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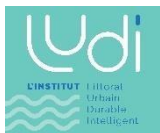
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FUNCTIONAL & EVOLUTIONARY ECOLOGY

Speaker

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**Ageing-related mechanisms in ectotherms: what can
they inform us about?**

Brood size and ectoparasite presence do not affect telomere dynamics in a Mediterranean blue tit population

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Telomere dynamics are good markers of stressful conditions because many stressful factors accelerate telomere shortening, and telomere shortening is associated with survival in various taxa. The early-life environment and ectoparasite pressure have been shown to impact telomere length and shortening in nestling birds. Here, we examined the effect of manipulated brood size and natural infestation by two nest-dwelling ectoparasites (blowflies: *Protocalliphora azurea*; hen fleas: *Ceratophyllus gallinae*) on nestling growth and telomere dynamics in a Mediterranean population of blue tits (*Cyanistes caeruleus*). The experimentally enlarged broods resulted in more fledged nestlings and more blowflies; however, the experiment did not result in a higher pressure by ectoparasites as the presence/absence of ectoparasites and the abundance of blowflies per nestling was similar among treatments. The presence of blowflies or fleas did not affect nestling telomere dynamics and mass gain. In contrast, nestlings were lighter at fledging in enlarged broods, whilst the brood size manipulation did not affect telomere dynamics. Telomeres shortened with age during the nestling stage, and larger nestlings showed larger telomeres, especially at younger ages. Our findings reveal that, in contrast to previous studies, stressful conditions during early life, such as increased brood size and ectoparasite presence, may have negligible or no effects on telomere dynamics. Tolerance and/or resistance mechanisms may mask the potential adverse effects that hard early-life conditions have on telomere dynamics.

Keywords: Telomeres, Nestlings, Blowflies, Fleas, Growth, Parasite Host Interactions

*Speaker

Reproductive behavior in the great tit *Parus major* in urban and rural environments

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Urbanization is a process characterized by rapid environmental change. Thus, urban areas provide a specific opportunity for studying organisms' phenotypic responses to new artificial conditions. Many studies have described phenotypic differences between urban and rural bird populations, e.g. in morphology or life history. Recently, several studies investigated the divergences in reproductive traits and the associated selection pressures between habitats. However, these studies only focused on first clutches, without considering multiple clutches. We quantified linear reproductive selection force and direction (using reproductive success as a proxy of reproductive output) on laying date for first and multiple clutches (replacement and second clutches) in urban and forest great tits exploiting a 12-year data set. We confirmed that urban birds bred on average earlier compared to their forest counterparts and that for their first clutches of the season, forest great tits exhibited negative selection favoring earlier breeding whereas statistically non-significant positive selection was found in the city. Interestingly, when combining the reproductive success from first and later clutches, selection patterns changed as both urban and forest great tits exhibited negative selection favoring earlier first breeding attempt. We propose that the between-habitat differences in reproductive strategies are probably caused by spatial variation in the peak-date of food required to rear the nestlings. Our study also highlights the need to consider later broods in further analyses.

Keywords: great tit, urbanization, life history traits, selection pressures

*Speaker

Birds' traits shape the phenological response to increasing temperature

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Rising temperatures are a major cause of phenological advancement. Phenological plasticity, the ability to adjust breeding timing in response to increasing temperature, varies significantly between species. The origins and consequences of such variations are still poorly understood. Unraveling the origins of these variations could help us predict species' vulnerability to climate change and provide insights into the evolution of plasticity. Based on a two-decade-long, Europe-wide, capture-based monitoring of the reproduction of common songbirds, we investigated the influence of species traits (migration distance, northern breeding latitude, number of broods per season, body mass and trophic level) on phenological plasticity in 50 species. For this, we performed a two steps analysis by 1) building a hierarchical model estimating fledging phenology and its response to spring temperatures for each species (i.e., phenological plasticity), and 2) examining the impact of evolutionary history and life history traits on species specific plasticity. This approach provides valuable insights into the adaptive responses of bird populations to climate change and sheds light on the factors shaping phenological variability among species.

Keywords: Phenological plasticity, Climate change, Bird, life history traits

*Speaker

Reproductive trade-offs in two albatross populations breeding under contrasting environmental conditions

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As resources are often limited, individuals have to decide on the amount of resources they allocate to reproduction or self-maintenance. This decision not only affects the current reproductive event but may also have carry-over effects on the resources available for future reproduction and survival. While recent evidence suggests that short-lived individuals may vary in the temporal scale at which they pay the cost of reproduction, this remains poorly studied in long-lived ones. To shed light on the temporal scale of resource allocation trade-offs, we examined allocation strategies in two black-browed albatross (*Thalassarche melanophris*) populations breeding in contrasted environments. By combining an extensive long-term individual-based monitoring of breeding success and novel statistical methods, we decomposed reproductive trade-offs at the individual level and explored individual heterogeneity in senescence rates and in the temporality and strength of short-term trade-offs. Individuals breeding at Kerguelen, where environmental conditions are highly predictable, displayed a significantly higher and less variable annual breeding success than individuals breeding at South Georgia, where environmental conditions fluctuate strongly between years. Birds from the Kerguelen population were also characterised by a faster pace-of-life than the ones from the Bird island population, delaying the cost of reproduction until late-life and showing an earlier onset of senescence associated with a strong rate of decline in reproductive performance. Individuals from the two populations also differed in the temporal scale of short-term reproductive trade-offs. By simultaneously modelling long- and short-term trade-offs, we showed for the first time that breeding under contrasted environmental conditions is associated with variation in reproductive strategies in long-lived species at both population- and individual-level. Understanding the drivers of heterogeneity in the time frame at which individuals pay the cost of reproduction is key to better understand the trade-offs between allocation into current versus future reproduction, and further studies should aim to simultaneously assess acquisition and allocation of resources into reproduction.

Keywords: albatross, life history trade off, pace of life, reproduction, seabird, senescence

*Speaker

Does colourfulness predict the relationship between song diversity and sexual selection intensity? A meta-analysis in songbirds.

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The diversity of bird song is a trait considered to evolve through sexual selection, with this diversity being viewed as more attractive to mates. However, while in some species there is a relationship between the degree of expression of this trait and the intensity of sexual selection, there are also many species for which this is not the case. In this study, we first conduct a meta-analysis of all studies conducted to date to quantitatively evaluate the relationship found between sexual selection intensity and song diversity in songbirds. We then perform a meta-regression to test the effect of different moderators that may modulate the association between song diversity and indicators of sexual selection. We thus attempt to determine if (i) the method used, (ii) the component of sexual selection measured, and (iii) the degree of elaboration of other sexual signals (here, colourfulness) can predict the relationship between song diversity and the observed intensity of sexual selection within species.

Keywords: meta analysis, signal evolution, songbirds, sexual selection, song diversity, color diversity.

*Speaker

Sexual selection in a sexually monogamous species.

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Sexual selection has been studied in many taxa and over the last decades, several indexes were developed to help its quantification. Most of the studies focused on polygamous and socially monogamous species to understand the effect of extra-pair paternity on selection in relation to sex. But sexually monogamous species, which are phylogenetically widespread, has been left aside. Additionally, how external factors, such as predation, can influence sexual selection is also rarely studied in wild population. We will use sociable weavers (*Philetairus socius*), a sexually monogamous social bird species that are facultative cooperative breeders. This species present low rate of divorce and low rate of extra-pair paternity. We have eight years of breeding data on 1659 individuals living in different communal nests, that were protected and not against snakes, the major predator of the chicks in this species. We will measure opportunity for selection and opportunity for sexual selection, Bateman gradients and Jones index in relation to sex and predation status of the colonies. Preliminary results suggest that predation impact differently males and females. Overall, our results will bring new information on how males and females undergo sexual selection in sexually monogamous species and how predation influence the sexual selection measures.

