Weiter soll ein Zusammenhang zwischen dem Kastentyp, sowie der Höhe der Aufhängung mit der Belegung des Kastens untersucht werden um damit Aufschluss über die Präferenzen der Arten zu gewinnen. Diese Erkenntnisse sollen bei der spezifischen Förderung einzelner Arten helfen. Zur Klärung der Fragestellung werden die Daten mithilfe von Excel und SPSS statistisch ausgewertet. Für die Kartierung der Kästen wird BaySFMobil, QGIS und Excel verwendet.

Acoustic orientation in the dark: About how the brain processes naturalistic echolocation sequences in the fruit-eating bat *Carollia perspicillata*

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Understanding, how neurons process natural stimuli and control animal behavior is a fundamental goal of neuroethologists. Here we present data on how natural and behaviorally relevant stimuli are processed in the brain of the bat *Carollia perspicillata*. For short range orientation, bats emit sequences of biosonar calls and listen to echoes. The echoes provide information that enable the bat to orientate acoustically in total darkness. We recorded neuronal signals from the inferior colliculus and auditory cortex, while the bats were stimulated with different echolocation sequences. Stimulating the bat with a sequence carrying echo information from a single object revealed that cortical and collicular suppression sharpens neuronal tuning to specific call-echo pairs of the sequence. Neuronal suppression is stronger in the cortex than in the inferior colliculus. When stimulating the bat with an echolocation sequence carrying echo information from multiple objects, the cortex responds more strongly to echo information from the nearest object. Increasing the stimulus rate with interfering calls from conspecifics does not potentiate neuronal suppression to a level that deteriorates the processing of the echolocation sequence. Altogether, this study provides important information that sheds light on the processing of natural, complex, acoustic streams in the brain.

Sonar glimpses in the bat cocktail party nightmare

Thejasvi Beleyur, Holger R Goerlitz

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Echolocation allows bats to navigate complex environments with ease, and a large body of literature has investigated the sensory cues and mechanisms bats use while echolocating alone. Echolocation in groups has remained a conceptually difficult problem as it is expected that when multiple conspecifics fly in close proximity their loud calls will mask incoming echoes – rendering individuals in a group acoustically 'blind'. We present a follow up on last year's talk at this conference, where we investigated the masking in pairs of flying bats.Using Monte-Carlo simulations, we calculated the probabilities that a single bat hears the echoes of its own calls with an increasing number of randomly arriving calls during its interpulse interval, assuming complete masking by temporally overlapping calls. We parameterised the model based on the masking study of Amichai et al (2015, Proc. R. Soc. B). Results suggest that almost never, even in the midst of the cocktail party nightmare, are all echoes masked. Thus, bats have partial, but regular 'glimpses' into their surroundings, even under worst conditions. This result is a contribution to explaining how bats are able to echolocate and fly in groups. We also discuss the kinds of data required to support or disprove the proposed model.

From bat communities to microbial communities: The effect of a changing habitat

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Neotropical forests host extremely diverse bat assemblages, with more than half of the species richness contributed by the Neotropical Leaf-nosed bats (Phyllostomidae). In response to habitat alterations, these assemblages often experience drastic changes, often resulting in the persistence of only the most adaptable species, while bats more susceptible to environmental change may go locally extinct. However, some frugivorous species may thrive in altered environments. A typical example for a bat species that can benefit from modified environments is the frugivorous *Carollia perspicillata*. Habitat alteration affects not only local species richness and leads to changes in species abundance, it may ultimately also affect fitness and health of animals. As bats are increasingly being recognized as important natural reservoir hosts for emerging viral pathogens, studying the impact of bat population dynamics and specific host traits on infection status in natural populations is crucial to understanding pathogen ecology. Our data indicate that an increase in host abundance may ultimately lead to an increase in virus infections, suggesting that habitat degradations may indirectly also promote virus prevalence. The gastrointestinal microbiome, i.e., the entirety of bacteria living in the digestive tract, contributes significantly to host immune functions and nutrition. Understanding the interactions between host habitat, local host abundance and the gastrointestinal microbiome are important as changes in the microbiome ultimately influence health. Here, we present the results of a survey, based on more than 6800 bats sampled during a two-year survey of mist netting in different landscapes, varying in the degree of habitat alteration. Our study targets the links between local host abundance and the observed animal health. We further present first results of an intestinal microflora community analysis for the frugivorous bat *Carollia perspicillata* (Phyllostomidae).

Rhythm analysis in three vocalization types of *Saccopteryx bilineata*

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Rhythm is an essential component of our speech and music. Surprisingly little is known about rhythm in animal vocalizations, even though this might give valuable insight into the evolution of rhythm and music. Using a method developed for zebra finch song, we found a regular, isochronous rhythm in three vocalization types of the neotropical bat *Saccopteryx bilineata*. As input we used multisyllabic vocalizations of different individuals. Inter-syllable-onsets were used to fit a signal-derived-pulse, pulseS. For all individuals and vocalization types (echolocation call sequences, territorial songs, isolation calls), pulseS frequencies were predominantly lying around 7.5 Hz - 20 Hz. For echolocation call sequences, we expected pulseS frequencies of 7.5 - 15 Hz because the production of echolocation calls is strongly coupled with wingbeat/respiration during flight, which are at approximately 7.5 Hz for *S. bilineata*. Surprisingly, we found pulseS frequencies similar to echolocation call sequences in social vocalizations, even without coupling between respiration and wingbeat. Territorial songs and isolation calls were uttered when bats were perched in the day-roost and, in case of isolation calls, when individuals were not volant yet. At present, we can only speculate about the reasons for this unexpectedly steady rhythm in bat vocalizations. Nevertheless, comparative studies on different echolocating and/or singing species may help to understand the evolution of rhythm and music, because animal vocalizations might be more rhythmic than previously thought.

Implications of differences in availability and abundance of roost resources for leaf-nosed bats (Phyllostomidae) across a lowland rainforest island system in Panamá

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Fragmentation of natural habitat has brought major losses of species diversity worldwide. The responses of forest-dwelling animals to fragmentation may vary widely, especially also within bird and bat species, as the species differ distinctly in mobility and abundance. The diverse family of neotropical leaf-nosed bats provides important ecosystem functions such as pollination, seed dispersal and herbivore predation. Roost resources are elementary for these bats, influencing occurrence and population size of the species. This particularly affects bats on small island fragments and may even limit species known to be quite flexible in roosting behavior through modifying leaves as roosting sites. However, roost site preferences of these leaf-tent roosting bats and the critical factors are still largely understudied. We investigate factors driving roost site preferences of leaf-nosed bats and quantify available roost resources along transects from mainland to island sites and towards forest edge habitats in a tropical lowland rainforest in Panamá. The objective of this study is to understand how bats cope with roost resource availability in a fragmented landscape. This information on roost preferences and availability will be linked to species occurrence data of our last large bat survey conducted between 2013 and 2016, in order to understand the effects limited roost resources can have on bat species assemblages, besides their difference in mobility. This knowledge is essential for decision making in all efforts towards conservation of tropical bat species.

Revelations about the mysterious intimacy of bats

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Among aspects of bat biology that still remain mysterious, we have mating and the fertilization that follows. In Vespertilionidae, males have the ability to separate the costs of spermatogenesis from those generated by the search for sexual partners. In addition, sperm storage by females extends the mating period, and consequently allows several males to copulate with them. In this context of extreme sperm competition, any attribute enhancing male fertility should be strongly selected. Therefore, to better understand the outcomes of mating and fertilization in several species of Vespertilionidae, we were interested in the anatomy of the erected penis, the morphology of spermatozoa and sperm mobility. Our results demonstrate a variety of forms and structures that were until now unsuspected. This work aims at better understand the still unrecognized intimacy of bats.

Characterization of babbling behavior in the bat *Saccopteryx bilineata*

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'Canonical babbling', the repeated production of syllables consisting of a consonant and a vowel, is a prominent developmental stage of human language acquisition which children undergo at the age of 6 months. Since babbling, often also termed vocal practice or vocal play, is crucial for human language acquisition, it is reasonable to expect that babbling also occurs in certain non-human animals with a complex vocal repertoire. Indeed, babbling has also been described in songbirds (plastic song), a few primates and one bat species, the greater sac-winged *Saccopteryx bilineata*. Vocal repertoire ontogeny in *S. bilineata* pups is characterized by a conspicuous babbling period. Babbling pups produce long sequences of syllables (bouts of up to 30 minutes in length) composed of adult-like syllable types and one highly variable "transition" syllable type which is not part of the adult vocal repertoire. Babbling is used for vocal practice; pups imitate at least one adult vocalization type, the territorial song, by listening to tutor songs and utter song precursors when babbling. We studied babbling behavior in *S. bilineata* pups to investigate whether there are general babbling characteristics that all species have in common, namely vocal overproduction, repetitiveness, undirectedness meaninglessness and universality. During two consecutive field seasons, we recorded and analyzed babbling behavior in two different *S. bilineata* populations (Costa Rica & Panama, 20 pups, 9 colonies). Our results revealed that the babbling behavior of *S. bilineata* pups was composed of three stages of increasing complexity. Interestingly, aggressive adult-like syllable types were produced earlier in ontogeny than affiliative ones. Babbling bouts were dominated by highly variable transition syllables (vocal overproduction) and repetitions of syllable types (repetitiveness). Moreover, preliminary analyses suggested that the transition probability of adult-like syllable types was not random; i.e. babbling bouts followed simple phonological syntax rules. Behavioral observations indicated that babbling pups were not addressing conspecifics (undirectedness) and did not communicate any obvious messages (meaninglessness). Pups of both sexes in all sampled colonies produced babbling bouts (universality). We can therefore conclude that babbling behavior in *S. bilineata* pups is characterized by general features shared with other babbling species. Future comparative studies may reveal that babbling is more common in the vocal ontogeny of species with a complex repertoire than currently known.

New insights on the ecology of the Giant noctule (*Nyctalus lasiopterus*) from a population of the middle of Southern France

Yann Gager

habit.art

Our work present the results of a 6-year study (2012-2017) of breeding colonies of the Giant noctule (*Nyctalus lasiopterus*) discovered in 2012 in the middle of Southern France (Puy de Dôme). The discovery was made possible without capture but relying on the development of a new method where observers follow bats back t-+o their roosts in the early morning using both acoustic and visual information. Once the colonies were discovered, we used complementary tools, such as capture / telemetry, night vision tools (infrared camera coupled with light intensifiers) or acoustic data from a network of Batcorders placed in fixed points. The population of Giant noctule exploits each year a particularly dense network of ancient lodges of Black woodpeckers (*Dryocopus martius*) found in a beech forest located in a deep valley. The breeding roosts (females and offspring) are concentrated in the part of the forest with the richest density in cavities, allowing regular transfers between roosts. Our results also show the presence of more isolated satellite roosts of non-breeding males (likely subadults) remaining in the surroundings of the females before their sexual maturity. These results not only question the hypotheses about latitudinal and altitudinal migrations advanced by the Spanish experience but also bring new insights about the notion of sexual segregation at the breeding colonies of giant noctules.

