112th Annual Conference of the German Zoological Society in Jena

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Satellite meeting

September 9–10th, 2019

Program

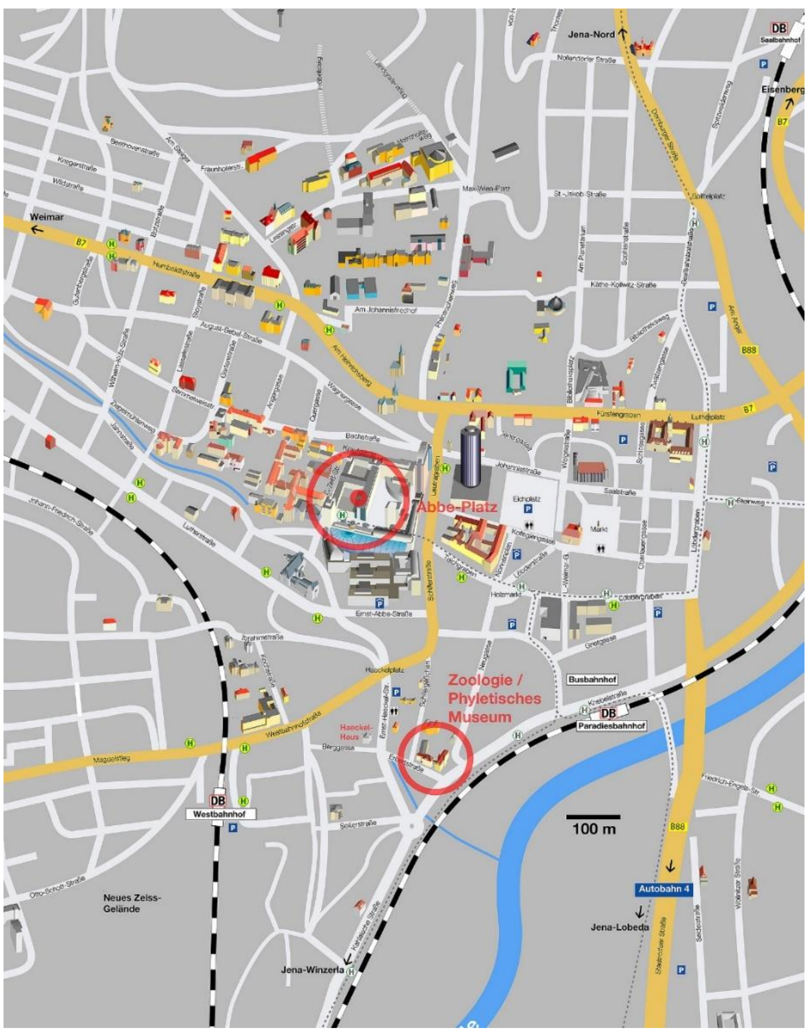
How to get to Jena by train:

Jena has two main train stations: Jena-West and Jena-Paradies. You can travel to both train stations as they both are only a few minutes away from the city center. There are currently no fast trains (ICE) passing by Jena. The most convenient way to get to Jena is to take a regional train (RB, RE) from Erfurt (there is a train every 30 mins.) to Jena-West. In addition, there are also regional trains to Jena-Paradies (from Nürnberg, Halle/Saale or Leipzig).

In case of last minute problems (e.g. delayed trains) please contact us directly via phone:
Tobias Kohl: +49 179-9117383 and Basil el Jundi: +49 160-95437199.

How to get to the venue:

The satellite meeting will take place in the main audience halls of the University of Jena (Zentrales Hörsaalgebäude, Ernst-Abbe-Platz) in **lecture hall 3** (**Hörsaal 3**).



Instructions for speakers:

Speakers are requested to upload their slides on the presentation computer during the session breaks prior to their talks. We will provide a presentation computer that will be running Windows 10 (PowerPoint). You are welcome to use your own notebook (e.g. Apple). In this case, please, ensure that you have an adapter that is compatible with HDMI or VGA. A slide advancer/laser pointer will be provided by us. The talks are 25 min (15 min) + 5 min discussion. Please, make sure that your talk will be within the time restrictions of your slot and that there is enough time for discussion.

Dinner:

We will book a table for dinner (9th of September) in a restaurant close to the venue. The exact location will be announced as soon as we have a confirmation for the reservation. We would be very pleased if you would join us for dinner.