Keywords: Sexual selection, Sexual metrics, Predation, Birds, Genetic monogamy, Social species

*Speaker

Telomere length and/or dynamics as proxy(ies) of individual survival? Case study in a highly social cooperative bird species, the Sociable Weaver (*Philetairus socius*)

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Telomeres are highly repeated terminal non-coding DNA sequences present at the end of vertebrate chromosomes. They serve to preserve the integrity of the genome, which is naturally altered over time during replication. Since DNA shortening is a normal feature of ageing, telomeres length and shortening have then been suggested as robust markers of individual quality in many vertebrate species. In this line, telomere length has been positively correlated with individual lifespan in some species. Moreover, telomere erosion has been found to be accelerated with the oxidative stress generated by various stressors, with potential effect on individual longevity. Telomere length and erosion may then give complementary informative individual features for assessing whether an organism is affected by its immediate environment, and how its quality is impacted in the short- and long-term. Here, we propose to determine to which extent telomere length and erosion are relevant markers of survival probability in a highly social and cooperative bird species, the Sociable Weaver (*Philetairus socius*), living in the semi-arid harsh and unpredictable habitats of southern Africa. Concretely, we are currently measuring telomere length at 1- and 3-years-old for 163 males from a population monitored over the long-term at Benfontein Reserve (South Africa). By coupling telomere characteristics and Bayesian capture-recapture data within the hidden Markov model framework, this study will describe how telomeres length and changes over two years relate to short- and long-term survival probability, while considering individual life-history (breeding status and success) and environmental attributes (temperature, precipitations). Ultimately, our longitudinal dataset would bring new insights into the evolutionary discussion about the reproductive and cooperation cost. Linking telomere length and/or erosion to survival probability in this cooperatively breeding species will also allow us to highlight the effect of environmental variables on individual quality.

Keywords: telomeres, survival probability, individual quality, sociable weaver, environmental influence, cooperation cost

*Speaker

Implication of bacteria in the sexual selection of Iberian red deer

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During the mating season, male Iberian red deer (*Cervus elaphus hispanicus*) exhibit a large dark patch on their ventral zone, which is mainly formed by hair impregnation with sprayed urine. Patch hairs present a specific morphology that allows urine retention and thus high concentration of these volatile compounds. Chemical profiles and the size of the patch are demonstrated to constitute both a visual and chemical signal directly related to their involvement in the intrasexual competition during the rut. Due to the known capacity of several bacterial phyla to produce and/or degrade compounds that are demonstrated to be present in the patch, we hypothesized that the hairs microbiome could be, at least in part, responsible for producing the characteristic volatiles.

Here we studied and compared the bacterial richness in hairs from the dark ventral patch and from other body parts of males and the same two locations in females.

We found that the bacterial load in male's dark ventral patch hairs is significantly higher than in the hairs located outside the patch, and also higher than in the same both areas in females. Thus, the first evidence points to a different microbiota in males' patch hairs compared to other body parts, as well as compared to females' ventral zone. Since this patch is known to be involved in sexual selection, bacteria could have a role in the communication between individuals. The next step will be to identify the isolated bacteria from dark ventral patch hairs and to study their volatile production.

Keywords: bacteria, microbiome, dark ventral patch, red deer, communication

*Speaker

Selection and evolvability of mitochondrial traits in alpine swift (*Tachymarptis melba*)

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Fundamental still-unanswered questions in evolutionary biology are related to the understanding of which mechanisms rule individual growth, reproduction, and survival (i.e., fitness). Mitochondria, also well-known as the powerhouse of the cell, are the organelles responsible for energy production in eukaryote cells through oxidative phosphorylation. It sets the efficiency to which food is converted into cellular energy, and thus how this energy is invested in fitness and overall maintenance. Mitochondrial functioning may be one of the key answers to explain individual heterogeneity in growth, reproduction, and survival. Oxidative phosphorylation produces up to 90% of the energy to fuel cell and therefore individuals. Thus, recent research suggested that variation in their functioning, efficiency and density might account for a large part of inter-individual differences in performance. Mitochondrial traits are also expected to show intra-individual variations and plasticity over the life course, depending on environmental factors such as parental care, diet, exposure to pollutants, or pathogen infections. The general objective of my PhD is to test how mitochondrial traits are selected and their potential evolvability across individuals and contexts, in a wild population of Alpine swift (*Tachymarptis melba*). Alpine swifts are caught in various colonies across Switzerland (Biel, Solothurn, Baden), where nestlings have been ringed for several decades and adults tracked since 1999. This long-term monitoring and the colonial nature of Alpine swift allows us to construct large pedigree over the years, establishing genetic link between offspring, parents, and the different colonies. Mitochondrial traits are measured in fresh blood samples within 24h after collection. The protocol is based on a substrate/inhibitor approach to quantify O₂ consumption used for ATP synthesis (OXPHOS), and during mitochondrial proton leak (LEAK) through the inner mitochondrial membrane. Endogenous mitochondrial respiration (ROUTINE), maximal mitochondrial respiration (ETS) and non-mitochondrial respiration will also be measured. Other markers of oxidative stress (superoxide dismutase, glutathione, oxidative damage, antioxidant capacity, protein carbonyl, glucose), growth (IGF-1) and ageing (telomere length) will be measured to complete the physiological picture. The selection and evolvability of the traits will be determined with quantitative genetic approaches using animal models. In addition, various environmental factors will be introduced in our models, such as pollutants (metal trace elements, persistent organic pollutants) and pathogen prevalence (*Trypanosoma sp.* screening). At the end, we are expecting to depict what is the genetic architecture of mitochondrial traits in this natural bird population and what is the strength and direction of selection on mitochondrial traits (inter-individual variations). We are also interested in the potential turn-over of mitochondrial efficiency over the life-course (within-individual variations), also depending on environmental factors. Finally, we aim to investigate what are the causal cascading effects of changes in mitochondrial function on reproduction or survival.

*Speaker

Keywords: mitochondria, oxidative phosphorylation, quantitative genetics, oxidative stress, fitness

Ecology on a Carapace - diatom diversity on the carapace of European pond turtle (*Emys orbicularis* L.)

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Algae represent a group of microorganisms which are known as good bioindicators and are in turn widely employed in numerous monitoring studies. A good example are filamentous and macroscopic algae on turtle carapaces which have been extensively studied, simply due to the fact they are observable to the naked eye and easily collectible. An intriguing subset of microalgae capable of colonizing turtle carapaces includes diatoms, also known as good bioindicators which often remain overlooked in such studies, due to their size. The aim of this study was exploring the distribution and comparing the communities of this organisms on turtle carapaces, which potentially could be used in biomonitoring studies. For the purpose of this pilot study, diatoms were collected from the carapaces of four European pond turtles (*Emys orbicularis*, Linnaeus, 1758), within the Special Nature Reserve "Deliblatska Peščara", Stevanove Ravnice. Diatoms were collected by brushing from the carapaces, preserved in 4% of formaldehyde. Samples were treated using solution KMnO₄ and conc. HCl, while permanent slides mounted with Naprax medium and meticulously examined under the microscope for precise identification. A total of 109 algal taxa belonging to 42 genera have been identified. The preliminary results have shown that the lowest diversity of algae (19) occurs on the turtle with the highest weight, as well as the width and length of the carapace and plastron (expressed in millimeter), while the highest diversity of taxa (37) is found on the male with the smallest weight and size of the plastron and carapace. Genera with the highest taxonomic diversity include *Navicula* (12) and *Gomphonema* (12). Taxon *Navicula cryptocephala* Kützing was found on three of four turtles - this taxon is broadly distributed in rivers and lakes. It is common in higher nutrient waters, and in sites with higher sedimentation, which is expected when we look at the researched area. *Epithemia adnata* (Kützing) Brébisson was also found on every turtle, which is expected, because this taxa was found to grow in more or less standing water. *Fragilaria campyla* (Hilse) was identified for the first time in Serbia, in this area, as well as in this part of Europe. This record is unique as it was found on turtle carapace. Despite this discovery, we still have limited knowledge about its ecology, since it's only found in central Europe (Switzerland and Belgium). Further research is needed to understand how *Fragilaria campyla* fits into the epibiotic diatoms community on the carapace of European pond turtle. Future studies might unveil more intricate insights into the ecology and interactions between diatoms and turtles, since this research was done on 4 turtles. Additionally, exploring the potential use of diatom-turtle communities in bioindication could be interesting.