Spiking activity in the auditory cortex is synchronized to local beta-band oscillations

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The extraction of temporal information from sensory input streams is of paramount importance in the auditory system. In this study, amplitude modulated sounds were used as stimuli to drive auditory cortex neurons of the bat species *Carollia perspicillata*, in order to assess the contribution of cortical spikes and local-field potentials (LFPs) to the processing of temporal acoustic cues. We show that the occurrence of cortical spikes is synchronized to beta-band (12-30 Hz) local field potential (LFP) oscillations, and that the latter is independent of the temporal modulation of the sound that triggers the spikes. Spike activity can track amplitude modulation rates only if they are lower than 30 Hz, while LFPs can be entrained by acoustic streams modulated at frequencies higher than 100 Hz. The presented data indicate that coherent beta-band oscillations in the auditory cortex are intrinsically related with stimulus-locked phasic neuronal discharges.

The effect of rain noise on roost emergence in two Neotropical bat species

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Bats depend on environmental cues for orientation and decision-making. To make an informed decision the cues need to be reliable, e.g., to avoid danger, and make optimal foraging decisions. Acoustic cues can provide reliable information about environmental conditions, e.g., climatic conditions such as rain, and are particularly useful for species roosting in cavities, such as tree holes or caves. Rain as an abiotic factor can have an impact on bat foraging behaviour. When bats are getting wet their metabolic rate is considerably reduced. Further, their prey might not be available, or their orientation abilities could be reduced, as echolocation signals might be overlapped by rain noise. Thus, the noise of a rainfall can function as a reliable cue and should influence the decision of bats to emerge from their roost to forage. We tested whether two Neotropical bat species, differing in foraging strategy and habitat, delay their emergence when exposed to rain noise. We conducted playback experiments at natural roosts of *Micronycteris microtis* (Phyllostomidae) and *Molossus* sp. (Molossidae) in Panama, while video recording the bats' behavior at the roost entrances. Both species significantly delayed their emergence time during rain noise treatments, compared to baseline or ambient noise treatments. We conclude that the two studied bat species can make an informed decision whether to forage based on an acoustic environmental cue.

Species-specific responses of Neotropical bats to human-induced habitat modifications

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Human-induced landscape modifications are often associated with habitat loss and fragmentation. Especially in the tropics where biodiversity is high, these habitat alterations pose serious threats to wildlife populations as they are known to impact species richness and abundance. Moreover, they may cause reductions in gene flow that might ultimately affect the potential of animals to adapt to environmental change through the loss of genetic diversity. Consequently, populations with low genetic diversity are expected to suffer more severely from diseases and parasites. We investigated six different phyllostomid bat species (*Artibeus jamaicensis*, *Carollia perspicillata*, *Uroderma bilobatum*, *Dermanura watsoni*, *Dermanura phaeotis* and *Trachops cirrhosus*) native to the area around the Panama Canal which has been highly modified by humans. While some of these species exhibit a high degree of mobility, others have been shown to be less mobile which limits their capability to reach isolated forest fragments. We obtained at least 150 genetic samples per investigated species - in some species data amounts to more than 400 individuals. Using a set of 9 to 16 nuclear microsatellite markers per species we determined levels of genetic differentiation and dispersal patterns for these species. While bat species with a high degree of mobility seem to be resilient to the habitat fragmentation within our study area, gene flow is restricted for less mobile species as indicated by population genetic structure. In particular, our results emphasize the importance of examining the effects of habitat fragmentation at the species level, as differences in responses to habitat alterations appear to be highly species-specific.

The influence of habitat loss on a bat ectoparasite community in Panama

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Habitat loss and fragmentation influence the survival of many species, especially in highly diverse tropical biomes. Recent studies on bats showed that successful persistence in degraded habitats depends on the degree of specialization: whereas generalist species may even profit of habitat alterations, specialist species may go locally extinct. For obligate bat ectoparasites such as bat flies (Diptera: Streblidae), the body of their host species represents their habitat. Bat flies are highly species-specific and show distinct site preferences on their bat host, e.g., wing membranes or fur, thus allowing the occurrence of several bat fly species on one host individual. Parasite species composition, prevalence and intensity of parasitism is influenced by the abundance of a host species, but also by individual host characteristics (e.g. sex, age or reproductive status). Therefore, changes in bat species composition and abundance by habitat alterations will directly influence also local parasite communities. Between 2013 and 2015 we captured bats in Panama in three habitat types with different human influence and collected from the six most common bat species (n=4444) a total of 3524 bat flies, belonging to 11 species. Prevalence per host species ranged from 8.0% to 67.9% and mean intensity of parasitism was between 1.1 and 2.8 flies per infested bat. Preliminary analyses show significant differences in prevalence and intensity of parasitism between bat host species, between habitat types as well as in age and sex within the host species. Further analyses will target the identification the habitat and host characteristics mostly affecting parasitism by bat flies on parasite species level and thus shed light on the complex host-parasite interactions.

Processing of fast temporal modulations in bat auditory cortex specifically matches communication call specific sound features

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Bats use a large repertoire of calls for social communication. In the bat *Phyllostomus discolor* social communication calls are often characterized by temporal amplitude and/or frequency modulation pattern in the range of 100- 150 Hz. However, in the mammalian auditory cortex modulation transfer functions are typically limited to modulation frequencies below 100Hz. We investigated general response properties related to the processing of communication calls such as coding of temporal modulation in amplitude and/or frequency and overall spectro-temporal structure. First results show that neurons in the auditory cortex of *P. discolor* can encode unusually high temporal modulations above 100Hz, characteristic for e.g. aggression calls of this species. Furthermore, neurons can respond to distinct social communication calls with a highly distinctive discharge pattern. Future experiments will investigate the role of FoxP2 on temporal processing and the processing of communication calls in the auditory cortex of *P. discolor.*

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Molecular phylogeny of African epauletted fruit bats

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DNA barcoding of African fruit bats with the standard barcode marker cytochrome c oxidase subunit I (COI) has failed to discriminate the widely accepted morphogenera Micropteropus and Epomophorus. The two genera belong to the group of epauletted fruit bats (Epomophorini, Pteropodidae, Yinpterochiroptera), comprising five genera, which are endemic in and distributed throughout Africa. Previous studies using mitochondrial and conserved nuclear genes recovered the Epomophorini as monophyletic clade, however, within this group the monophyly of some individual genera and species has not been confirmed yet or the molecular markers of choice have failed to differentiate the taxa respectively. We combined mitochondrial (cytb) and conserved nuclear genes (RAG1, RAG2) with different nuclear introns (ACOX2, ROGDI, FGB intron 7) for a detailed analysis of the relationships within the Epomophorini including samples of fruit bat taxa from West and East Africa. The FGB Intron 7 proved to be a reliable molecular (barcode) marker to discriminate between the African fruit bat genera, including Micropteropus, Epomophorus and Epomops as distinct taxa. The concatenated analyses verified the two species of Epomops, *Epomops buettikoferi* and *Epomops franqueti* as distinct species and Stenonycteris was confirmed as independent genus. The investigated molecular markers did not provide resolution among the most species-rich group of Epomophorus. The study highlights the need for a combination of different conserved and rapidly evolving molecular markers to identify the recently diversified African fruit bat taxa to the genus and species level.

Foraging behavior of black mastiff bats (*Molossus rufus*)

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The black mastiff bat (*Molossus rufus*) is a fast flying hunter of hard-shelled flying insects with extremely short foraging bouts. The bats broadcast alternating lower and higher frequency echolocation calls that include slowly modulated narrowband and steep broadband sections. Little is known about how the flight aerodynamics and the echolocation behavior contribute to the efficient foraging strategy. We used miniature devices with ultrasonic microphones and accelerometers to study the movements and vocalizations of this species in the field near Veracruz, Mexico. The ultrasonic recordings reveal presence of conspecifics and detailed insight into the echolocation behavior of the tagged individual, and accelerometer data allows linking body movements to call emission. The foraging success can be quantified using impact sounds after the buzz as indicator of prey capture.

Lassen sich Fledermausgesellschaften umsiedeln?

Karl Kugelschafter

Lohra

Bislang beschränkten sich „Umsiedlungsmaßnahmen“ bei Fledermäusen vor allem auf baumbewohnende Arten. Dabei wurden i.d.R. In der näheren Umgebung der Eingriffsfläche Fledermauskästen als Ausweichquartiere aufgehängt, in der Hoffnung, dass die Tiere diese dann irgendwann auch nutzen. Als schwierig, wenn nicht gar unmöglich, wird in Fachkreisen jedoch die gezielte Umsiedlung von Fledermauswinterschlaf- bzw. Wochenstubengesellschaften angesehen, auch wenn es 2010/ 2011 in Göttingen erstmals gelungen war, eine kleine Mausohrwochenstubenkolonie erfolgreich an einem neuen Standort zu etablieren. Limitierender Faktor bei solchen Umsiedlungsprojekten ist der Faktor Zeit. Im Vorgriff auf den geplanten Neubau der Echelsbacher Brücke (Landkreis Garmisch-Partenkirchen) bestand nun aber die Möglichkeit einer mehrjährigen experimentellen Studie. Ziel war es, eine 300köpfige Mausohrwochenstubenkolonie von ihrem traditionellen Hangplatz im südlichen Brückenbogen in ein großzügig konzipiertes und im April 2011 an den Brückenbogen angedocktes Ersatzquartier umzusiedeln. Über einen kleinen Tunnel (Durchmesser ca. 20 cm, ca. 1m lang) war das Ersatzquartier mit dem Hangplatz verbunden. Darüber hinaus bestanden drei Einflugöffnungen, die nächstliegende etwa drei Meter vom gewohnten Einflug entfernt. 2011 wurde versucht, mittels Klangattrappen auf Basis arteigener Ortungs- und Soziallaute, die Tiere in das neue Quartier zu locken. Ohne merkbaren Effekt. Als die Tiere im Frühjahr 2012 zurückkehrten, waren die Einflugöffnungen verschlossen. Die Folge war, dass die Tiere in den nördlichen Brückenbogen umzogen. Nachdem die alten Öffnungen wieder geöffnet waren, kehrten die Tiere aber an ihren traditionellen Hangplatz zurück. Am 16./ 17. August 2012 wurde ein Teil der Kolonie vom gewohnten Hangplatz in das neue Quartier umgesetzt. Der Effekt: geradezu panikartig verließen die Tiere das Ersatzquartier. Erste Erfolge stellten sich 2013 ein, als die Mausohren mit vorsichtigem Druck angehalten wurden, beim abendlichen Ausflug nicht die gewohnte Öffnung zu nutzen, sondern über das Ersatzquartier auszufliegen. Obwohl sich die Kolonie im Laufe des Sommers an den neuen Ausflug gewöhnt hatte, „weigerten“ sich die Weibchen, über die neue Öffnung auch wieder einzufliegen. Im Laufe des Frühsommers 2014 orientierte sich ein Großteil der Mausohren nach und nach um und flog über den Tunnel und das angedockte Ersatzquartier aus. Im Gegensatz dazu nutzten maximal ein halbes Dutzend Weibchen die neue Öffnung bei ihrer morgendlichen Rückkehr. Das Umsetzen der nicht-flüggen Jungtiere sollte die Kolonie dann endgültig

zum Umzug in das neue Quartier bewegen. Aber auch dieser Versuch blieb erfolglos. Ein Erfolg stellte sich erst ein, nachdem die flügge werdenden Jungtiere auf die neue Öffnung trainiert worden waren. Während der dreitägigen Trainingsphase wurde der Zugang zum alten Hangplatz aber jeweils kurz vor Dämmerungsbeginn wieder geöffnet, damit die ad. Weibchen einfliegen konnten. Am 1. August blieb die alte Öffnung verschlossen. Im Gegensatz zum Vorjahr schlossen sich die ad. Weibchen jetzt aber den Jungtieren an und flogen über die neue Öffnung ein. Zwei Wochen später war es bereits zu einer Hangplatzverlagerung in das neue Quartier gekommen, ein Effekt, der aber Ende August wieder zunichte gemacht wurde, nachdem Siebenschläfer im Quartier aufgetaucht waren. Aufgrund neuer Planungen wurde das Umsiedlungsexperiment danach nicht mehr weiter fortgeführt. Dass mit diesem Vorgehen aber ein nachhaltiger Lerneffekt hätte erzielt werden können, zeigten die Erfahrungen im folgenden Frühjahr. Obwohl die alte Einflugöffnung wieder zugänglich war, nutzte der überwiegende Anteil der Kolonie zunächst nämlich weiterhin die neue Öffnung.