Support:

The neuroethology satellite meeting 2019 is supported by the DZG.

Monday, 9th of September

14:00 – 14:15: ***Welcome remarks*** (Basil el Jundi & Tobias Kohl)

14:15 – 14:45: An orientation strategy that is robust to light pollution

James J. Foster, Marie Dacke

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The nocturnal dung beetle *Escarabaeus satyrus* uses a number of celestial cues to orient itself when rolling its dung ball, including the Milky Way (Dacke *et al*., (2013) *Curr. Biol.* 23, 298; Smolka *et al*., (2016) *Anim. Behav.* 111, 127), moon (Dacke *et al*., (2004) *Proc. R. Soc. B* 271, 361) and lunar polarization pattern (Dacke *et al.*, (2003) *Nature* 424, 33). In our recent work, we demonstrated that *E. satyrus* relies on a generalised interpretation of stellar brightness patterns (Foster *et al*., (2017) *Phil. Trans. R. Soc. B* 372, 20160079) that could be used by other nocturnal species incapable of resolving individual stars (Foster *et al*., (2018) *Proc. Biol. Sci.* 285, 20172322). We also found that *E. satyrus* remains sensitive to polarization at low levels of brightness and degree of polarization, permitting orientation to polarized lunar skylight across the lunar cycle (Foster *et al*., (2019) *J. Exp. Biol.* 222, jeb188532).
We now present the results of experiments at urban and rural sites investigating the impact of anthropogenic light on the orientation behaviour. While our sky measurements show that vital natural cues are obscured by urban skyglow, we find that nocturnal dung beetles are well equipped to orient under both pristine and polluted night skies. We propose that under these conditions the beetles rely on broad-scale brightness patterns resulting from artificial lights. It appears that dung beetles may be uniquely placed to take advantage of adverse anthropogenic sky conditions that could drastically hinder other nocturnal species.

14:45 – 15:15: A close look to the bilateral collision detection in locusts - inspiration for a bionic solution

Konstantinos Kostarakos, Manfred Hartbauer

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Locusts exhibit a transition from the solitary to the gregarious phase when the population density increases due to specific environmental influences. As behavioral repulsion among solitary insects declines, they become social and form flying swarms as adults. Visual and acoustic cues contribute to swarm cohesion. Importantly, the collision detecting system of the insects responds very sensitive to approaching neighbors. Approaching objects lead to an increase of object size over the ommatidia (looming). A major component of the collision detecting system in locusts constitutes the DCMD-neuron (descending contralateral movement dete0ctor) that forwards the visual information from the brain to the thorax that houses the flight muscles. We recorded and analyzed the response of both DCMD-neurons to various looming paradigms by means of a pair of hook electrodes placed at the neck connectives. The stimuli were displayed by two curved monitors covering a field of view of 180 degrees. The results provided insights into specific response properties and the directionality of the collision detection system. Furthermore, we analyzed the responses of DCMD neurons to various near-crash scenarios recorded by two cameras attached to drones. Based on the activity of DCMD neurons we developed a bionic algorithm for collision detection that works in the absence of any distance estimation and object recognition algorithm. In a further project, we aim to implement this algorithm on a hardware for real time collision risk estimation and the computation of an evasive vector.

15:15 – 15:45: The role of optic flow cues in hawkmoth flight control

Anna Stöckl, Rebecca Grittner, Keram Pfeiffer

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Flying animals require sensory feedback on changes in body position and distance to nearby objects to safely negotiate their environment. The apparent image motion, or optic flow, which is generated as animals move through the air can provide this information. Flight tunnel experiments have been crucial for our understanding of how insects use optic flow for flight control. Previous work focused particularly on species from two insect orders: Hymenoptera and Diptera. To test whether their flight control strategies also apply to other insect groups, we investigated an insect species with a different phylogenetic background, flight kinematics, and visual anatomy: the hummingbird hawkmoth *Macroglossum stellatarum*. We show that these hawkmoths use a similar strategy for lateral position control as bees and flies in balancing the magnitude of translational optic flow perceived in both eyes. However, their control of flight speed was markedly different, as it was not invariant to the spatial structure of the optic flow patterns. Moreover, the use of ventral and dorsal visual cues differed distinctly from strategies previously described in bees and highlights that hawkmoths use different portions of their visual field for different flight control functions: while ventral visual cues were mainly used for speed control, dorsal visual patterns were used as directional guides. Our findings highlight ubiquitous functions of optic flow in flight control across insect orders, but also marked differences that suggest that the use of optic flow for flight control is adapted to each insect species' specific anatomical prerequisites and ecological needs.