Keywords: *Fragilaria campyla*, Special nature reserve "Deliblatska peščara", endangered species

*Speaker

Tweet or treat: unveiling the effect of brood size on begging behaviour in Blue Tits

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Dependent young use behavioural begging to signal their need for resources, usually food. In birds, vocal and postural begging typically reflect hunger levels and depend on various factors such as brood size, feeding status, and parental effort. Hungry nestlings increase the frequency and intensity of their begging displays, potentially making parents to increase their feeding rate. Furthermore, an increase in brood size intensifies competition for resources among siblings, which can affect the frequency and intensity of begging. However, the complex relationships between these factors remain largely unresolved. We investigated begging behaviour in a Mediterranean population of blue tits (*Cyanistes caeruleus*) subjected to a brood size manipulation experiment. By placing cameras within the nest boxes, we monitored the mean begging time per nest, the parental feeding rate, and the quality of feeds defined as the proportion of Lepidoptera among prey items. Additionally, we considered the body mass difference between the largest and smallest nestlings of the brood, along with the laying date and clutch size. The manipulation of brood size affected begging intensity: enlarged broods increased average begging, while reduced broods decreased it. Moreover, begging intensity positively correlated with provisioning by parents and the quality of prey items provided (proportion of lepidopterans). These results show that begging behaviour may adapt to specific brood conditions such as increased or reduced sibling competition, and is linked not only to feeding rate but also to feed quality. These findings enhance our understanding of the factors modulating parent-offspring communication in relation to parental effort and local food resources.

Keywords: Begging behaviour, parent, offspring communication, parental care, brood size

*Speaker

Effect of manipulation of brood size on mouth colouration in Blue Tits

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Carotenoid-based colourations in birds are often indicators of bird fitness because carotenoids, which are obtained solely through the diet, can be limiting resources that are also traded-off between multiple physiological functions. In many altricial birds, nestling mouth flanges show a conspicuous carotenoid-based colouration that mirrors their physical condition and acts as a visual indicator for parent-offspring communication. However, the role that multiple factors such as parental effort, sibling competition, food quality, parasitic status, and breeding habitat may play in the expression of these ornaments is still widely unknown. To investigate how these factors, influence carotenoid-based nestling mouth colouration, we conducted a brood size manipulation experiment in a population of blue tits (*Cyanistes caeruleus*). Moreover, we examined how colour saturation of nestling mouth flanges (an indicator of carotenoid concentration) covaries with parental feeding rate, food quality (proxied as a percentage of Lepidoptera in the nestling diet), the size hierarchy of nestlings, and ectoparasites infestation. The effect of brood size manipulation on mouth flange colouration depended in a complex way on parental effort and food quality. Specifically, in reduced broods, a higher feeding rate was associated with lower mouth flange saturation, while in enlarged broods a higher quality of prey items was related to higher saturation. Moreover, mouth colour saturation positively correlated with the presence of fleas in the nest and laying date. This variation in carotenoid-based mouth colouration in nestlings may reflect differences in the physical condition of nestlings and underlying trade-offs, with potential effects on their survival and fitness. These results point towards a complex interdependence of the expression of these visual signals with various extrinsic and intrinsic factors acting on the breeding environment.

Keywords: bird, carotenoid, coloration, feeding rate, nestling

*Speaker

Divergence in the antennal lobes of *Heliconius* butterflies as an evolutionary response to selection

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Adapting to novel environments often requires behavioural changes which depend on changes to the sensory and neural systems or both. The antennal lobe functions as the primary olfactory organ in invertebrates and changes in its volume between species living in divergent environments have been recorded in a variety of taxa. However, we are still unsure of the generality of this association across bigger taxa and whether environmental or ecological factors are facilitating these changes in the antennal lobe volume. Here we tested for changes in the antennal lobe volume across 41 species in the Heliconiini tribe, in relation to environmental and ecological factors. Preliminary results suggest no significant differences in the antennal lobe volume between different phylogenetic groups but we found that antennal lobe evolution was not explained purely by phylogeny. We will then further delve into the possible environmental and ecological constraints affecting antennal lobe evolution. We believe that our results will ultimately shed light on how sensory systems evolution is affected by evolutionary constraints.

Keywords: *Heliconius*, sensory systems evolution, brain, comparative studies

*Speaker

Conflict and evolution: unravelling the influence of superfetation on male reproductive structures in viviparous fish

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Conflict in nature acts as a driving force leading to the diversification of structures and behaviours, including aspects related to reproductive organs. Competition between sexes for control over reproductive decisions can lead to the coevolution of male and female sexual traits. This sexual conflict results from an evolutionary struggle to maximize reproductive interests, causing conflicts in mating and fertilization decisions. The aggressive characteristics of males and the resistance of females create a situation of conflict that drives patterns of mate selection through an arms race between males and females, favouring evolutionary diversification of reproductive strategies in both sexes. This conflict promotes adaptation, leading females to evolve mechanisms like cryptic female choice to influence sperm usage and prevent polyspermy. Additionally, complex placental structures allow females to selectively regulate resource allocation, influencing which embryos receive more or fewer resources. In this study we explored how specific reproductive strategies, such as placentotrophy and superfetation, influence the evolution of male gonopodial structures within the diverse family of Poeciliidae. This family exhibit diversity in the mode of maternal nourishment and high interspecific variation in male attributes associated with sexual selection and mating strategies. Within the family Poeciliidae, there's a spectrum of nutrient transfer from females to embryos, ranging from depositing yolk before fertilization (lecithotrophy) to ongoing nutrient transfer during gestation (placentotrophy). Some species also exhibit superfetation, carrying multiple broods at different developmental stages. The degree of superfetation varies widely among species. Superfetation is linked to higher levels of placentation in this family. Our previous expectations suggested that species with both placentotrophy and superfetation would diversify more, but our results showed otherwise. Surprisingly, lecithotrophic species without superfetation showed higher rates of diversification in gonopodial depth and length. This suggests two mating tactics: courtship behavior and coercive behavior, leading to morphological diversification. Gonopodial length was mainly influenced by superfetation, with species employing this strategy having longer gonopodia. Likewise, species with superfetation had more serrae on their gonopodia, indicating their importance in copulatory success in the male competition. Although the link between placentotrophy, superfetation, and gonopodial diversification wasn't fully confirmed, superfetation seems crucial in shaping gonopodial structures among viviparous fish species. We tested this idea by comparing the evolutionary

*Speaker

diversification of gonopodial morphology between placentotrophic species with superfetation and lecithotrophic species with and without superfetation, using a phylogenetic comparative method. This study is a significant contribution to the knowledge of genital diversification, particularly as a consequence of the conflict arising from the presence of placentotrophy, superfetation, and post-copulatory sexual selection in viviparous fishes.

Keywords: coevolution, divergent evolution, sexual conflict, poeciliids

Investigating the plasticity of cold and heat tolerance in the invasive *Drosophila suzukii*'s larvae using the Thermal Death Time analysis

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Temperature is the one of the main drivers of insect distribution, and with the current and future warming of many of the earth's biomes, it is crucial that we investigate insects' thermal tolerances. Specifically, determining both heat and cold limits for impactful species could help predict changes in their distribution. Invasive species - like *Drosophila suzukii* - who ravage crops could get even harder to manage if they broaden their thermal limits due to warming. There are, however, a lot of discrepancies in the ways to determine insects' thermal limits, but the Thermal Death Time analysis has been created to smooth out those differences. It allows for the representation of a species' thermal limits with a few metrics and proves the existence of an exponential relationship between the duration and intensity of thermal stress. It has successfully been tested on adults of a few *Drosophila* species for both heat and cold temperatures. Here, we looked into the thermal sensitivity of two larval stages of *D. suzukii* and found that they were less sensitive to heat stress than adults, and could endure higher temperatures. For cold temperatures, the analysis clearly represented the shift to critical temperatures by an increase in sensitivity. Finally, we played with plasticity by testing the recovery and additive effects of heat stress on 3rd stage larvae.