Durchgeführt wurde das Umsiedlungsexperiment im Auftrag des Staatlichen Bauamtes Weilheim in Zusammenarbeit mit R. Heuser (FOEA) und in Abstimmung mit einem Beirat unter der Leitung der Koordinationsstelle für den Fledermausschutz in Südbayern (Leiter: R. Zahn).

Reaction towards con- and heterospecific feeding buzzes depends on food patch quality

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Insectivorous bats eavesdrop on the feeding buzzes of other bats, which indicate the presence of potential prey. In this study we asked whether a bat's approach to feeding buzzes depends on insect quantity as indicated by feeding buzz rate and prey suitability as inferred from species-specific call structure; heterospecifics with little dietary overlap should be less attractive than species foraging on the same prey. To test this hypothesis, we broadcast 1-min long echolocation call sequences of six bat species with variable feeding buzz rates (0 – 96 per minute) at lakes in Southern Bavaria and recorded bat activity before, during, and after each playback. Preliminary analyses indicate that *Myotis daubentonii* was attracted towards feeding buzzes form *M. capaccinii*, *M. nattereri*, and *Nyctalus leisleri* but repelled by those from conspecifics and *Pipistrellus pipistrellus*. Response intensity increased with feeding buzz rate. *M. daubentonii* did not respond to feeding buzzes from *P. pygmaeus*. Our results demonstrate that *M. daubentonii* distinguishes between species which differ in dietary overlap with *M. daubentonii*. Further, our data suggest that *M. daubentonii* trades potential prey availability off against costs for exploring the origin of feeding buzzes, such as increased energy expenditure, competition, and antagonistic interactions.

The magnetic sense of migrating bats – Its biophysical character and putative role in true navigation

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Only eleven years ago, bats were added to the list of animals possessing a magnetic sense (*Eptesicus fuscus* in a homing task, Holland *et al.* 2006). In the following year, a laboratory-based assay confirmed the finding of magnetosensation during roosting (*Nyctalus plancyi*, Wang *et al.* 2007). The latter study also highlighted a magnetic North preference of tested bats indicating a polarity compass which meets a basic premise for magnetite particles (iron oxide) being the relevant integral part of any "magnetic compass organelle". In 2008, the behavioural experiment considered the acid test – a strong, brief magnetic pulse – designed to alter the magnetisation of particles was successful (Holland *et al.* 2008). The orientation of these particles compared to Earth's magnetic field was changed, literally guiding homing bats using a magnetic compass consistently in the wrong direction. In terms of experimental manipulation of sensory cues, migratory mammals are notoriously challenging to study including the bat species among them. Here, we asked whether migratory Nathusius' bats (*Pipistrellus nathusii*) would be responsive to a biasing magnetic field and a pulse when confronted with a true navigation task: a displacement from their migratory corridor. For this work, in the 2016 late summer and autumn migration season, we caught 70 adult *P. nathusii* at Pape Biological Research Station (PBRS) at the Latvian Baltic Sea coast. In principle, bats were randomly assigned into one control and two experimental groups which either underwent biasing field exposure or an additional antiparallel pulse treatment, both produced in a Helmholtz coil at PBRS. The antiparallel pulse was oriented in a way that hypothetically could cause either random orientation on the group-level or reversely oriented migratory flights. Bats were radio-tagged, subsequently displaced 11 km inland and individually tracked from the site of release to record departure flight behaviour and vanishing bearings. In the control group we observed seasonally appropriate south-southwesterly departure directions in line with previous results (Lindecke et al. 2015). Vanishing bearing of bats briefly exposed to a biasing field did not differ from controls. However, we observed randomly oriented departure directions in the group which experienced the pulse treatment.In conclusion, our results provide first evidence for magnetite-based magnetoreception relevant for orientation during mammal migration and support that migratory (adult) bats display true navigation capacity. Based on these results, we can for the first time reasonably speculate on the role of the bat's magnetic sense in the map and compass theory (Kramer 1953), and whether it might be part of the map or compass step (or both).

Vocal development after acoustic deafening in juvenile bats (*P. discolor*)

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In contrast to most mammals that have a vocal repertoire that is innate, bats have been indicated as vocal learners. Vocal production learning refers to the ability to acquire new vocalizations through imitation. The development of human language and songbird songs are the best studied examples. Vocal production learning requires the individual being able to hear new sounds and then being able to imitate them. Therefore deafening experiments, where the individual cannot hear others or itself, are critical tests for vocal production learning. Here we acoustically deafened three anaesthetised juvenile bats (p9 to p11) with intense (140 dB SPL) frequency modulated sweeps (1-45 kHz) played back in a continuous loop for 2 h. Permanent hearing loss is monitored by means of auditory brainstem responses to short broadband clicks (5 to 90 kHz) and to short (2.5 ms) tone pips with carriers between 5 and 90 kHz. Vocalisations between isolated juveniles and their mothers are recorded one to three times a week for 20 min in a fixed setting with the individuals being ca. 1 m apart from each other and 3 microphones directed towards each of them. A control group consists of three normal hearing juveniles and their mothers. Results show that both deafened and normal-hearing juveniles are socially integrated in the colony, developed physically normal and learned to fly. Deafness persisted for the entire observation period of 6 months. Vocal development of the deaf juveniles, however, differs from the control group. Deaf juveniles vocalise more often and they use shorter and weaker communication calls with higher fundamental frequencies. Preliminary inspections of call spectrograms indicate that while deafened juveniles can still produce normal communication calls, most of their calls seem degraded and/or fragmented. The data suggest that deafened juveniles may be vocally locked in a babbling phase.

FMCW Radar System at Millimeter-wave Frequencies for the Detection of Bats at Wind Turbine Installations: Initial Results From a Field Study

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Wind energy plants generate an impact on wildlife with significant fatality rates for various bat (and bird) species, e.g. due to a collision with the rotor blades or barotrauma. Monitoring approaches, such as acoustic or vision-based systems, are needed to reduce their mortality by means of an optimized turbine control strategy as soon as flying animals are detected. However, acoustic systems are limited in terms of their detection range and conventional vision-based systems require daylight. This means that advanced sensor technologies are needed for a bat-friendly wind turbine operation. A novel approach for the detection of bats are radar systems in the millimeter-wave frequency band that are of high interest to mitigate bat fatalities. In a first step, a frequency modulated continuous wave (FMCW) radar system operating from 34GHz to 36GHz will be presented. One important aspect is the arrangement of the antennas to generate the best possible image in 3D. In a second step, results from a field study will be discussed where the multistatic radar array is installed at the tower of a 2 MW wind turbine at approximately 95m above ground.

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Duration tuning in the IC of *Carollia perspicillata*

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Bats alter call duration during flight. Call duration can be resolved by dedicated duration tuned neurons (DTNs) in the IC. Most studies on duration tuning (DT) have been conducted on insect-eating bats that use echolocation for hunting prey. We conducted electrophysiological recordings in the IC of the fruit eating bat *Carollia perspicillata*. Our goal was to characterise DT in a non-predatory bat that uses ultra-short echolocation calls (2 ms- 0.8 ms). Two different stimulus designs, a pure tone (PT) and a downward frequency modulated sweep (FM), were presented to the animals at 10 to 70 dB SPL in steps of 10 dB SPL. From a total of 122 neurons recorded, 86 (70.5 %) showed some type of duration tuning response to at least one of the level/stimulus-design combinations tested. 64 % of DTNs responded to FM only, 13 % to PT only and 23 % to either stimulus design. We found an overrepresentation of long pass selectivity in the IC of *C. perspicillata*. The latter resembles more what occurs in non-echolocating species such as rats, than what has been reported in insect-eating bats. Our results raise questions on the evolution and functional value of duration tuning in vertebrates.

Paläobiologie der fossilen Fledermäuse aus Messel

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Aus den knapp 50 Millionen Jahre (Tertiär, Eozän) alten Seeablagerungen des heutigen Weltnaturerbes „Grube Messel“ bei Darmstadt wurden seit dem industriellen Abbau des sog. „Ölschiefers“ (1884 bis in die 1960er) zahlreiche und oft gut erhaltene fossile Pflanzen, Insekten und Wirbeltiere gefunden. Durch wissenschaftliche Grabungen und Forschungen seit den 1970er Jahren ergab sich ein ungewöhnlich umfangreicher Einblick in ein fossiles Ökosystem, einen kleinen See umgeben von tropischem Regenwald, Lebensraum von bisher sieben beschriebenen Arten von Fledermäusen aus drei fossilen und einer rezenten Familie (Archaeonycteridae, Palaeochiropterygidae, Hassianycteridae und Emballonuridae). Durch REM-Untersuchungen überlieferter Magen-Darm-Inhalte wiesen die senckenbergischen Forscher Dr. Gotthard Richter und Dr. Gerhard Storch direkt die insectivore Ernährung der vier Arten nach und zusammen mit Dr. Jörg Habersetzer durch seine radiologischen Studien die bereits im Eozän erfolgte flugbiologische Einnischung und die Fähigkeit zur Echoortung. Als Besonderheit sind sogar einzelne schwangere Weibchen und subadulte Messeler Tiere überliefert, an denen durch Stereo-Mikroradiografien der Zahnwechsel vom Milch- zum Dauergebiss untersucht wurde. Zuletzt gelang einem internationalen Forscherteam bei den beiden Arten *Palaeochiropteryx tupaiodon* und *Hassianycteris messelensis* sogar der Erstnachweis der Fellfarbe eines fossilen Säugetiers.