15:45 – 16:15: ***Coffee Break***

16:15 – 16:45: Mating in Bushcrickets: Attuned Behavior and Ear

Manuela Nowotny, Jan Scherberich

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Using acoustic communication for mating requires harmonizing many processes. Sender and receiver need to be attuned to each other and phonotaxis has to be coordinated. In bushcrickets (katydids), with more than 7000 different species, several different scenarios of such acoustic behaviors have evolved. In our talk we will present two of these schemes (i: *Mecopoda elongata*, Tettigoniidae: Mecopodinae and ii: *Ancylecha fenestrata*, Tettigoniidae: Phaneropterinae) with their different mating strategies and ear adaptions. Our anatomical, behavioral, biomechanical and neurophysiological data reveal pronounced differences in the sender and receiver structures between these two Tettigoniidae groups, which fits to their diverging phonotaxis behaviors. Detailed neuronal investigations of the signal processing along the auditory pathway were used to discover adaptions in the underlying neuronal network in both species. This work is supported by the DFG (NO 841/8-1, 10-1).

16:45 – 17:15: Sound localization in American alligators (and other birds)

Lutz Kettler[1], Catherine E. Carr[2]

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The localization of sounds is computationally more complicated than localizing stimuli with other senses. In contrast to the eye with its retinal image of the visual field, the auditory receptor organ, the cochlea, does not feature a topographic image of the auditory space. Instead the location of a sound is computed in the auditory pathway. The neural code for sound location has to be adapted to either encoding a preexisting directional signal, as with internally coupled eardrums (or pressure difference receivers), or to computing a directional signal from two inherently non-directional binaural inputs. Neural maps are especially relevant in encoding spatial sensory cues. Neurons in a *map* have location specific receptive fields. A population of systematically placed neurons then maps the entire stimulus space (therefore also called *place code*). A simple model to create a map of interaural time difference was proposed by Lloyd Jeffress in 1948. His model assumes two core elements: neuronal delay lines from each ear that compensate for all possible direction specific interaural time differences, and coincidence detectors. The input of one or both sides is delayed matching a specific interaural time difference. A coincidence detector neuron therefore encodes a small portion of naturally occurring ITDs. We identified such a map in the brainstem *nucleus laminaris* of American alligators, similar to those in barn owls, where the nucleus laminaris neurons function as coincidence detectors. These neurons receive input from the ipsi- and contralateral cochlear nuclei magnocellularis, whose axons act as delay lines. An ITD map would only be optimal if the neurons of the map encode solely ITDs that naturally occur. However, in the American alligator (and birds) we find neurons in nucleus laminaris that are tuned to, i.e. respond with maximum action potential rate to, ITDs that are larger than those occurring at 90° incident angles and can only be artificially created with earphones, while these cells are still systematically embedded in a neural map. However, as described above crocodilians have internally coupled ears, and therefore have directional eardrums. The directionality may be encoded by a *meter* in monaural brain nuclei like in lizards, but more important, pressure difference receiving eardrums enhance both interaural time and level difference. Both facts have implications on the coding of ITD with an anatomical map, which I will discuss.

17:15 – 17:45: ***Coffee Break***

17:45 – 18:45: **Keynote lecture -** The electrosensory ecology of weakly electric fish

Rüdiger Krahe

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Most research on sensory processing is conducted in lab environments under standardized conditions and using standardized sets of stimuli to probe the nervous system. This contrasts with the fact that we know remarkably little about the complexities and challenges under which sensory systems have to function under natural conditions. We have been using multiple approaches to characterize the real-life tasks and challenges one such system has to deal with, the active electrosensory system of weakly electric fish. These fish generate weak electric fields and sense perturbations of the field resulting from objects in the water or from the signals of conspecifics. This active electric sense allows the fish to forage and communicate at night and in turbid waters. We explore the roles of biotic and abiotic factors that shape the acquisition of electrosensory information and on the natural sensory stimuli encountered by electric fish in their tropical rainforest habitat. Our field data suggest that the presence of electroreceptive predators can promote shifts in the properties of the electric signals, to become less conspicuous to the predators. Electric signal production also incurs sizable metabolic costs, which can become particularly challenging when the animals are energy-limited by low oxygen availability, such as in hypoxic swamps. Using electrode arrays in the wild, we reconstructed electrosensory scenes resulting from interactions with conspecifics and heterospecifics. These natural scenes significantly expand the stimulus space to be explored in studies of electrosensory processing. Our work highlights the importance of field work for understanding sensory systems.