Keywords: *Drosophila*, Thermal Death Time, Heat stress, Cold stress, Plasticity

*Speaker



POPULATION DYNAMICS

Speaker

SARAH CUBAYNES

Lecturer EPHE, CEFE, Human Animal Interactions team

**Insights from evolutionary demography into
conservation biology**

Survival strategies of the Little Owl: Investigating population dynamics for conservation

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In the current context of global changes, it is crucial to better understand the dynamics of natural populations to anticipate their future evolutions. The Little Owl (*Athene noctua*) is a declining species in France and more broadly in Europe. In order to adapt conservation strategies and prevent the risks of extinction, it is important to determine the factors impacting population size and more specifically the vital rates of individuals (e.g., survival rates, reproductive success). Through individual monitoring of Little Owls in various ecological contexts for many years in France, we evaluate the intrinsic and extrinsic determinants of survival in this species. Particularly, our study aims to assess the effect of age, sex, and time on individual survival rates. In this species with an intermediate life history characterized by sexual maturity at one year old, a clutch typically consisting of two to five offspring, and an average lifespan of around ten years, we test the hypothesis that adult survival would be relatively constant over the years, unlike that of juveniles, which is much more variable, in accordance with the environmental canalization hypothesis. We assess the shape of senescence patterns by identifying factors that may influence individual aging. To do so, we develop capture-mark-recapture models that account for imperfect detection of individuals during annual monitoring sessions of populations. By expanding our knowledge on this iconic "umbrella" species of anthropized environments, we will be better equipped to design and implement environmental conservation measures tailored to its long-term preservation.

Keywords: CMR, decline, demography, reproduction, senescence

*Speaker

Using Bayesian removal models to estimate large-scale population dynamics of an invasive predator over 20 years of control

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Invasive mammalian predators are a major leading cause of global defaunation, contributing to over half of all recorded vertebrate extinctions. Eradication efforts of long-established species over large invaded areas are usually prohibitively expensive, leading to long-term population control management strategies instead. These operate assuming that suppressing the invader's residual populations below desirable thresholds will reduce their impact to negligible levels. However, to test such assumptions and optimise control strategies, reliable methods are needed to estimate how removal efforts change population residual abundances over time. Removal models have been historically used for these strategies, but classical formulations require assumptions such as population closure (no mortality or recruitment events) and can perform poorly under scenarios of high capture effort and spatial heterogeneity. One of these scenarios is the American mink *Neovison vison* invasion in mainland Scotland, encompassing a wide range of habitats and causing significant harm to native species such as the water vole *Arvicola amphibius*. By integrating recent developments in Bayesian removal models, we provide the first estimation of invasive American mink spatiotemporal residual population dynamics under long-term removal efforts. We use data from 20 years of control with varying intensity led by citizen conservation efforts within a 29,000 km² area in Scotland. We estimated within- and between-year regional dynamics as a function of a wide gradient of environmental factors while accounting for heterogeneous capture effort, probabilities, spatial biases, and missing data patterns commonly found in citizen-science programmes. The results show how spatiotemporal patterns in abundance, depletion and capture rates vary along environmental gradients and control efforts. Additionally, we show how sex and age distributions of captured and residual populations change across time and space depending on habitat features, suggesting settlement patterns of breeding individuals in line with previous studies. We also predict regional extinction probabilities under different levels of control effort to predict future invader population trends. The modelling framework and results provide a blueprint tool to reliably estimate residual invader abundances under high environmental and effort heterogeneity and could serve to optimise ongoing and future large-scale invasive predator removal efforts.

Keywords: Population dynamics, Removal models, Landscape ecology, Invasive species, Invasive predator, Invasion biology, Bayesian statistics, American mink, Statistical modelling

*Speaker

The Effects of Early Growth on Little Penguins' Life-History Traits

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The early growth development of young individuals can impact their future lives. Yet, this impact on individual fitness is uncertain because of trade-offs between life-history traits. Using a 24-year dataset, we examined the growth patterns of 2030 little penguin chicks to evaluate the impact of early growth on juvenile survival, adult reproductive success, and lifespan. Three growth patterns were identified: rapid, slow, and light. Chicks with rapid growth had high survival rates until fledging (87%), lived longer, and reproduced more successfully. Under slow growth, individuals exhibited irregular and slow growth. Still, they reached fairly large masses at independence, and showed similarly high survival rates to fledging (83%) but matured later and produced fewer offspring. Light chicks had lower fledging success (50%), but those recruited into the breeding population did not experience lasting negative effects on reproduction or lifespan, likely due to strong selection of individuals from an early age. While no trade-off between growth rate and longevity was found, irregular growth negatively affected longevity and reproduction. These findings underscore the critical role of early development in shaping individual fitness and highlight the need to investigate the environmental factors and food availability during this critical development period to inform conservation strategies.

Keywords: early growth, life history traits, fitness, pace of life

*Speaker

Improving Prediction of Habitat Fragmentation Consequences: A Multi-Species Hierarchical Revisit of Hanski's Incidence Function Model

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Understanding population dynamics is crucial in the context of current environmental changes and human-induced disturbances. This comprehension is essential to develop effective conservation strategies, ensuring ecosystem sustainability. Hanski incidence function model stands out among approaches addressing the consequences of habitat fragmentation on population dynamics. This model assesses how landscape structure influences species dynamics and persistence, based on factors such as patch size and inter-patch connectivity. It is widely used in conservation biology for its practicality because it can be parameterized using presence-absence data. However, this approach has limitations, notably its monospecific nature leading to a restricted understanding of biological diversity effects on population viability. We propose to revisit the incidence function model to integrate several species using a hierarchical model. This enables us to obtain more accurate results than the standard incidence function model by applying to similar species, information obtained from other ones. Our approach broadens the perspectives of Hanski's incidence function, making it more realistic in the context of complex fragmented ecosystems. While retaining the practicality of the original model, configurable with presence-absence data, our model allows a more robust anticipation of the consequences of habitat fragmentation on biodiversity, thus providing a solid foundation for the development of more holistic conservation strategies.

Keywords: habitat fragmentation, incidence function model, metapopulation theory, agroforestry, landscape ecology, conservation strategies

*Speaker

Relative contributions of local and neighbourhood colony size and breeding success to the dynamics of a metapopulation of Black-Headed Gulls (*Chroicocephalus ridibundus*)

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Dispersal as a demographic process is central to metapopulation dynamics as it largely contributes to the extinction, colonisation and synchronisation of populations. Given its impact on fitness, dispersal between habitat patches is also not random, but relies on information gathered by individuals. Both personal and social information are known to direct emigration and settlement decisions in a number of species. Yet, aside of theoretical work, information use as a driver of dispersal has rarely been included in studies aiming at understanding metapopulation dynamics. Here, we incorporate public information likely to drive dispersal decisions into a dynamic occupancy and population model, in order to shed some light on how and at what spatial scale informed dispersal may shape the dynamics of a colonial bird species, the Black-Headed Gull (*Chroicocephalus ridibundus*), occupying a network of continental ponds in central France. More precisely, we investigate how the size or breeding success of local and neighbouring colonies in the previous year affect colony persistence and pond colonisation probabilities, as well as local growth rate of the colonies. Preliminary results suggest that while the positive effects of colony size and breeding success on colony persistence probabilities cannot be dissociated, colonisation probabilities depend only on the breeding success of the nearest neighbouring colonies. New colonies are more likely to appear in areas that hosted successful colonies in the previous year, while areas where colonies failed their reproduction are less likely to be colonised. Persistence of colonies could thus result from any combination of local demographics, conspecific attraction and use of personal or public information. However, the redistribution of individuals in the vicinity of successful colonies and the avoidance of unsuccessful colonies is more likely to result from the use of conspecific breeding success as public information at a spatial scale of a few kilometres.