Extreme flexibility in torpor patterns in a tropical bat (*Hipposideros commersoni*)

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The energy budget of an animal species is closely linked to its ecology and balancing energy expenditure with energy acquisition is key for survival. Changes in an animal's environment can be challenging and particularly bats are extremely affected since they are small endotherms with large uninsulated flight membranes. Bats make up nearly a quarter of all mammalian species worldwide and provide important ecosystem services vital to the preservation of natural ecosystems and human economies but little is known about Madagascar's bat fauna. Almost no information detailing their physiological requirements are available although especially this knowledge is crucial to understand their adaptive potential to habitat alterations. Heterothermy is a very powerful response to cope with changing conditions but only a handful of studies on it exist for free-ranging tropical bats in their natural environment, and none in Madagascar. Here, we will report first data on heterothermy found in the Malagasy bat *Hipposideros commersoni*. We examined the energy management and thermal biology of *H. commersoni* directly in the field performing skin temperature and metabolic rate measurements. These were related to local environmental characteristics during a feasibility study in the dry season in 2016. *H. commersoni* showed extreme variability in torpor use and was exclusively found in one cave implying that this cave might be essential for the overwintering and reproduction success of this particular species. Interestingly, this cave was the hottest in the area (constantly above 30°C), raising intriguing questions about microclimate choice during a heterothermy-prone season.

Lunarphilia in open-space foragers

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Lunarphobia of wildlife is a widely recognized phenomenon, and often considered an anti-predator strategy for nocturnal animals. Yet, clear behavioural responses towards the lunar cycle have rarely been described quantitatively and hints towards the underlying causes most often remain obscure. We thus asked if an obligate nocturnal mammal, the common noctule bat *Nyctalus noctula*, adjusts its habitat use and 3-dimensional flight behaviour to the lunar period. We recorded 22 flight tracks of nine noctule bats during midsummer, using GPS loggers which captured 3-dimensional locations every 15 seconds. We then related the resulting flight paths and altitudes to the lunar cycle and the underlying habitat structures, as revealed by aerial laserscans (LiDAR). Noctule bats frequently foraged above the canopy of coniferous forest around new moon, but moved towards open grasslands and arable fields under moonlit conditions. We conclude that lunarphilia may be a strategy to increase foraging success for nocturnal top predators like noctule bats. Their low vulnerability towards predators may allow them to hunt for insects that emerge and disperse over the aerosphere of open fields under moonlit condition. Although overall activity might not be affected by moonlight, habitat use of nocturnal predators may change drastically during the lunar cycle.

Social calls of *Myotis nattereri* during swarming

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Swarming is a characteristic behavior of bats that occurs in different social contexts. Although this behavior is known since decades swarming related social calls are barely described. We studied the swarming behavior of *Myotis nattereri* at a maternity colony and a hibernaculum by using synchronized acoustic and video recordings. The bats showed a typical flight behavior that was characterized by oscillating flights to the entrance of the roost and also by chasing flights. The social calls can be classified into three basic call types which occur in different variations. All call types were recorded at the maternity colony as well as at the hibernaculum. The first call type was rather short with a steep shallow steep frequency modulation. The second call type was longer with a steeply modulated component followed by a shallowly modulated component that sometimes ended with an upward modulation. These call types occurred mainly at the maternity colony. The third call type was classified by its typical sinusoidal signal structure. This call was recorded very frequently at the hibernaculum and was less common at the maternity colony. The complexity of this call type was higher at the hibernaculum. It can be assumed that this social call is strongly connected to the reproduction behavior of Natterer's bats.

Movement ecology of noctule bats in an urban environment

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Urbanisation, the increase of human populations in cities, spread of urban areas and simultaneous decrease of rural populations, drives one of the profoundest and most persistent types of land use change on a global scale. It poses a dramatic impact on the affected ecosystems, as humans introduce new species and materials and change biotic and abiotic environmental factors. This poses the question how species living in the affected ecosystems use this extremely altered environment. The common noctule bat (*Nyctalus noctula*) is a bat species frequently found in urban areas. We used miniaturised GPS loggers to record fine-scale positional data of common noctule bats in the urban area of Berlin, Germany in 2015-2017 and analysed the obtained flight paths in a presence vs. pseudo-absence approach. The analysis investigated the potential influence of artificial lighting, land use and linear landscape structures such as traffic routes, waterways and powerlines on the space utilisation of *N. noctula*.

Vocal learning in bats: from genes to behavior

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Vocal production learning (herein 'vocal learning') - the ability to modify vocal signals based on conspecific auditory feedback - is an essential component of human spoken language (Bolhuis, Okanoya, & Scharff, 2010; Nowicki & Searcy, 2014). This task involves auditory perception, memorization of template, vocal motor planning and production, template matching to determine goodness of fit and modification of the vocal-motor output (Petkov & Jarvis, 2012). The complexity of this task suggests that multiple neurobiological and genetic mechanisms are likely to underlie its evolution and biological encoding. Given the necessary limitations of studying vocal learning in humans, animal models represent an opportunity to understand the neurogenetic mechanisms underlying this spoken language-relevant trait (Vernes, 2017). Vocal learning is a rare trait in the animal kingdom. Few non-human species have convincingly shown this trait. To date, vocal learning has been documented in some cetacean, pinniped, elephant, bat and bird species (Bolhuis et al., 2010; Janik & Slater, 1997). Bats are highly social animals that have developed sophisticated vocal systems for navigation and communication. Their capacity for vocal learning, small size, amenability to neurogenetic manipulations and the long history of studying the neuroethological traits in bats, makes them an excellent system to model vocal learning (Esser, 1994; Knörnschild, 2014; Prat, Taub, & Yovel, 2015). I will present work investigating neurogenetic mechanisms underlying vocal learning, including the role of individual genes and gene networks. These studies encompass single gene studies and genetic knockdowns, transcriptomics, network building, and de novo genome sequencing. These approaches will ultimately show how genetic mechanisms can drive a complex behaviour like vocal learning and may shed new light on the biological encoding of human speech. Bringing together genetic, neurobiological and behavioural studies in this way will shed light on the encoding of vocal learning in bats, and ultimately inform our understanding of the evolution of this language-relevant trait.

Habitat use of pteropodid bats and their importance as seed dispersers, compared to birds, on the slopes of Mt. Kilimanjaro, Tanzania

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Frugivorous birds and bats are known to be important mutualists for plants, yet little information is available on their function as seed dispersers in Africa, especially on how land-use changes may affect the associated ecosystem services. We investigated the community structure of six pteropodid bat species in five different habitats and analyzed the interaction networks of bats and birds with their associated food-plants over an altitudinal and land-use gradient on the slopes of Mt. Kilimanjaro, Tanzania. To determine the food resources of birds, we used direct observation only and for bats, we additionally collected fecal samples. Food plants were further identified by morphological characteristics of seeds in the fecal samples and by metabarcoding of plant DNA extracted from these samples. Analyses show distinct changes in community composition of pteropodid bats in the different habitat types, probably due to habitat degradation, which may have negative consequences on overall seed dispersal and forest regeneration functions. We further found changes of specialization in the seed dispersal networks of bats and birds with increasing mean annual temperature and intensified land use. Our study stresses the importance of bats as seed dispersers compared to birds on Mt. Kilimanjaro and gives new insight into the diets via metabarcoding techniques.

Ladies' Night Out: Sex-dependent resource defense in *Glossophaga soricina*

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Aggressive resource defense is frequently observed throughout the animal kingdom and although it is a widespread phenomenon in nectar-feeding birds, reports of interference competition in nectarivorous bats are extremely rare. *Glossophaga soricina* has been observed to defend flowers of *Agave desmettiana* but not much is known about the social structure during resource defense and how interference competition affects the nectar intake of individual bats. Here, we investigated the resource defense behavior of *G. soricina* in a laboratory setting. By using an experimental setup consisting of two patches of computer-controlled artificial flowers we tracked the nectar intake of every group member. Furthermore, we were able to establish an automated method for flagging potentially aggressive interactions at close proximity to the artificial flowers. Theoretical models of interference competition predict that aggressive interactions increase when resources are spatially more clumped. Within each experimental night the resource distribution changed from clumped to distributed across two patches, in order to assess how changes in the distribution of resources influence the number of aggressive interactions. Resource defense behavior was assessed in 36 individuals divided into one male and one female group, as well as four mixed-sex groups. Throughout the experiment, males engaged in aggressive interactions significantly more often than females and only males were successful in defending artificial flowers. Subordinate males experienced a substantial decrease in their nectar intake. However, females were only marginally affected by male aggression and were able to maintain their level of nectar intake throughout the experiment. These results suggest that the number of aggressive interactions and the influence of aggressive resource defense on individual nectar intake are sex-dependent in *G. soricina*. Furthermore, as expected, the number of aggressive interactions was higher and resource defense was only successful during the first part of the night when resources were clumped.

When a virus uses another entrance - Immune mechanisms involved in innate anti- Lyssaviruses immune response in nasal cavity of European bats

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Lyssaviruses are neurotropic viruses causing fatal encephalitis of central nerve system, rabies. In Europe, bats act as reservoir hosts for two specific Lyssaviruses, European Bat Lyssavirus (EBLV-1 and -2). Although cases of rabies in bats caused by EBLV 1 or 2 are described, there are no reports about epidemics in bats and Lyssavirus specific antibody titers in European bats were only rarely detected. This indicates that innate immune pathways might be responsible for the observed resistance in bats. The interferon Type I and III family of two European bats species *E. serotinus* and *M. myotis* were cloned and sequenced. Using established cell lines from nasal epithelium (MmNep) nervus olfactorius (MmNol), M. myotis brain (MmBr) the IFN responses along the aerosol infection route by investigation of IFN signaling pathways, induction of IFNs and interferon stimulated genes (ISGs) and anti-viral effects in correlation to the expressions of viral receptors was analyzed in-vitro. Finally the influence of the bat-specific thermoregulation during daily torpor on IFN response and Lyssavirus replication was characterized. A gradual decreased susceptibility along of cells the aerosol route combined with an increased IFN response was measured. Also a positive effect of changing body temperature on IFN response and a negative influence on viral replication was measured. Conclusion: Bats as reservoir host for EBLV 'provide' a peripheral replication site but also block effectively the spread of Lyssaviruses to central nerve system indicating a specific co-evolutionary relation.

Posters

Investigating the neurogenetic mechanisms of vocal learning using a bat model

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Vocal learning, the ability to modify vocalisations based on the auditory feedback of conspecifics, is crucial to human spoken language and thus indispensable for our daily communication. However, the genetic and neural mechanisms of this complex task are to date not well understood. Apart from humans, only few animal species have developed vocal learning. Given the limitations to study the underlying Biology in humans, birds have dominated this research field, due to their vocal learning abilities and ease of handling. In order to fill the gaps of knowledge between work on birds and humans, we are in need of a mammal model of vocal learning. Bats belong to the rare mammal species that have shown evidence to be capable of this trait. Understanding the Biology of vocal learning would provide a unique opportunity to study underlying genetic and neuronal mechanisms. Some genes that have been discovered to be directly involved in vocal learning are FoxP2, FoxP1 and CntnaP2. Aiming to understand the genetic underpinnings of vocal learning, we comprehensively mapped these genes in the brain of the bat *Phyllostomus discolor*, a promising vocal learning candidate. This information has been collected in a public brain atlas database (a.k.a. Batlas). Furthermore, to obtain a better understanding of the neuronal mechanisms, we are working on defining brain regions that are activated during vocal learning related tasks. We made use of a genetic marker for neuronal activity to visualise and define cortical brain regions that responded to the bats' communication calls. Future investigations will focus on brain regions that are involved in production tasks as well as the effects of deafening at early juvenile stages. Having established these tools, the genetic and neural fundaments of vocal learning can be investigated in an exciting mammal model and they might enable us to get better insight on the evolution of speech and language.