18:45 – open end: ***Get together and Dinner***

Tuesday, 10th of September

9:30 – 10:30: **Keynote lecture -** What does a bee see? Imaging the visual world of bees to explore the link between eyes and foraging behaviour

Emily Baird
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Bees and other flying insects rely heavily on vision to control a broad range of behaviours when in flight, including position and speed control, collision avoidance, navigation and foraging. While much is understood about the visual guidance behaviour of a few model species – such as *Apis mellifera* and *Bombus terrestris* – in controlled lab conditions, we still understand very little about about how insects use vision to control flight in natural habitats. One of the most challenging of all visual habitats is the dim, cluttered tropical rainforest. Nonetheless, many different bee species make their homes here – do these bees have specialisations that enable them to acquire the visual information necessary to guide flight in their forest habitat? Does the size of visual system affect the kind of information that the bees can acquire? To answer these questions, we developed a method that uses X-ray micro computed-tomography to develop 3D models of the visual systems of insects that enable us to reconstruct their visual world and to make direct comparisons of visual specialisations between species. In particular, we are interested in exploring if and how bees possess visual and/or behavioural adaptations to forage efficiently in their different habitats.

10:30 – 11:00: ***Coffee Break***

11:00 – 11:30: Lifestyle matters: Brain morphology in cursorial and stationary hunting spiders

Philip O.M. Steinhoff, Steffen Harzsch, Gabriele Uhl
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The specific lifestyle of an animal is reflected in the structure of brain areas that process sensory information. Spiders (Araneae) include stationary species that build webs for prey capture and cursorial species that do not build webs. These distinct lifestyles are associated with major differences in sensory equipment. We investigated if brain morphology differs depending on lifestyle. To this aim, we analyzed the brains of four spider species: two cursorial hunters, *Marpissa muscosa* (Salticidae) and *Pardosa amentata* (Lycosidae), which strongly rely on visual cues, and two stationary web building hunters, *Argiope bruennichi* (Araneidae) and *Parasteatoda tepidariorum* (Theridiidae), which detect prey using vibrational cues. We predicted that the differences in primary sensory input between the different species are mirrored by differences in those brain areas that process the incoming information. By means of microCT analysis, paraffin histology and immunohistochemistry we show that the brains of the investigated species differ in number, arrangement, structure and volume of neuropils. These differences are especially pronounced in the visual system of the brain and pertain to first order, second order and higher order brain centers. While the investigated cursorial hunters have large visual neuropils and mushroom bodies, these are smaller or even absent in the investigated stationary hunters. Our results thus demonstrate that depending on the sensory specializations, profound differences in spider brain morphology exist.

11:30 – 12:00: How to run fast – strategies in desert ants

Harald Wolf, Sarah Pfeffer

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Fast running locomotion has evolved in several arthropods, particularly in hot and hostile climates. Desert ants of the genus *Cataglyphis* are well-studied examples here. These ants are long-legged scavengers of desert and steppe habitats, different species having adopted different strategies to achieve high running speeds.
One strategy relies on long legs that allow large stride lengths and resulting high running speeds - stride length maximisers. *Cataglyphis bicolor*, is a typical example, much like the particularly well-studied *C. fortis*. These ants are large, *C. bicolor* ~3.63 mm in alitrunk length, front, middle and hindlegs measuring ~6.72, ~7.97 and ~10.49 mm.
Another strategy favours high stride frequencies, a feat that cannot be achieved with long legs due to their large inertial momentum. Typical representatives of short-legged (by long-legged *Cataglyphis* standards) high frequency runners are *C. albicans*, and the fastest desert runner, the silver ant *C. bombycina*. Legs of *C. albicans*, while short in absolute terms (~3.74, ~4.01 and ~5.47 mm), are in isometric proportion to the smaller body size of *C. albicans* (alitrunk ~1.94 mm) compared to *C. bicolor*.
Comparison of *C. bicolor* and *C. albicans* appears particularly profitable considering their virtually isometric body dimensions, identical habitats, with prey spectra constituting the main species difference. Any differences in walking behaviour can thus be attributed rather confidently to differences in body size. Stride lengths and frequencies in the two species agree with the concept of spring-loaded inverted pendulum (SLIP) of walking, smaller species exhibiting higher characteristic frequencies of the leg-body oscillator. However, swing and stance durations show idiosyncratic characteristics. These merit comparison to the closely related *C. fortis* and *C. bombycina*, respectively.