*Speaker

Keywords: metapopulation dynamics, dispersal, colonial breeding, public information, demography, occupancy, long term monitoring, Bayesian modelling

Changes in the temporal patterns of feeding events of a central place forager : how did the spotted hyaena (*Crocuta crocuta*) adapt to changes in the repartition of its prey caused by climate change

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Climate change, through the distortion of climatic factors such as rainfall and temperature, is recognized as a significant force capable of disrupting ecosystem dynamics. In the Serengeti National Park, there has been a notable increase in both dry and wet season rainfall over the last decades. This is suspected to have influenced migratory patterns of three herbivore species: *Connochaetes taurinus* (blue wildebeest), *Eudorcas nasalis* (Thomson's gazelle), and *Equus quagga* (plains zebra) that migrate along a gradient of rainfall. These species dominate mammalian herbivore species in the park and are the main prey of the spotted hyaena, *Crocuta crocuta*, known to adapt its foraging strategy to the presence of migratory prey in their clan territory. When migratory prey is present in large numbers, hyaenas remain in the clan to feed. When there is little or no migratory herbivore, low-ranking individuals commute and leave the territory to feed in areas rich in prey. Thus, any alteration in the spatial and temporal repartition of migratory prey is likely to have further consequences on hyaena behaviour and demography. In the park, previous studies have shown that the presence of migratory herd in the territory of three hyaena clans (monitored continuously since 1990) have decline over years and that this correlates with the increase in rainfall. To compensate for this decrease in the availability of prey in their territory, one might expect hyaenas to commute more often to areas of the park where migratory herbivores are abundant, and thus to be less present at their dens. However, hyaena presence at communal dens has remained unchanged over time. Since hyaena do not seem more absent from their territory as prey presence declines, we aim at exploring what happened within hyaena clan territories and how did the patterns of kills evolve there. To do so, we use opportunistic observations of kills made in the three hyaena clan territories and recorded during each monitoring session since 1990. We investigated temporal trends in the number of feeding event observed using Generalized Additive and Linear Models. We then performed an Analysis of Deviance to test if these patterns relate to those of prey presence in hyaena clan territories and rainfall. We hypothesized that more kills are detected in months when prey is abundant, and thus that the number of kills decreased over years together with decreased prey presence and increased rainfall. Results indeed indicate a correspondence between temporal trends of the number of kills observed and prey presence in hyaena clan territories, and that more kills

*Speaker

are detected in general when prey are abundant in clan territories. However, the relationship with annual rainfall remains less conclusive. We discuss why the link between rainfall and the number of kills may be less straightforward than what we tested, and alternative hypotheses that may explain the patterns observed. By exploring the links between the number of feeding events and prey availability, this study seeks to shed light on the mechanisms driving hyaena foraging strategies and their response to environmental changes in the park.

Keywords: Feeding behaviour, resource repartition, climate change, hyaena

Breeding Ecology of the marbled teal in Morocco

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It is very important to get robust estimates of the breeding population size of waterfowl in order to develop effective management and conservation plans for the species and the environments they occupy. In Morocco, no such studies have been carried out in the past, which makes it very difficult to assess the population status of various waterbird species in the country. A national survey was developed in 2023 for monitoring the breeding of several species of waterfowl with a special focus on the white-headed-duck (*Oxyura Leucocephala*) and the marbled teal (*Marmaronetta angustirostris*). The survey combined two protocols: one with random sampling of 20 sites among wetlands, and another that covered the most known breeding sites for the species if they were not selected within the first protocol. Globally, we surveyed more than 38 sites spread-out in all of Morocco from Laayoune in the South, to Moulouya mouth river in the North. New breeding sites were discovered for the first time for both species. A total number of 13 broods were recorded for the white-headed duck, and 61 broods for the marbled teal. To estimate the breeding population size of the marbled teal, we used zero inflated N-mixture models in Unmarked package in R. First results showed that emergent vegetation is one of the most important factors explaining the variation in the abundance for the marbled teal, and yielded an estimate of 1.2 broods per sampling unit. These results are preliminary, and needs further examination and analysis to get more precise estimates of the breeding population size. Another year of data will be incorporated into the data analysis with a bayesian approach, to get more precise results. We considered that this national survey should be carried out for at least two more years in order to get sufficient data for robust breeding population size estimation and also for the identification of environmental variables explaining the presence of the species during breeding season. This same protocol may be replicated in the other north African countries (Algeria and Tunisia), in order to get the whole picture of the north African population sizes and draw suitable management and conservation plans for the species and their habitats.

*Speaker

Keywords: breeding ecology, N, mixture models, abundance, Marbled teal

I'll be back ... or not: Survival of juvenile Adélie penguins continues to decline across the species range

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As the summer sea ice extent around Antarctica continues to dwindle, reaching record low numbers for the third year in a row, quantifying the demographic response of polar species to environmental variability becomes more urgent than ever. To help with future forecasts of population trends under such fast climate-driven ecosystem transformation, measuring annual survival is key and yet quantifying it remains a formidable challenge. Because of their tight association with sea ice, Adélie penguins are considered bellwethers of climate change in Antarctica and determining what drives population recruitment is critical. Using a 17-years time series of known-age individually marked Adélie penguins from Pointe Géologie archipelago, Adélie Land, we investigated the relationships between juvenile survival and intrinsic (cohort size, body mass) and environmental (modes of climate variability, sea ice concentrations) parameters. In parallel, we examined the temporal trends in juvenile survival for this population. We found that juvenile survival was the most impacted by sea ice concentration near the natal colony in the months following fledging, while it declined by -2.5% annually between 2007 and 2020. As evidence from other regions of Antarctica points to population shrinkages driven by declining survival probabilities for juveniles, we can wonder whether we might soon be witnessing a range-wide decline in a previously stable population.

Keywords: CMR, survival, population dynamics, Antarctica

*Speaker

Can tiger (*Panthera tigris*) return to a landscape? Assessing conservation using long-term prey base survey as an indicator.

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Prey abundance is recognized as a key component for recovery of tigers (*Panthera tigris*). Long-term monitoring is imperative for increasing the understanding of the trends in prey populations and it helps in assessing the management interventions. We provide density data from 2010 to 2022 on five tiger prey species from Kawal Tiger Reserve (KTR), Telangana, India, where we used permanently marked random transects to estimate the abundance. We compared the trends in the principal tiger prey population across years. The chital (*Axis axis*) and nilgai (*Boselaphus tragocamelus*) populations have doubled but chousingha (*Tetracerus quadricornis*) populations did not show a decreasing trend. The wild pig (*Sus scrofa*) population is typically showing extreme fluctuations. Based on the observed growth rates, we also predicted population doubling/halving times of these populations, and we used the most recent density estimates of prey species to predict the carrying capacity of tigers in KTR. We estimated that the prey base of KTR can support more than 25 tigers in its core. But, reestablishing a tiger population in KTR requires functional corridor connectivity with source populations, reduced human footprint and perhaps re-stocking females from nearest source population. In past 10 years, many transient tigers have been reported from the reserve, but due to the pressing issues, a breeding population is yet to be established in KTR.

Keywords: Adaptive management, carrying capacity, corridors, Kawal Tiger Reserve, line transect, population growth, prey densities.

*Speaker

Impact of climate change on population ecology of edible dormice

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Climate change has far-reaching effects on various animal species within an ecosystem, including direct and indirect effects. Indirect effects can be observed, for instance, by studying pulsed resource systems. Resource pulses often create lagged responses in successive trophic levels of ecological communities and can be major drivers of the abundance and dynamics of small mammals. Especially mast seeding trees (e.g., European beech (*Fagus sylvatica*)), where the mast patterns are triggered by weather cues, are likely to be strongly affected by climate change.

Since seed consumer's life history strategies and population dynamics are often directly linked to seed availability, one of their main food sources, altered mast patterns may ultimately impact reproduction and survival rates of seed consumers. Edible dormice (*Glis glis*), small forest-dwelling and hibernating mast seed consumers, have highly adapted their life-history strategy to the seed pulse of the beech. Entire populations skip reproduction in years with a lack of mast seeds (so called mast-failure years). Due to costs of reproduction, adults have a generally lower survival probability in mast years with high seed availability compared to mast-failure years. Based on this strong adaptation, dormice seem an excellent study species to investigate and disentangle the indirect effects of climate change on a seed consumer.

Here, capture-recapture data from in total 2,528 individuals captured in 128 nest-boxes over a 17-years period (2006-2022), from an edible dormouse population in the Vienna woods, Austria, were used. It is hypothesized that a climate change induced increase in beech mast frequency affects the proportion of reproductively active females and/or litter size. Subsequently, based on life-history theory, it is hypothesized that an increased reproductive investment due to more mast years lead to decreased survival probabilities in adult and yearling (both sexually mature) dormice. We compared local survival probabilities of dormice between two periods within the long-term dataset. The division into period 1 (2006-2013) and period 2 (2014-2022) was based on a splitting point with a strong effect on mean temperature per period to evaluate the indirect effect of climate change through an altered masting pattern associated with on average higher temperatures. Based on capture-mark-recapture data, program MARK was used to estimate the survival probability of dormice.