Intraspecific variation in the Food habit of Noack's round leaf bat (*Hipposideros.* cf. *ruber*) from Ghana

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We investigated intraspecific variation in the diet of *Hipposideros*. cf. *ruber* species from agricultural environments of central Ghana. We tested the hypothesis that the species exhibits variation in diet among different demographic and reproductive groups. It was also expected that seasonality and cave locations will influence major prey item intake by this species. To test these hypotheses, 983 faecal samples from *Hipposideros* cf. *ruber* collected from bats roosting in five caves situated in the forest and forest-savannah transitional zones were analysed. Percentage volumes of major prey items were arcsine transformed before subjecting the data to one-way ANOVA and MANOVA analysis. Our results showed that the diet of *H*. cf. *ruber* contained at least 7 insect orders, Araneae, and unidentified arthropods. Lepidoptera (61.7% by volume) was the major prey item followed by Coleoptera (28.3% by volume). The consumption of Coleoptera ($F_{(1, 875)} = 0.337$, $p = 0.146$) and Lepidoptera ($F_{(1, 875)} = 0.328$, $p = 0.177$) was similar between adult males and females. However, pregnant females consumed more Coleoptera compared to lactating and non-reproductive females ($F_{(2,396)} = 4.412$, $p = 0.013$). Also, our result showed that intake of major prey items was influenced by seasonality and geographical locations of the bats (Wilk's lambda (Λ) = 0.925, $p<0.05$).

What makes the ripples risky? Surface wave perception with echolocation

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Bats across many different taxa forage on water. On a calm water surface, a floating prey item or a ring of spreading ripples are the only structures that reflect echoes back to the bat. In my doctoral thesis I test the hypothesis that echolocating bats perceive both the spatial and temporal structure of surface waves. My work so far shows that for both spatial and temporal frequency domain, bats best perceive high frequencies. This implies that they can likely filter sharp-edged prey on smooth surface waves and can detect moving waves, too. To better understand the profoundness of echo-imaging in complex scenes we took the research "into the wild", more specifically to the Panamanian jungle. The neotropical bat *Trachops cirrhosus* forages on frogs and can use water ripples (created by the courtship-calling frogs' inflating vocal sacs) as an additional foraging cue. Here we addressed the following questions: What are the exact spatial and temporal frequencies of the ripples generated by calling frogs' vocal sacs? Can Trachops rely on changes in the echoes' loudness and frequency to detect ripples? As echoes from water ripples depend very much on call impingement angle, how does Trachops optimize its calling angle to detect frog-generated ripples?

A new application of wireless sensor networks in bat research: assessing foraging strategies in nectar-feeding bats

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Employing an efficient foraging strategy is a key-determinant of an animal's fitness. Nectar-feedings bats need to visit many flowers each night to maintain a positive energy balance. Nectar is generally found only in small portions, while, being small, flying mammals, the bats have to satisfy a very high energetic demand. Therefore, we expect that foraging strategies in nectar-feeding bats underlie strong selective pressures towards a highly efficient exploitation of their floral resources. Until very recently, the foraging strategy employed by nectar-feeding bats remained elusive. So far, our knowledge about their foraging behavior derived mainly from experiments conducted with captive animals or artificial flowers, and from opportunistic observations made at single flowers. Further, the low spatial resolution of a classical radio telemetry approach does in general not provide sufficient information to assess foraging strategies of bats in the wild. Groundbreaking developments in the field of wireless sensor technology allow now to track visitation rates of bats at their food plants in their natural environment. We present a new application of the BATS-system* that we implemented at La Selva Biological Station in Costa Rica. We aim to trace the foraging behavior of *Glossophaga* sp. at the steady-state flowering and staple-resource for nectar-feeding bats *Merinthopodium neuranthum* and at flowers of the massive-flowering bromeliad *Werauhia gladioliflora*. Currently, up to 60 bats and flowers may be monitored simultaneously over the course of several days. Using this promising new approach we hope to gain a deeper insight into the foraging strategies employed by wild nectar-feeding bats in their natural habitat and understand how they adjust their behavior to the availability to different nectar resources.

* www.for-bats.de

Automatic location monitoring in wind farm planning process

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German law prohibits the killing of bats but wind farms are one major reason for bat mortality. Local authorities often assume that the distance to known bat roosts and the monitoring of bat calls at nacelle height are sufficient measures to avoid mortalities. An analysis of the functional significance of a given area is rarely demanded probably due to financial reasons. A solution might be a cost-effective automatic location monitoring. This system relies on common devices for telemetry and monitors cira-concentric, automatic and continuous the usage of a certain area for e.g. transfer flights or foraging. The number of monitored animals is per se unlimited only being restricted by temporal resolution and power/storage supply. The monitored area is defined by transmitter capacity and local habitat and is based on a project-specific calibration of the system. Audio data are automatically analyzed by a custom program. This system allows for a cost-efficient registration of conflict areas in time and space making a valuable and affordable tool in wind farm planning processes.

Migratory pathways of bats in the Gießener Lahntal and adjoining mountain landscapes

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Mammals have different strategies to cope with the food restriction and cold in winter: they adapt, hibernate or migrate. Bats might combine two strategies and migrate from north to south to hibernate southwards. One of this migratory species is the Noctule bat *Nyctalus noctula* with one of the longest known migration distance for bats of 1546 km. Up to date little is known about the actual migration pathways. It is possible, that they migrate in broad fronts (board-front migration) or that they orient themselves by landscape characteristics and follow them along specific pathways (migration corridors). A further indication of migration behavior is the approach phase to hibernation sites and whether they come from all directions or show a preference for a direction (focus migration). My aim is to define the migratory pathways of *Nyctalus noctula* in the Gießen-Lahnthal using acoustic monitoring.

Social behaviour and social call repertoire of *Carollia castanea* from the wild, in a flight cage

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The function of social calls as a premating isolation barrier has been reported from different animal taxa. This mechanism may be of particular importance for a long-term coexistence of closely related, nocturnal species living in sympatry, which may rely on acoustic communication for species recognition at a distance such as bats. Due to their similar characteristics in morphology and food consumption, sympatrically living species of the genus *Carollia* represent a good example to investigate the role of social calls for species separation in bats. Within the genus, social behaviour and call repertoire have been well studied in *C. perspicillata*. On the contrary, data for congeneric species living in sympatry are missing. The aim of this study is therefore to investigate interactions and concomitant social calls in *C. castanea* and compare the results with the ones of *C. perspicillata*. The investigation was carried out at the Hitoy Cerere Biological Reserve, Costa Rica, from September to December 2017. 14 individuals (7 females, 7 males) of *C. castanea* were captured and kept temporarily in a flight cage for behavioural observations and call recordings. Plastic rings on the forearm allowed for individual discrimination. Data collection was mainly performed from 6 pm to 12 pm using a SONY camcorder and two Raspberry Pi IR-sensitive cameras and a Wildlife acoustics bat recorder connected to one, or two, ultrasonic microphones. The present poster presents typical examples of social interactions between bat dyads with the concomitant vocalisations.

Auf den Spuren von Batmans Familie… Was uns der genetische Fingerabdruck über die Fledermaus verrät.

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In den letzten Jahren haben die Speziesidentifikation und die genetische Individualisierung von Tieren einen immer höheren Stellenwert erlangt. Eine gängige Methode zur Artbestimmung ist die Amplifikation spezifischer mitochondrialer Fragmente und anschließender Restriktionsfragment-Längen-Polymorphismus (RFLP) oder Sequenzierungs-Analyse. Das Ziel dieser Studie ist es, eine STR basierte Multiplex-PCR für die gleichzeitige Amplifikation von mindestens 10 Markersystemen spezifisch für verschiedene Fledermaus-Arten (z.B. *Myotis bechsteinii*) zu etablieren. Diese können dann zur Identifikation von Individuen, zur Verwandtschaftsanalyse, Artbestimmung sowie genetischen Beurteilung der Population genutzt werden.

Irrational Choice and Suboptimal Decision-Making in Nectar-Drinking Bats

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Classical models of animal decision making assume that animals make decisions that tend to maximize the rate of return of caloric reward (Charnov, 1976, for example). However, experiments with both pigeons and European starlings have shown that, when faced with a choice between an information-rich, energetically poor option and an information-poor, energetically-rich option, the animals tend to prefer the former, information-rich option, making an “irrational” choice. Further experiments by Kacelnik and co-workers have indicated that this may be due to the adaptive advantage of utilizing post-choice information. Our aim is to examine whether nectar-feeding bats also prioritize information over simple caloric reward, and investigate some of the hypotheses put forth to explain this.

The alternating low and high frequency echolocation signals of *Saccopteryx bilineata* may have different functions

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The greater sac-winged bat *S. bilineata* is known for using two different echolocation patterns: at roosting sites they use monotonous sequences with high frequency calls at a maximum frequency of ~48 kHz and at foraging sites they use sequences with alternating low and high calls at ~45 and ~48 kHz. Detailed studies of the echolocation behavior of *S. bilineata* while foraging in differently structured foraging habitats on Barro Colorado Island (Panama) suggested that the two call types may have different functions.

Bats use echolocation to perform two main tasks: orientation in space and acquisition of food. While performing a specific task they choose signals which are optimally adapted to solve the given echolocation problem. For example, during the approach to prey they reduce pulse duration and interval, and during spatial orientation they shorten their signals with decreasing distance to background targets. In the alternating echolocation sequences of foraging *S. bilineata* the two signal types are altered independently according to the two main echolocation tasks. Low-note calls at ~45 kHz are changed according to the typical approach behavior of an insect-feeding bat and are therefore used for prey detection (prey detection calls) whereas high-note calls at ~48 kHz are changed according to distance to background and are therefore used for spatial orientation (orientation calls). This gets evident when bats reduced the signal duration of low-note prey detection calls during the approach to prey without changing the duration of the high-note orientation calls. Thus, we hypothesize that the two alternating signal types serve different functions. Our hypothesis also explains the monotonous sequences at roosting sites where only spatial orientation with the high-note orientation calls is needed.

Semi-natural bat roosts as continuous ecological functionality-measures (CEF)

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Tree hollows are favorite roosts for bats but are frequently felled in the course of landscape planning. A frequent continuous ecological functionality-measure is the installation of wood-cement bat boxes. However, monitoring projects have revealed that naive bat populations might need several years to accept these boxes as roosts probably because of the different appearance and microclimate compared to natural tree hollows. In a seven year monitoring project we compared semi-natural bat roosts to wood-cement bat boxes. Semi-natural bat roosts consisting of oak wood are more thermally stable, are accepted more readily by naive populations, showed a more continuous use throughout the years and almost all installed roosts were used. We also found the most species and individuals in the semi-natural oak bat roosts. These results underline the functionality of semi-natural bat roosts as continuous ecological functionality-measures.