12:00 – 13:15: ***Lunch Break***

13:15 – 13:35: Proprioceptive input to a descending interneuron in the stick insect *Carausius morosus*

Bianca Jaske, Gaetan Lepreux, Volker Dürr

Department of Biological Cybernetics, Bielefeld University, Bielefeld, Germany; bianca.jaske@uni-bielefeld.de

In insects the tactile sense is important for near-range orientation (Staudacher (2005), Adv.InsectPhysiol., 32, 49). Its relevance can be observed in many species for different behaviors. For example, the stick insect *Carausius morosus* continuously actively moves its antennae while walking to explore the surrounding environment (Dürr (2001), J.Comp.Physiol., 187, 131). Upon antennal contact with obstacles, stick insects often show tactually induced, aimed front-leg movements (Schütz, (2011), Phil.Trans.R.Soc.Lond., 366, 2996). So far, a number of descending interneurons have been recorded from, that may contribute to mediating this behavior. One of these is the contralateral ON-type velocity-sensitive neuron (cONv). cONv was found to encode antennal joint-angle velocity as well as substrate vibration (Ache (2015), J.Neurosci., 35, 4081). Here, we investigate which proprioceptive input is responsible for the joint-angle velocity sensitivity of cONv. Different mechanoreceptors on the antennae, as tactile hairs, hair fields, campaniform sensilla and chordotonal organs, could potentially contribute. Ache et al. 2015 hypothesized that antennal hair fields supply this input because their afferent terminals were found to arborize close to cONv dendrites. To test this hypothesis, we conducted bilateral extracellular recordings of both cONv interneurons per animal, and compared the velocity tuning before and after antennal hair field ablation. Preliminary results suggest that hair fields are not the only source for the encoding of antennal joint-angle velocity in cONv.

13:35 – 13:55: Stick insects use visual landmarks for orientation but not for climbing

Ronja Bigge, Thierry Hoinville, Volker Dürr
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Stick insects of the species *Carausius morosus* initiate visually induced turning by a change in front leg movement, both in response to large-field motion (Dürr and Ebeling (2005) J.Exp.Biol.) and when turning towards a landmark (Rosano and Webb (2007) Biol.Cybern.). Similarly, they initiate climbing with a directed movement of a front leg (Schütz and Dürr (2012) Phil.Trans.R.Soc.L.). Behavioural experiments showed that a visual landmark on an obstacle is not influencing the movement sequence during climbing, even though the landmark should be well visible on account of its apparent size and contrast. Here, we show that walking stick insects show a strong preference for high-contrast landmarks over low-contrast ones in a choice paradigm. At the decision point, the visual size of the landmark is in the same size range as landmarks that are disregarded during climbing. Using motion capture of the head and front legs in both behavioural paradigms, we investigate the relationship between the visual image size of the landmarks and the change in leg movement that initiates turning or climbing. In order to find out what the stick insect actually sees and how much its behaviour relies on the perceived visual information, we use a 3D reconstruction of the stick insect compound eye to reconstruct how the landmark contours change in the visual field of a turning or climbing stick insect. Our aim is to relate the differences in differences in the initiating leg movement to distinct differences in the image of the landmark, as projected onto the compound eye optics.