A strong signal was found that climate change has already visible effects on life-history strategies in dormice. Both, adult and yearling dormice, increased their reproductive investment most likely in response to higher seed availability in times of higher temperatures. This increased reproductive investment was paralleled by lower survival probabilities in mast years in both age classes. However, while survival probabilities of adults remained stable over the study period, survival probabilities of yearlings were lower in times of higher temperatures. This might be attributed to higher above-ground activity in mast-failure years and its associated predation risk of yearlings compared to adults. The results provide novel insights into the relationship between climate change, mast pattern, and reproductive strategies and survival dynamics of dormice.

*Speaker

Keywords: beech mast, edible dormouse, *Glis glis*, mark–recapture, reproduction, survival, climate change, pulsed resource

Evolution of European hedgehog (*Erinaceus europaeus*) population density in rural and urban areas, for conservation purposes

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Currently, biodiversity loss appears to be a major environmental challenge. Despite numerous alerts from medias and wildlife protection association on the imminent disappearance of the hedgehog *Erinaceus europaeus* and several studies reporting population decline in bordering countries (England, Switzerland, and Italy), there is still no study in France to confirm this. We will contribute to fill this lack of information by providing necessary knowledge to promote hedgehog conservation. The purpose of this study is to assess population abundance in the Ardennes department (northern France) and compare the current population density to the result of a previous study, which took place in 2006 - 2007. This will be the first step assessing hedgehog's status in France, especially in rural areas where it is rarely studied, before looking for potential decline factors.

For comparison purpose, we plan to use the same protocol as used in 2006 – 2007. The density was estimated from Distance Sampling surveys applied to 43 line-transects, visited monthly, near Sedan city, with 6 transects in urban areas and 37 in rural areas. Hedgehogs were detected by using infrared binoculars. We will survey the same transects, also monthly but for only a year, as this will not affect the results. At that time, the population density was 36.5 ± 15.2 individuals per km² in the urban area, and 4.4 ± 1.3 individuals per km² in the rural area. Thanks to these results, we will be able to establish whether hedgehogs population is actually in decline in the Ardennes, and to compare the evolution of population density in urban and in rural areas. We predict that population density is declining, but faster in rural areas than in urban areas, where food resources were already rarer in 2006-2007.

This work is part of a wider study that is also looking at the effects of rural landscape fragmentation on hedgehog populations, focusing on population genetic clustering. Lastly, we want to identify and characterise the environmental features that are important for the species, in particular, foraging areas, features used for movement and shelters.

Keywords: European hedgehog, population density, distance sampling

*Speaker

Does the mantle matter in sooty albatrosses' sensitivity to global changes?

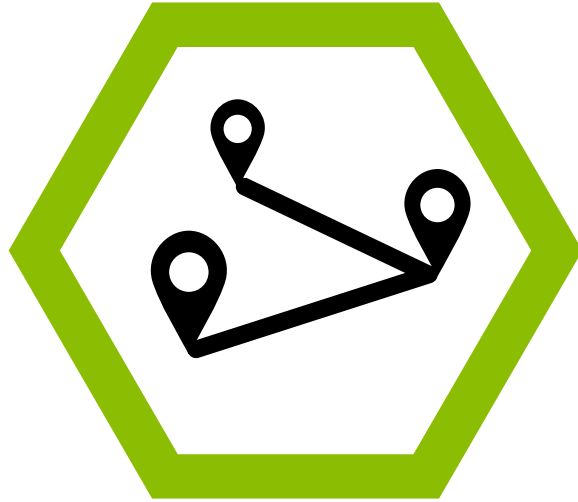
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Today seabirds are one of the most threatened groups of birds, especially albatrosses which suffer additional mortality due to bycatch in fisheries, disease and impact of introduced predators, resulting in population declines. Successful conservation programs require estimations of demographic parameters, which are possible through the study of long-time series of capture–recapture data. However, the demography of several albatross species and populations remain poorly known. Here, we estimated multiple demographics parameters (survival probability, return probability, breeding probability and breeding success probability) for four populations of two closely related species of albatrosses: Sooty Albatrosses (*Phoebetria fusca*) and Light-Mantled Sooty Albatrosses (*Phoebetria palpebrata*) from two different biomes (subtropical and subantarctic). We also looked at whether fisheries and environmental covariates had an impact on these demographic parameters over time. Data were collected from 1966 to 2021 during several decades for each population on Amsterdam Island for Sooty Albatrosses, Kerguelen Island for Light-Mantled Sooty Albatrosses and Crozet Island for both species. Both species are quasi-biennial breeders. We thus used multievent mark–recapture models to account for quasi-biennial breeding and for dealing with non-breeding individuals and state uncertainty. Results were contrasted because these four populations of albatross have different sensitivities to the environmental variables tested, acting on different demographic parameters. By understanding the way these population respond in different ways to global changes, despite their close link(same species or genus), can improve our knowledge on the way other populations may do, and so have a better knowledges of how will the species respond to this changes.

Keywords: Albatross, Phoebetria, Global Changes, Fisheries, Demography, CMR

*Speaker



MOVEMENT ECOLOGY & BIOLOGGING

Speaker

TIPHAINE JEANNIARD-DU-DOT

CNRS Research Fellow, CEBC, Marine Predators team

**Hooded seals as sentinels of a changing Arctic in the
last 30 years and beyond**

Predicting foraging trips of the world's seabirds

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Threatened by climate change and competition with fisheries for food, worldwide seabird populations have declined since the mid-20th century. Seabirds are central-place foragers during breeding, commuting long distances between colonies and feeding areas. Understanding their foraging areas is essential for informing spatial management measures to protect habitats and prey populations. While foraging of several seabirds has been intensively studied, knowledge on two-thirds of the world's seabird species is still lacking. Here, we propose to calculate species-specific foraging features (e.g., distance from the colony, time at sea, habitat use) for well-studied species and use those to predict these features for understudied species. By compiling 350 datasets from two global seabird tracking databases (> 14,000 individuals), we have estimated the foraging features for 87 seabird species. Then, we have developed phylogenetically informed models by including morphological traits and diving capabilities as explanatory variables. The results will be integrated into a bio-energetic model to calculate energy requirements of the world's seabirds and estimate their prey requirements.

Keywords: seabird, GPS loggers, foraging trip, phylogeny, distance

*Speaker

Personality and movement behaviour in Galapagos short-eared owls (*Asio flammeus galapagoensis*)

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Understanding how animal personality links to individual spatial requirements in keystone species is of great importance for conservation management. While personality and home range have been studied separately in some owl species, largely nocturnal predators that stabilise ecosystems, their association has not yet been explored. The aim of this study was to link personality to spatial utilisation of Galapagos short-eared owls (*Asio flammeus ssp. Galapagoensis*), to inform their captive holding and re-introduction back into the wild as part of the conservation action ‘Floreana re-wild’. The species is the only endemic terrestrial predator on the island, showing behavioural adaptability by switching from birds and lizards as historic prey, to invasive rodents, making it highly vulnerable to secondary poisoning in face of an island-wide eradication of invasive rats and mice. 31 individuals were tagged with GPS and ACC loggers to determine their pre-eradication movement. Four different personality traits (boldness, activity, aggressiveness, and sociability) were measured in the wild across different contexts. We used both established and novel methods to link these traits to their movement patterns. We found a trend between the measurements ascribed to boldness across contexts, a strong correlation between three movement-inferred activity measurements, but no obvious link between personality and spatial utilisation. This research is conducted in preparation for the necessary safeguarding and post-eradication release of the population. Our results could help inform conservation decisions on these unique island predators, and be applicable to other systems particularly those involving the eradication of invasive prey, translocation, and capture-and-release programmes.

Keywords: Owl, animal personality, GPS, movement ecology, island ecology, conservation biology, keystone species, bird of prey, behavioural biology

*Speaker

Does personality expressed by roe deer during an acute stress explain their movement syndrome in the wild ?