Monumental bats – Historic buildings as a biodiverse habitat and an object of monument preservation

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Stiftung FLEDERMAUS

Several bat species use historical buildings as day roost (or hibernaculum). Due to their historic inventory or construction, these often centuries-old buildings are frequently declared as historic monuments. Historical buildings are often altered due to changes in the usage – either abandonment and decay or intensifications of use which is often linked to energetic renovations. In both cases wildlife/bat and monument conservation unavoidably meet in these places. The project addressed possibly conflicts but also common interests of both conservation groups. An interdisciplinary group of biologists, art historians, monument conservationists and engineers studied several listed buildings in the three states of Central Germany that are or were used by *Myotis myotis* or *Rhinolophus hipposideros*. The group studied the history and future of the building with regard to reconstruction or restoration, the usage of wood preservatives and fire retardants, work and health protection measurements and other aspects. As a result of the project, a guideline with practical advice, for instance regarding bat-compatible work-flows or protection of historic structures against the input of soluble components from the feces was compiled.

Resilience or Resistance – How do European bats cope with White-Nose infections?

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Pseudogymnoascus destructans (*Pd*), the causing agent of the White-nose disease, colonizes bats during hibernation. The cold-loving fungus affects the snout and all the hairless skin membranes of torpid bats where it causes lesions. The spreading epidemic in North America (so called White-nose syndrome) is characterized by mass mortalities and regional extinctions of certain bat populations. In Europe, *Pd* has been recorded since several decades as a widespread pathogen, yet it does not cause mass mortalities. Several studies confirm that *Pd* is native to Europe and appeared as a new pathogen in North America in 2006. If and how European bats adapted to the disease and why North American bats cannot cope with the fungus remains unclear. Physiological and immunological data from infected and non-infected European bats were analysed to investigate, if bats suffer from White-nose disease and how the immune systems reacts to fungal infections during hibernation. Our first ecological, physiological and immunological results discuss resilience and resistance of European bats towards *Pd*.

Neuronal response patterns and coherence dynamics in response to distress vocalization sequences

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The ethological relevance of communication calls in the animal kingdom is undisputable. Bats species such as *Carollia perspicillata*, a highly vocal animal, include in their repertoire a wide variety of vocalizations that are used for both social interactions and for the signaling of distressful situations. How such vocalizations are represented in the bat's brain is not yet fully understood. In this study, we address such issue by describing the way in which neurons of awake bats (*C. perspicillata*) cope with distress streams, and how the coherence of spikes and local-field potentials in the auditory cortex is shaped by the stimulus' characteristics. Our results indicate that neurons in the cortex of Carollia are able to represent distinct features of the temporal structure of the perceived sounds, and that different coherence dynamics between field potentials and spikes are associated to specific patterns of neuronal firing. Our data suggest that auditory cortical oscillations are deeply entangled with neuronal spiking, and that the temporal structure of the perceived vocalizations plays a role in the modulation of cortical synchronicity.

Roosting patterns in a captive colony of *Carollia perspicillata*

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Bats form social groups in different contexts e.g. for thermoregulation, raising pups or to counteract predation. In the natural environment, *Carollia perspicillata* forms different agglomerations, namely harem groups, mixed-sex subadult groups and male-only bachelor-groups, as well as solitary bachelors. A field study on the social organization of the species suggested a labile composition of harem groups. However, a stable roosting pattern has been reported for freshly captured bats in a flight cage. To further explore roosting dynamics and patterns in captivity, we observed a colony of captivity-bred *Carollia perspicillata* for seven weeks. In the colony were 21 adult individuals (13 = male; 8 = female) and two female pups which were born at the beginning of the observation period. The bats lived under a 12h day (resting period: 10:00pm-10:00am)/12h night (activity period: 10:00am-10:00pm) cycle. Differently colored rings on the forearms were used to identify the individuals. Roosting patterns in the keeping room (6,22m² x 2,09m) were recorded once a day, alternatingly at about 09:30 am (toward the end of the resting period) or at 2:30 pm (after a third of the active period). The position of every individual was marked in a grid map. During the study period, the bats formed two harem groups, one mixed-sex group with only adults and one mixed-sex group with only subadults, or roosted as solitary bachelors. Adult individuals remained in their harem group, or the adult mixed-sex group, and occupied a constant grid position throughout the study period. Subadults of the mixed-sex group were found in an area of about 1/3 of the ceiling space in the keeping room. Within this area, individuals frequently changed their roosting places as well as grooming partners. The present data suggest a stable group composition and roosting pattern for adult individuals, however, a more dynamic pattern for subadults. These data are related to the physical conditions of the bats expressed by the forearm mass index.

More than a big nose-leaf: echolocation behavior of the phyllostomid insectivorous bat *Lonchorhina aurita*

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Most insectivorous phyllostomid bat species forage in dense forest and glean insects from surfaces. They use rather similar and stereotypical echolocation calls. These calls are generally very short (<1-3 ms), multi-harmonic and frequency-modulated (FM). We recently discovered that the insectivorous Sword-nosed bat *Lonchorhina aurita*, which shows the longest noseleaf in the entire phyllostomid family, emits additionally also longer echolocation calls with durations up to 8.7 ms. They are in general composed of a quasi-constant frequency (QCF) component of variable length at the onset of the call (45kHz, second harmonic), followed by a short FM down-sweep. On some occasions we recorded even pure QCF calls in the field without a terminal FM-component. In more cluttered environments (flight cage) the QCF component of the calls was significantly shortened. The relatively long, shallow modulated QCF echolocation calls of the insectivorous *Lonchorhina aurita* can be assumed to be used in aerial prey detection over larger distances because they facilitate the detection of even faint prey echoes. From *Lonchorhina aurita* flying in its natural forest habitat we recorded a distinct terminal group that closely matches the feeding buzzes of aerial hawking species from other bat families. So far, the only species of phyllostomids known to regularly also hunt aerial prey is the trawling *Macrophyllum macrophyllum* that uses standard phyllostomid echolocation calls for prey detection and a terminal phase for prey localization. Our initial observations suggest that the echolocation system of *Lonchorhina aurita* shows distinct adaptations toward an - for phyllostomids - rather unusual aerial hawking foraging mode, however, more observations on echolocation and hunting behavior will be needed for verifying the preferred hunting style.

Bat hibernacula are more than only winter places: species and sex specific activity patterns show the year-round importance for bats

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In the temperate zone, bats depend on hibernacula that protect them from adverse weather in order to survive the winter. In addition, it is known that several species aggregate in late summer and autumn at hibernacula for mating. Consequently, protection of hibernacula against human disturbances such as visitations by cavers and tourists is typically limited to the time between September and April. However, at present, the species specific phenology at hibernacula is largely unknown and therefore current bat conservation plans for hibernacula may be insufficient. In our study we analysed individual activity-data from a hibernaculum in northern Germany of six consecutive years. Bats of two sympatric species with different diets and foraging capabilities, *Myotis nattereri* and *Myotis daubentonii*, were automatically monitored using PIT-tags. Our data show that with the exception of July, bats are present at the hibernaculum throughout the whole year. Our results suggest that *Myotis daubentonii* follows the same annual activity patterns every year, whereas *Myotis nattereri* shows activity differences between the years. We observed differences in the seasonal activity between the two species and between the sexes of the same species. Our findings can be used to implement more appropriate protection plans for hibernacula taking into consideration the phenological, species and sex specific aspects. Based on our results, we strongly recommend to strictly protect bat hibernacula during the whole year.

The neuro-molecular basis of vocal learning in bats

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In contrast to songbirds, only few mammals are considered to be vocal learners. Bats are among those few. Within the framework of an HFSP funded international project we will investigate the neuro-molecular basis of vocal learning in the bat *Phyllostomus discolor*. As auditory experience is critical for the acquisition and maintenance of learned vocalizations, our first aim is to characterize neuronal responses to natural vocalizations of the bat *P. discolor*. Currently, we are extracellularly recording neuronal responses in the auditory cortex of anaesthetized bats. Stimuli consist of various communication call types presented via free-field loudspeaker. Our data analysis aims towards answering the following questions: 1) Are responses call specific? 2) What are the temporal integration times for maintaining response integrity? 3) What are the physical acoustic parameters encoded by the responses to communication calls? Future experiments plan to knock down the language related gene FoxP2 in different brain areas of juvenile bats in order to quantify its influence on vocal learning and neural representation of communication calls.

Acoustic response of European bushcrickets to bat echolocation calls

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Male bushcrickets use ultrasonic songs to attract females and defend their territories. However, these songs are also exploited by eavesdropping predators such as bats. Singing bushcrickets are thus under strong pressure to constantly trade-off between singing for mate attraction and territory defense and stopping to sing to avoid predation. Bushcrickets have sensitive hearing to recognize conspecific signals well extending into the ultrasonic range, as well as for detecting bat echolocation calls from large distances. In the present study, we investigated the acoustic response threshold of several European bushcricket species for the echolocation calls from *Myotis blythii* under two different scenarios. In a sound-insulated chamber, we presented sequences of bat calls mimicking a predator at different distances (from 1 to 15 m), to individual singing male bushcrickets. We hypothesize that the threshold to stop singing will differ between bushcricket species depending on their species-specific habitats which influence exposure to bat predators. In a second experiment, we used the same design as above, but additionally played a conspecific competitor's song simultaneously with the bat calls. Under this scenario, we hypothesized that bushcrickets trade-off predator avoidance against territory competition and expect that thresholds will increase when conspecific calls are presented.

Escaping a bat: Behavioural variability as anti-predator adaptation in moths

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How not to end up as a predator's meal? This question is crucial for animals of prey. Therefore, a multitude of adaptations for avoiding or escaping predators evolved; one of them being erratic and unpredictable movement. Echolocating bats and eared moths are ideal to study this kind of movements: upon detecting a bat with their ultrasound sensitive ears, many moths engage in evasive flight manoeuvres to escape. Surprisingly however, these manoeuvres seem to show some degree of stereotypy. As successful defence behaviour should be based on unpredictability, an open question is how such stereotypical behaviour can be still effective. We hypothesize that variation in evasive flight exists interspecifically, masking the potential stereotypy of single moth species. We recorded the evasive flight behaviour of multiple moth species using two different approaches: (A) An automated force-transducer to record behavioural audiograms of stationary flying moths and (B) recording 3D trajectories of free flying moths in a sound-attenuated chamber. In both cases, pure tone pulses of different frequencies and intensities were presented to stimulate evasive flight. This study will shed light on the specialized adaptations of moths as response to their highly specialized predators, nocturnal flying echolocating bats.

How well does roosting proximity and kinship predict social grooming in common vampire bats?

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Symmetrical cooperative interactions (such as grooming or food sharing) might depend on reciprocal investments, or they might emerge as simple byproducts of inherently symmetrical factors such as kinship or spatial proximity. Past studies with common vampire bats found that food sharing and social grooming are more correlated with each other than either is with kinship. However, roosting proximity has not been measured as a potential explanatory factor for cooperation. We therefore measured the consistency of roosting proximity in a captive colony of 36 individually marked vampire bats from two distant capture sites in Panama, and we compared spatial proximity networks with pairwise kinship and with social grooming networks. To measure proximity while roosting, we took 117 photos of roosting groups, twice per day in the morning and afternoon over two months. To estimate kinship estimates, we used known maternal pedigrees and 17 polymorphic microsatellite genotypes. We hypothesized that (1) roosting proximity will be stable over time and only moderately correlated with kinship and grooming, and (2) directional social grooming will be correlated with reciprocal grooming even after controlling for proximity and kinship. Results are forthcoming.