13:55 – 14:15: Quantifying the acoustic parameters of overlapping echolocation calls in free-flying horseshoe bat aggregations

Neetash Mysuru[1], Thejasvi Beleyur[1], Aditya Krishna[2], Holger R. Goerlitz[1]
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Bats are social animals living and flying in groups. They use echolocation to navigate the environment. While echolocation in single bats is more comprehensively studied, group echolocation is more complex and less understood, especially in horseshoe bats. Horseshoe bats have long echolocation calls, where a long constant frequency (CF) part is sandwiched between two short frequency modulated (FM) sections. The long duration calls suffer from spectrotemporal overlap by other bat calls and Doppler-shifted echoes, challenging acoustic analysis of multi-bat situations. Our study addresses this methodological challenge to fill the gap in understanding how horseshoe bats vary their echolocation call parameters when flying alone and together with conspecific or heterospecific bats. We predict that bats will alter their call parameters in multi-bat contexts by 1) increasing FM bandwidth to increase information in dense situations, and by 2) by emitting higher intensity calls (Lombard effect). We further test whether CF-bats also alter their CF frequency to avoid spectral overlap, as FM bats do. We used multi-channel synchronized audio and video to record bat activity in a natural cave habitat. We first obtained independent estimates of the number of simultaneously flying bats based on the video data, peaks in the call spectra, and visual screening of call spectrograms. We then obtained average call parameters such as peak CF bandwidth, terminal frequency bandwidth, and peak amplitudes which were then compared to the number of counted bats. Our study presents a novel approach for studying echolocation in groups of CF bats.

14:15 – 14:45: (What) Do bats hear in the cocktail party nightmare?

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Every evening echolocating bats around the world fly out of their roosts in groups of tens to millions. Despite the orderly spatial appearance of such emergences, acoustically this situation was considered a 'sonar cocktail party nightmare'. In an emergence, every bat needs to constantly listen for its own echoes within a cacophony of the loud calls of other bats and their returning. Do bats use echolocation at all in such behavioural contexts? Whether bats are able to detect their own echoes in the cacophony of the cocktail party nightmare still remains unanswered. We present sensory simulations to quantify echo detection in the sonar cocktail party nightmare for the first time. We quantified detection rates of echoes in the presence of an increasing number of loud conspecific calls. We parameterized our s0imulations to experimental data on bat echolocation, auditory perception, and spatial arrangement in group flight. We show that a bat detects the majority of echoes mostly within just one emitted call, and all echoes once or twice within just six or eight emitted calls, respectively (i.e, within 0.5 seconds). Our results indicate that bats obtain regular, though partial 'glimpses' of their surroundings, even under apparently difficult sensory conditions. We thus conclude that bats may still be using echolocation even while flying in groups. Our simulation framework is also applicable to understanding group echolocation in pinnipeds, oilbirds, as well as in human-made robotic sonar systems. In sum, the so-called sonar cocktail party may be more of a 'challenge' than a nightmare.

14:45 – 15:15: Anti-predator strategies in singing and non-singing insects against echolocating bats

Antoniya Hubancheva[1,2*], Theresa Hüel[1*], Dragan Chobanov[2], **Holger R. Goerlitz[1]**

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Predator avoidance is a key component of survival, often composed of different strategies adapted to different predator types and threat levels. In contrast to the defence strategies of visually guided animals, we know comparatively little about the defence strategies guided by other sensory modalities. Echolocating insectivorous bats drove the multiple independent evolution of hearing and auditory-guided anti-predator strategies in many insects.
Many male insects sing to attract females, thereby also attracting eavesdropping predators. Males thus trade-off singing (mate attraction) with song cessation (predator avoidance). We hypothesized that males prioritize predator avoidance over mate attraction early in the mating season, yet accept higher predation risk towards the end of their life span, to optimize reproductive success. Male great green bushcrickets (*Tettigonia viridissima*) indeed stopped singing in response to acoustically simulated bat attacks. Notably, song cessation occurred less for low simulated predation threat and old males. Singing male bushcrickets thus optimize reproductive success by adapting decision making to predation threat and remaining life span.
Silent flying moths rely on erratic evasive flight to escape attacking bats. The escape-tactic diversity hypothesis postulates that the overall unpredictability of evasive movements increases if species with different evasion strategies mix, resulting in enhanced predator protection for all. We recorded tethered flight of eight moth species under acoustically simulated bat attacks. Moth escape flight was species-specific, size-independent and (in some species) individual-specific, by differing in overall flight strength and temporal reaction pattern, thus confirming for the first time the escape-tactic diversity hypothesis for eared moths.

15:15 – 15:30: ***Closing remarks*** *(Basil el Jundi & Tobias Kohl)*