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Human activities have increased the amount of disturbance and risks wild animals experience. When faced with stressful situations, individuals vary in their behavioural and physiological responses depending on their behavioural type. For mobile species, movement is often the first behavioural tool to deal with challenging conditions, such as global warming, resource depletion or habitat fragmentation. Movement syndromes, suites of correlated consistent movement traits, have been identified in various taxa, and are associated to differences in risk taking, resource acquisition and in individual performance. To identify behavioural types, standardised tests have been used to categorise individuals, through an evaluation of docility, boldness or exploration for example. However, behaviours evaluated in controlled settings might not accurately represent movement syndromes expressed in the wild. Using on a long-term monitored roe deer (*Capreolus capreolus*) population, we investigated the existence of a movement syndrome linking activity, space use and spatial behaviour in roe deer, that we quantified through six repeatable movement metrics computed monthly. In particular, we studied the correlation between stress physiological and behavioural traits during capture, docility and three physiological parameters (neutrophil to lymphocyte ratio, haematocrit level and mean rectal temperature), and the routine movement and space use patterns of free-ranging roe deer. We hypothesised that the among-individual differences in the stress response during a standardized stress induced by capture correlate with their movement syndrome in the wild over a year. Using Bayesian multivariate mixed models, we unravelled the existence of a movement syndrome in roe deer, with individuals using risky open habitats more during daytime being less active and having a higher average speed of movement, as well as a bigger home range. These individuals also tend to stay further away from roads during daytime, compared with their mean distance from roads in general. This movement syndrome highlights the existence of separate and consistent movement tactics, which can have consequences on population persistence, individual survival and reproductive success. However, we found no association between the stress response and movement syndrome, suggesting that, in roe deer, behavioural types measured during the standardised setting of capture does not inform on the movement-based personality traits in the wild. Stressful capture and handling by humans do not relate in terms of the response needed to daily disturbances and natural conditions, even in an anthropized landscape, for this population of roe deer. In previous studies, we found that among-individual differences in stress response during capture were correlated to individual differences in performance, such as fawn survival and annual reproductive success. Thus, the lack of correlation between movement and stress response in our study might suggest that individual variations in performance may not be mediated by differences in movement syndromes. Instead of examining the influence of the response to acute stress on the average behaviour, i.e. behavioural types, one perspective of

*Speaker

this study would be to investigate the link between stress response and plasticity in movement metrics, which could represent the differences of individual adaptability to stressful situations of roe deer.

Keywords: personality, syndrome, stress response, movement, GPS, roe deer

Uncovering movement patterns of belugas in the St. Lawrence Estuary from telemetry data

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Estimating the impacts of anthropogenic stressors on animal populations requires an in-depth understanding of movement patterns of individuals. Here, we used fine-scale location data from 74 St. Lawrence Estuary (SLEB) radio-tracked during daytime to better understand their movement patterns, and provide the basis for assessing impact of noise from maritime traffic on their behavior, which represents one of the main threats to SLEB recovery. Specifically, we decomposed the *SLEB* movements to infer behavioral states and their relation to environmental and social factors. Belugas were tracked on average 4 hours 58 mins. Over 2,600 locations were processed using Hidden Markov models, leading to the differentiation between two behavioral states: multidirectional swimming in restricted spatial area that might relate to foraging or socializing, and unidirectional swimming over longer distances that might relate to environment exploration or transit among habitats. These behavioral states will be discussed in relation to extrinsic (areas used and previously attributed functions) and intrinsic factors (group and herd composition and size). Overall, these results will enhance ecological and behavioral realism in current beluga movement simulations aiming at evaluating the level of noise perceived by SLEB both at the individual, and population scales.

Keywords: Endangered specie, Spatial ecology, social behavior, Hidden Markov models, Conservation Biology

*Speaker

Spatial behaviour, age and gender correlate with pattern of infections in roe deer

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In the realm of eco-epidemiology, understanding the dynamics of infection involving both zoonotic and non-zoonotic pathogens in wildlife is pivotal, given the implications for public health, economies, and ecosystems. A fundamental objective is to unravel the myriad variables influencing the probability of infection by these pathogens. Among these, the concept of "Exposure," representing the likelihood of host-pathogen encounters, stands out as a crucial research domain to fathom pathogen cycles and devise effective management strategies. Certain pathogen traits, such as mode of transmission or host specificity, make certain habitats more favorable to the survival and the abundance of these pathogens. The spatial behavior of the host, encompassing movement and activity in these pathogen-suitable environments, emerges as a key factor influencing exposure, hence modulating the inter-individual variability of the pathogen community. Notably, the inter-individual variability in spatial behavior further modulates infection probabilities and pathogen infra-community structures within host species. Moreover, the co-presence of multiple pathogens within an organism can lead to intricate interactions, including direct and indirect effects, both negative and positive, mediated by immunomodulation or competition between pathogens for host resources. Beside exposure differences, within-pathogen interactions may also drive between-individual variability of the pathogen community.

We aim to decipher whether spatial behaviour of host and/or the pathogen traits correlate with inter-individual variability in pathogen community in roe deer (*Capreolus capreolus*), a widespread ungulate known to host many pathogens, including livestock-shared and zoonotic pathogens. The demonstrated inter-individual variability in spatial behavior, encompassing activity and habitat use, positions the roe deer as an intriguing biological model to explore the intricate link between spatial behavior and infection risk.

Focusing on 10 different pathogens, our objective is to identify if the community of pathogens hosted by roe deer is influenced by the spatial behaviour of individuals (exposure), or by pathogen traits related to off-host and in-host life stages.

Utilizing data from GPS tracking and pathogen analysis (bacteria, viruses, and gastrointestinal parasites), we employed a hierarchical Bayesian model on data from 222 individuals captured between 2016 and 2022 in South-West France. Our analysis encompassed the effects of space use, activity, age, sex, pathogen traits, and pathogen interactions on infection probability and the structure of co-infection patterns.

Our findings reveal that the utilization of pathogen-suitable environments by hosts amplifies

*Speaker

the probability of infection by considered pathogens. Additionally, we underscore significant variability in infection rates across age and sex, with younger and male individuals exhibiting higher pathogen susceptibility. While host activity positively correlates with pathogen species richness, this effect diminishes in older individuals. Lastly, our study does not unveil strong relationships between pathogen interactions and the structuring of co-infection patterns.

In conclusion, our research sheds light on the intricate interplay of spatial behavior, individual characteristics, and pathogen dynamics in the co-infection ecology of roe deer, offering valuable insights for both wildlife management and public health considerations.

Keywords: Roe deer, co, infection, movement, behaviour, exposure

Mapping fine-scale temporal and spatial variability of little penguin foraging areas: implications for habitat use in relation to oceanographic conditions

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Little penguins are resident top predators foraging on small pelagic fish. Thirteen years of tracking data from Phillip Island, Australia, revealed patchy foraging areas that vary in time and space, depending on years, sub-colonies, age classes, and breeding stages. Despite oceanographic factors being associated with foraging performance over time, a fine-scale spatial analysis linking environmental factors to penguin habitats has not been conducted. Using GPS data for 422 adult penguins from 2010 to 2022, we investigated the spatiotemporal distribution variability at-sea in relation to oceanographic conditions. Using little penguin average presence and variability maps derived from kriging, we showed that little penguins did not have consistent habitat use over the years, only occasional, suggesting a high prey variability. In fact, 75% of the potentially reachable area around the colony was never visited. Spatial density models showed that these unused habitats were mainly situated in the West, or far from the colony and in deeper waters, while the use of occasional habitats depended on changes in oceanographic conditions. The detailed analysis of habitat usage offers essential guidance for studying prey distribution within the foraging zone of little penguins, using acoustic surveys conducted by an autonomous surface vehicle, the sailing drone.