Fundamental frequency discrimination in *Phyllostomus discolor*

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Communication calls of most bats are highly diverse in spectral content and temporal pattern. A typical call repertoire within a species is common to all individuals, however small differences among individuals are often observed. To which extent these differences are relevant or detectable to an individual depends mainly on the auditory system. This is important when studying communication calls and its diversity in any context, but in particular during investigations on vocal learning where small variations can make the difference. Here we test with a psychophysical two-alternative forced-choice paradigm to which extend adult phyllostomid bats, *P. discolor*, are able to distinguish small differences in the fundamental frequency of communication calls. The bats are trained to report from which of the loudspeakers at both ends of a Y-maze (about 30 cm away of the animal) the standard stimulus, a 50 ms complex signal with a fundamental frequency at 15 kHz and 5 harmonics, is played at 73 dB SPL. Test stimuli with a difference in fundamental frequency of +/- 50, 20, 10, 5, 2, 1, 0.5 or 0.2 % to the rewarded standard stimulus are played alternating at the other loudspeaker at a rate of 2 Hz. The bats' performances will provide psychometrical functions, allowing conclusions on the species ability to distinguish between communication calls with similar frequency content and temporal characteristics.

Changes in migratory status of bats revealed by stable isotopes

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Global climate change and urbanization are two important anthropogenic factors influencing ecosystems worldwide. Many species are expected to rapidly adjust their phenology, range and physiology in order to cope with ongoing environmental challenges. Migratory species are of specific concern, because they depend on a sequence of habitats. Recent studies show that animals with greater within population migratory variability are most resilient to environmental change. Among volant species, such as bats, knowledge about changes in migratory patterns remains limited. We studied changes in the migratory status of a European bat species (*Nyctalus noctula*) in Eastern Europe – an area of recent overlap between breeding grounds in woodlands and hibernation places in urban areas. We used stable isotope ratios of non-exchangeable hydrogen in fur keratin (δ2Hf), as markers for the summer origin of individuals which were captured during breeding, migration and hibernation over a 12 year period. We found a decrease in the proportion of migratory sub-adult individuals from 25% to 10% over the years both during migration and hibernation season. However, the proportion of migrants among adult individuals during hibernation was 21% and remained stable over time. In a second approach, we analysed bat communities during hibernation because social structure may influence migratory decisions. We found an increase in the proportion of adult individuals from 18.5% to 53.3% over time, which might indicate a growing population. Interestingly, we observed a sable sex ratio for adult individuals (1♂:1♀) over years, whereas it fluctuated among subadult individuals from (3♂:1♀) to (1♂:1♀) (frequently with male predominance). This might indicate a higher mortality or dispersal of young males at an age of two. Our results shed light on processes of recent colonization of northward hibernation grounds and formation of sedentary population in bats at temperate latitudes.

Bat flight in conflicting sensory flow fields

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Flying animals face the challenge to navigate fast in highly structured environments. Sensory flow has been shown to affect flight guidance across the animal kingdom: visually guided animals use optic flow to adjust their flight trajectory as well as flight velocity. Bats, flying in complete darkness, use echo-acoustic flow to adjust their flight trajectory and echolocation behavior to their surroundings. However, depending on the species, bats are not only active during complete darkness, but also in half- or even daylight. It is known that bats use visual information in various contexts, especially when tasks like landmark detection exceed the working range of echolocation. Furthermore, the availability of visual cues can enhance performance during prey detection or obstacle avoidance. In this experiment we aim to titrate visual flow against echo-acoustic flow: Specifically, we want to test which sensory modality dominates flight guidance when both visual and echo-acoustic cues are available. To this end, we monitor the flight and echolocation behavior of the little spear nosed bat, *Phyllostomus discolor*, while flying through conflicting visual and echo-acoustic flow fields. The intensity and wavelength of illumination of the flight path allows manipulating the relative perceptual salience of putative visual flow against the echo-acoustic flow of fixed salience.

Vocal production learning through imitation of frequency-shifted sounds by bats?

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Vocal learning and specifically vocal production learning is the capacity of some animals to imitate sounds outside their innate vocal repertoire. Besides the well-known imitation ability of e.g. parrots and some songbirds, dolphins have also been shown to imitate technically synthesized whistle patterns. Several recent studies presented evidence suggesting that bats also have the ability to perform vocal production learning. If bats are indeed vocal learners, they should be able to imitate e.g. conspecific communication calls that are shifted in fundamental frequency outside the natural range of frequencies normally used by the bats. Here we tested the extent to which pale spear-nosed bats (*Phyllostomus discolor*) can imitate frequency-shifted versions of their own communication calls. Six bats were successfully trained to produce communication calls for food reward in isolation. Once the animals had learned this task, a template call, downward shifted in fundamental frequency by 24% (from e.g. 15 kHz to 12.1 kHz) was presented when the bat broke a light barrier. The bats were only rewarded when they emitted a communication call within 5 s after template presentation and when this communication call was lowered in fundamental frequency. Thus bats were encouraged to lower their fundamental frequency by both presenting a downward-shifted template and by rewarding them dependent on the magnitude of their imitated frequency shift. Although an extended training period of 60-90 training sessions was needed, five of six bats indeed shifted their fundamental frequency significantly downward by about 0.5-0.8 kHz (~ 4-6 %). While these results indicate that bats can indeed be trained on fundamental-frequency shifts, the extended training and relative small effect size highlight the necessity for further thorough experiments investigating the bats' ability to imitate sounds.

Migrating Nathusius' bats (*Pipistrellus nathusii*) avoid social and foraging vocalizations

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During late summer and autumn, migratory bats of the temperate zone face the challenge of accomplishing two energy demanding tasks almost simultaneously, migration and mating. Both activities require a finely tuned sensory system to orient themselves spatiotemporally, forage efficiently and locate conspecifics. Under such circumstances eavesdropping on bat vocalizations may help to locate foraging patches and mating sites. Yet it is unknown if migrating bats use eavesdropping on conspecific feeding and social calls for efficient fuel acquisition and mate finding, respectively. Here, we investigated the vocal response of migratory Nathusius' bats (*Pipistrellus nathusii*) to simulated feeding and courtship aggregations. Using a playback setup, we presented wild bats flying by either feeding buzzes or courtship calls of their own or a heterospecific species (*Nyctalus noctula*) at a migration corridor along the coastline of the Baltic Sea in Latvia and subsequently in a mating area in northeastern Germany. We hypothesized that the response of bats would differ depending on location, i.e. migratory corridor vs. mating area, and time, if bats ponder the relevance of call information with respect to the seasonal context and energetic requirements. As a result, we observed a decrease of echolocation and social call activity in response to every of our four broadcasted vocalizations at the migration corridor and also at the mating area, suggesting avoidance behavior, which contrasts previous studies. Our findings show that Nathusius' bats avoid, or may even be repelled by conspecific and heterospecific aggregations while en route during migration.

How to spend the winter: Species and sex specific hibernation phenology of two sympatric European bat species

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Detailed phenological insights in the timing of hibernation in bats of the temperate zone are needed to better understand the peculiarities of their unusual life cycle. Moreover, they are important for dealing with the increasing threats to bats such as human interference with habitats, insects decline, climate change and infectious diseases. However, individualized information of the phenology of bats are currently largely lacking. Long-term phenology studies of hibernating individually marked bats are rare due to limitations of traditional field methods. More modern automatized methods, such as light barrier census or acoustic surveys, also cannot provide individualized information necessary to understand the fitness consequences of different hibernation strategies. Here, we provide individualized hibernation data based on PIT-tagged individuals of two sympatric species, *Myotis daubentonii* and *Myotis nattereri*, for seven consecutive years from a large hibernaculum in northern Germany. Our study species have different foraging as well as reproduction strategies, which should influence their hibernation strategies. We analysed the start and end of hibernation of each individual. Our results suggest that hibernation timing of individual *M. daubentonii* is similar every year whereas that of individual *M. nattereri* can vary between years. In general, hibernation length of *M. daubentonii* was longer than that of *M. nattereri*. Furthermore, the results indicate differences in hibernation timing even within species. As a consequence, we conclude that differences in hibernation strategies within and between bat species might lead to varying risks due to the abovementioned threats and, therefore, need to be considered in conservation management.

Activity of bats around streetlights

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The number and intensity of streetlights is increasing all over the world. Since these light sources disturb the natural day and night rhythm they have a great effect on the fauna. Insects that are active at night are for instance attracted by the light and are often not able to escape it until they die. Bats have different strategies to deal with the artificial light. Some avoid these areas all together, while others hunt directly in the light cone. In my study, I assessed the main factors that influence foraging activity beneath street lights like insect abundance, climatic variables and the vicinity of the light sources. On 20 acoustic monitored transects preliminary results suggested that the mass of insects and the weather conditions have a high effect on the bat activity.

Do temperate bats keep their detection distances constant by adjusting call parameters to daily weather fluctuations?

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Bats rely on ultrasonic echolocation for orientation and prey detection in the night. Ultrasound is strongly attenuated in air, thus making echolocation a short-range sense up to a few to some tens of meters, depending on call frequency. Moreover, atmospheric attenuation of sound depends on weather conditions, notably on ambient temperature and relative humidity. Thus, fluctuating evening weather conditions and seasonal variations cause changes in sound attenuation and thus the maximum prey detection distance. We hypothesized that bats adjust call frequency and/or call source level to these weather conditions to maintain their maximum prey detection distance. Secondly, we hypothesized to find species-specific differences depending on each species' foraging ecology, predicting stronger effects for open-space bats that rely on long detection distances for finding prey than edge-space bats. We recorded echolocation calls of temperate bat species on a microphone array, reconstructed their flight trajectory and measured call frequency and source level as a function of local weather conditions. We currently test our predictions of species- and ecology-specific differences in the reaction to changing weather conditions. These results will also shed light on the question whether and how different species of bats might cope with altered atmospheric attenuation due to global warming.

Miniaturized wireless sensors provide novel insights into the social life of bats

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Bats are extremely diverse, not only in terms of species numbers but also regarding their social lives. Despite the great diversity of social organizations, mating systems and social structures, relatively few species have been studied in detail, so far. Observations on social behavior are time consuming and usually restricted to the roost because of their nocturnal activity, their cryptic lifestyle and their high mobility. In addition, the relatively small average body size of bats restricts the applicability of automated tracking devices to few large-bodied species. We developed a miniaturized and highly automated sensor network that is designed to detect encounters among individual bats both inside the roost and during foraging. We present the BATS (Broadly applicable tracking systems *) architecture and functionality. Insights from our first studies on free-ranging bats showcase that miniaturized wireless sensors provide a powerful means to automatically generate valuable data sets on intraspecific interactions and to improve our understanding of complex social behaviors.

* www.for-bats.de

Laminar activity in the auditory cortex of vocalizing bats

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Different cortical layers play different roles for the processing of sensory information. While several studies have examined laminar differences in structure, less emphasis has been given to physiological differences between layers, especially regarding neural synchronization. A common method for measuring synchrony is to compute the spike-field coherence, which measures how cortical spiking is modulated by the phase of local field potential (LFP) oscillations. In our ongoing studies, to determine laminar differences and attentional effects on neuronal responses in the bat auditory cortex (AC), we are recording cortical spiking and LFPs in superficial and deep layers of the AC of the awake short-tailed fruit bat (*Carollia perspicillata*). Specifically, we examine laminar differences in spike-field interactions across multiple translaminar electrodes during two distinct behavioral contexts: 1) while the bat is passively listening to sounds, and 2) while the bat is self-emitting sounds. In the second context, the bat is attentively waiting for the returning echoes, which allows to estimate whether there are any attentional effects on the neuronal responses within different layers of the auditory cortex.

Exploring social learning during ontogeny: Do juvenile flower-visiting bats follow their mothers on first foraging flights?

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While adult bats of several species readily acquire foraging related information from conspecifics, there is almost nothing known about social learning processes during ontogeny of juveniles. Unexperienced juvenile bats are generally faced with the challenge to properly decide when, where, what and how to feed. Besides innate knowledge about principles of foraging behavior and individual learning strategies, young bats should have plenty opportunities to gain foraging related information from adults. It is often discussed that following their mothers during first foraging flights would represent a suchlike valuable option for juveniles to socially learn about foraging, e.g. where to find resource rich foraging patches. However, explicit tests are scarce, and evidence for communal or separate foraging of mother-pup pairs in some species is mainly based on partially anecdotal reports with rather vague methods, e.g. as concluded from emergence observations at roosts, reasoned from joint captures of mothers and pups in mist nets, or based on rather imprecise telemetry data. In the present study, we used a novel approach to investigate the early foraging behavior of free flying flower-visiting bats (*Glossophaga soricina,* Phyllostomidae: Glossophaginae) in the National Park Santa Rosa in Costa Rica. We tested whether recently volant, but still nursed pups perform first foraging flights alone, indicating a rather individual learning strategy, or whether pups follow their mothers, which would enable pups to learn socially. For that, we used an experimental setup of inexhaustible artificial flowers that were placed in the forest nearby the bats' roost. Each flower comprised an RFID reading system that allowed us to precisely record individual visits of RFID tagged mothers and their pups. Unexpectedly, artificial flowers near to the roost were almost entirely visited by pups, while mothers seemed to forage somewhere further away. Our results demonstrate that juvenile flower-visiting bats perform first foraging flights without accompanying their mothers. While searching for food, juveniles seem to apply an individual learning strategy while progressively exploring the environment in spatial proximity to their roost. A potential lack of foraging success during this period might be compensated due to an ongoing maternal provisioning with breast milk during daytime.

Precise Doppler shift compensation in the hipposiderid bat, *Hipposideros armiger*: resting and reference frequencies are coupled but variable

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Bats of the family Rhinolophidae, Hipposideridae and the mormoopid bat *Pteronotus parnellii* compensate for Doppler shifts generated by their own flight movement to adjust the echo frequency of background echoes to the reference frequency of the auditory fovea. These adaptations enable the evaluation of flutter information in prey echoes. Some studies in hipposiderids suggested a less sophisticated or even incomplete Doppler shift compensation. To investigate the precision of the Doppler shift compensation in *Hipposideros armiger,* we recorded the echolocation and flight behaviour of bats flying to a landing grid, reconstructed the flight path, measured the flight speed, calculated the returning echo frequency and compared it with the resting frequency prior to each flight. Within each flight, the average echo frequency or reference frequency was kept constant with a standard deviation of 0.17% independent of flight speed. Resting frequency and reference frequency were always coupled with an average offset of 80 Hz, but varied slightly from flight to flight. Thus, the precision of Doppler shift compensation and the offset were similar to that of Rhinolophidae and *P. parnellii*. The described frequency variations may explain why it has been assumed that Doppler shift compensation in hipposiderid bats is incomplete.

Vocal repertoire of phyllostomid bats, *Phyllostomus discolor*

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Widely known for their ability to echolocate, bats also vocalize to communicate with one another and have been shown to possess rich vocal repertoires. Some studies have attempted to match vocalizations to specific behavioral observations, but doing so can be complicated as bats usually aggregate in large numbers in a small space and thus matching vocalizations to specific individuals and their behaviors is difficult. As such, many studies only describe the vocal repertoire of a bat species and not the contexts in which certain vocalizations occur or differences in vocalizations emitted by different individuals in the same context. Here we aim to assess behavioral interactions between individual bats (*Phyllostomus discolor*) in addition to the general examination of their vocal repertoire. Bats are observed in different combinations of two to six individuals at a time to elicit a wide range of behaviors and associated calls and are recorded with both high temporal and spatial resolution. An acoustic camera, consisting of a 16-microphone ultrasonic beam-forming array, synchronized with infrared video, allows for precise identification of vocalizing individual even within tightly clustered groups. The behavioral context of the vocalizations is identified in real time, and subsequently spatio-temporal emission patterns, call composition, and acoustic parameters are analyzed. The features of vocalizations are then compared across both behavioral contexts and individuals. Ultimately, this study will provide detailed information about the structure, function, and timing of communication calls of P. discolor, which can serve as a basis for future research using *P. discolor* as a model organism for vocal communication and vocal learning.

Physiological traits in phyllostomid bat species related to roosting temperature

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The energetic costs of thermoregulation play an important role in the daily energy budget of mammals. Bats spend all day and sometimes also long periods of the night in their day roosts. Therefore, choosing roost sites with a suitable microclimate offers essential possibilities to save energy. Bats of the Neotropical family Phyllostomidae use a variety of different roosting types. These include foliage or modified leave tents with low insulation capacity, caves with a very stable climate and tree cavities, which can trap metabolic heat of the bats. We hypothesized that bats try to maintain roost temperatures close to their thermal neutral zone, in order to preserve energy resources throughout the day. We also assumed that generalist species using different roosting types should be adapted to a wider range of temperatures, compared to roosting specialists, which are limited to one roosting type. In our study we compared phyllostomid species with different roosting habits and analyzed to what extent they adapted their metabolism to the respective temperatures we measured at their roosting sites. For determining the metabolic rate of the bats, we used open-flow respirometry under laboratory conditions. We tested the effects of different temperatures (21 °C – 32 °C) on the metabolic rate, which resembles the range of temperatures a bat individual may experience in their roosting environment.

Detection of biosonar target changes in FM bats

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Bats use different echo cues to navigate their habitat and to find prey. While the auditory system excels at measuring tiny temporal differences between perceived sounds, the sparse temporal sampling in the biosonar of FM bats potentially impairs the assessment of changes in the target over time: FM calls usually are far too short (1-5ms) for one single echo to carry information encoding an insect's wing beat over a full cycle (typically 10 to 200 ms). Nevertheless, FM-bats are sensitive to both flutter (rotating motion) and jitter (back-and-forth motion). To detect the wing beat of an insect at least two parameters are available: distance modulation and amplitude modulation. Doppler shifts which dominate flutter detection in CF bats are unlikely available for FM bats, due to the lack of an auditory fovea. In two formal psychophysical experiments with the echolocating bat *Phyllostomus discolor*, we have systematically evaluated 1) biosonar sensitivity to target-delay (=distance) modulation and 2) sensitivity to target-strength modulation of virtual targets. Bats were trained and tested in modulation detection at modulation frequencies between 2 and 500 Hz. Data show that *P. discolor* can detect modulations in both target delay and target strength quite effectively, despite using short FM calls: For target-delay modulations, bats reveal a conspicuous modulation sensitivity: good sensitivity at low and high modulation frequencies and worse sensitivity for intermediate modulation frequencies around 20 and 50 Hz. For target-strength modulations, sensitivity is also unusual with improving sensitivity for increasing modulation frequencies. These results are quite the opposite of passive-acoustic sensitivity to amplitude modulation. Results are discussed with respect to biosonar sampling strategies of FM bats and the specific ecological requirements to detect target modulations with biosonar.

Berlin's Nightlife: Studying Urban Bats with Citizen Scientists

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Urban areas are expanding worldwide. It is expected that by 2050, 70% of the Earth's population will be in urban centres. However, our understanding of how species successfully adapt and survive in the urban environment is still limited. Berlin provides a unique arena for the study of urbanisation on bat populations given its history of separated urban development (Eastern versus Western), and its comparative high urban species richness, with 18 of Germany's 25 bats residing in the city. With the help of citizen scientists and in cooperation with the NABU (The Nature and Biodiversity Conservation Union) federal association and federal state association of Berlin, we will investigate the underlying mechanisms (e.g. morphological and behavioural traits) that enable Berlin's bats to successfully survive and thrive in the urban environment. While there is a clear ecological focus in these projects, one project (funded by the BMBF) will be particularly designed in close collaboration with social scientists to contribute to a better insight into knowledge transfer among citizen scientists. Studying urban bats with interested citizens not only enables us to gather large data sets but also improve our understanding of how to create more bat-friendly cities. Moreover, it will also contribute to our current knowledge about designing citizen science projects that have a positive effect on citizens' attitudes and scientific literacy. Given the ongoing global urban growth, this knowledge will contribute to urban bat conservation as well as citizen science projects that foster a better understanding and potential support of the natural world.

White blood cells as an indicator of immunological status of bats

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Among all volant mammals, bats are the most species-rich group, though they remain still insufficiently studied. Unique bat ecological features (e.g. active flight, high longevity, heterothermy) could impact physiological processes, especially immunological ones, which are the most unrevealed aspect of bat biology currently. Because all European bats are under protection from one side and could act as a vector for various infections from another side it is an urgent need to recognize indicators of immunological status in wildlife bat populations. This information is highly important for public health implication. Our study aims to estimate profiles of immunological parameters for free-ranging and rehabilitated (injured individuals being in captivity) bats. Total sample size consists of 166 samples from 8 bat species, including *Nyctalus noctula* - 77, *N. leisleri* - 1, *N. lasiopterus* - 2, *Eptesicus serotinus* - 41, *Pipistrellus nathusii* - 5, *P. kuhlii* - 6, *Vespertilio murinus* - 7, *Plecotus auritus* - 10. Bats were caught in two locations in Ukraine - Chernobyl Extinction Zone (Kyiv region) and Kharkiv city and Kharkiv region (the North-eastern Ukraine). Total white and red blood cells count in each sample were estimated manually. The different types of leukocytes were counted in each sample when it was possible. Results of this survey show that the ratio of cellular immunity to humoral immunity is reflected in percentages of different white blood cell lineages.

Holes or boxes – Where to roost in an urban forest?

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Human influence in urbanized areas leads to loss of natural habitats and endangers the existence of bats. Yet, compensatory measures try to substitute the losses of natural roosts (tree holes) by supplying artificial ones (bat boxes). The dynamics which influence the use of natural and/or artificial roosts are poorly understood. One frequently discussed driving factor is variation in internal temperature. The aim of our study was to determine the extent to which different types of roosts differ in their thermal properties and how these differences affect the use of bat roosts. The study was carried out in the Königsheide Forst, an urban forest in Berlin. We measured the temperature profiles of three different box types and tree holes by using temperature data loggers. Occupation of 133 boxes was assessed during four inspections from the 7th of June to the 27th of July. We found that natural roosts buffered temperature extremes better than all three types of artificial roosts. An assessment of box usage over time showed that the occupation tended to increase during the course of the study. Our results support previous findings showing that bats prefer tree holes during cooler outdoor temperatures and move into bat boxes later in the year when temperatures rise. For the conservation of tree-dwelling taxa in urban areas, it is necessary to maintain natural roosts and to improve artificial roosts that better resemble conditions of natural ones.