Keywords: foraging, habitats, little penguin, spatial density model

*Speaker

Toward a better understanding of avian collision causes in wind farms using data from Automatic Detection Systems

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Wind energy is growing dynamically as a sustainable alternative to fossil and nuclear energy. This rapid expansion has direct negative impacts on biodiversity, for example on avifauna through collisions with turbines. A better understanding of the causes of collisions is key to improving mitigation efforts, as required by public policy in most European countries. Collisions are the result of different combinations of environmental factors that increase the sensitivity (i.e. bird presence within the risk zone) and/or exposure (i.e. frequency with which birds use the zone) of birds, varying across temporal and spatial scales. To date, potential risk factors have mostly been assessed individually, by looking at fatalities in a few species of interest and/or at a small spatio-temporal scale. Addressing the multifaceted nature of collision risk is a prerequisite for advancing our understanding of its causes. To tackle this challenge, we jointly studied several species, sites, factors and years to simultaneously assess the effect of behavioral and environmental factors on birds' sensitivity and exposure. To conduct such a global analysis, we used, for the first time, data from 14 wind farms in Europe, recorded between 2018 and 2023 by Automatic Detection Systems (ADS). These sophisticated systems use 2D or 3D optics to detect, identify and monitor birds in the vicinity of turbines. Regarding birds' sensitivity, results show that birds come closer and spend more time in the risk zone when rotor speed is low. A possible explanation is that some bird species have a better visual perception of the rotary motion at high speeds than low speeds. Sensitivity does not only depend on factors related to the birds' visual perception of wind turbines, but also on the birds' behavior. Birds are particularly sensitive and exposed during the first hours of daylight and in summer. Large species and/or species with a soaring flight spend more time flying within the risk zone. Regarding birds' exposure, ADS detected more birds at low temperatures, mean humidity, low nebulosity and high visibility. ADS also detected more birds in early spring and autumn, although birds' sensitivity was higher during summer. This last result highlights the importance of considering both drivers of risk when examining the impact of collision risk. To date, very few studies have evaluated ADS data other than to assess system performance. Our results show that this non-invasive approach can be a promising alternative to telemetry-data and traditional bird counting methods when studying diurnal bird behavior. They provide new insights into bird behavior in anthropic environments that are valuable to biodiversity stakeholders in bridging the gap between wind farm productivity and mitigation efforts.

*Speaker

Keywords: bird fatality, collision risk, windfarm, detection systems, flight behaviour

Intrinsic and extrinsic factors affecting foraging behaviour of breeding Mediterranean gulls

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During foraging, wild animals negotiate information with the surrounding environment, adopting specific behaviours to maintain an overall positive energy budget. To do so, generalist species exhibit a plastic foraging behaviour including flexible diet and habitat use, affected by both intrinsic (e.g. internal) and extrinsic (e.g. environmental) drivers. The Mediterranean Gull *Ichthyaetus melanocephalus* is a generalist feeder that can forage both at sea and on land during breeding. We investigated the drivers of choosing marine vs. land foraging by GPS tracking 20 breeding individuals across more than 1300 foraging trips. The average proportion of GPS fixes at sea per trip was 13%. Overall, birds foraged at sea more during chick-rearing compared to incubation stage, and males were more prone to face at sea trips than females. Both weather conditions and timing were found to be key drivers for foraging habitat choice, with at-sea foraging being more likely during late morning, under conditions of low precipitation, minimal wave activity, and at intermediate wind speeds. Our results highlight that the habitat foraging choice of this species depends on the interplay between both extrinsic and intrinsic factors and provide a novel insight into the fine-scale foraging movements of a generalist feeder.

Keywords: GPS tracking, Generalist foraging, Habitat use, Breeding ecology, *Ichthyaetus melanocephalus*

*Speaker

Reproductive excursions as an alternative mechanism for inbreeding avoidance in female roe deer (*Capreolus capreolus*)

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Reproductive excursions refer to short, occasional movements outside the usual home range performed for mating purposes. This behaviour has been described in several species of birds, such as the common yellowthroat or the hooded warbler, but also in large herbivores. For instance, around half of female roe deer (*Capreolus capreolus*) perform excursions during the rutting season, often travelling further than the limits of the territory of the resident male. It has been suggested that this behaviour could be linked to inbreeding avoidance, potentially reducing the likelihood of females mating with close relatives. This would be especially true for philopatric females since males have a strong spatial fidelity and hold the same territory throughout their life. However, this hypothesis remains unconfirmed.

To investigate this phenomenon, we used GPS data from 90 juvenile females from a long-term monitored population of roe deer in the South of France. Individual females were caught and GPS-monitored from their first winter to the end of the rutting season, which lasts approximately from mid-July to the end of August. Natal dispersal usually occurring between March and May, when the individual is around one year old, the females were classified as philopatric or dispersers based on their space use stability. Then, their spatial behaviour during the rutting season was analysed to identify excursions. An excursion was defined as a trip outside the usual home range, estimated with an 80% fixed-kernel method. Reproductive excursions should take up a significant portion of oestrus duration, typically lasting 24h to 36h in this monestrous species. Therefore, we only considered trips which lasted a minimum of 12 hours. To test our hypothesis, we compared the probability of performing an excursion between philopatric and disperser primiparous females.

Because the analyses are not finalised at this time, the first results will be presented during this congress. According to the inbreeding avoidance hypothesis, we expected that philopatric females should be more likely to engage in reproductive excursions. Indeed, compared to females that dispersed from their natal home range, they are more at risk of mating with a close relative. An alternative hypothesis is that females perform excursions as a way to exercise mate choice in a larger sense.

Keywords: sexual selection, mate choice, GPS telemetry, dispersal

*Speaker

Effects of GPS devices on little auk parental behaviour

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Recognizing foraging performance of seabird parents has long been a challenge due to remoteness of the foraging areas. Modern technology, with global positioning system (GPS) devices, now enables to follow even small seabirds out on their foraging trips. Growing number of studies are demonstrating, however, that individuals equipped with loggers may increase their foraging duration and/or increase the number of feedings, which may affect chick growth rate and/or survival. In this study, we attached GPS devices to a breeding small Arctic seabird, the little auk (*Alle alle*), to examine birds foraging performance (locations/diving). Simultaneously, we set up cameras to record colony presence and behaviour of tagged individuals and their breeding partner. We also recorded a control group (with none of the parents being tagged). We aimed to investigate how attached loggers affect individuals' behaviour and how partners of tagged individuals respond to such an impairment. We found that individuals with GPS device fed their chicks on average less frequently and their foraging trips were much longer than in the control group. Moreover, there was a difference in the number of feeds between the partners of tracked individual and the control group. Although chicks of the tagged pairs developed in quite similar rate compared to the control group (with no difference in survival rate), our results indicate that devices do affect not only behaviour of the tagged individuals but also its partner.

Keywords: Foraging, Behaviour, Tracking, Seabirds

*Speaker

Searching for a bit of peace and quiet: dispersal, settlement, and fitness of a top avian predator in multi-use forests

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During dispersal, organisms may gather information to judge the suitability and quality of a potential territory to settle in. This information may be derived from direct experience, or from the presence and productivity of conspecifics, which can be gathered with prospecting behaviour. However, this information may be unreliable, due to seasonal changes in conditions forming temporal ecological traps and maladaptive habitat selection.

The reintroduction of the northern goshawk, *Accipiter gentilis*, in the north of the UK has provided an opportunity to explore which factors are driving the dispersal behaviour of a still expanding population within a highly dynamic landscape. Goshawks typically favour areas in closed canopy forests with low disturbance, however, such habitat is becoming scarcer due to the prevailing age structure of trees in Scotland and the increasing demand for recreational access post-covid. Furthermore, forestry operations (felling and thinning) outside the breeding season can displace breeding pairs, which may lead to breeding dispersal to less suitable areas if high-quality, alternative sites are limited.

Using a combination of GPS data from over 50 tagged goshawk fledglings and long-term monitoring records, I will utilize hidden Markov models to identify different behavioural states during dispersal, determine key movement characteristics and discern the types of information goshawks are potentially gleaned from their environment to then infer how they may respond to changes in land use within the commercial forestry sector.

Keywords: hidden markov models, dispersal, northern goshawk, movement ecology, forestry, land use, management, gps

*Speaker

Intraseasonal variations in the spatial behaviour of an Arctic predator

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Background: In highly constrained ecosystems such as in the Arctic, animals must constantly adjust their movements to cope with the highly versatile environmental conditions. However, to date most studies have focused on coarse-scale, interseasonal differences in spatial behaviour, while intraseasonal dynamics are much less described.

Methods: To fill this knowledge gap, we studied the movement patterns of an Arctic predator, the arctic fox (*Vulpes lagopus*) at the intraseasonal scale. To unravel temporal patterns in space use and movement metrics, we used GPS data collected on 20 individual foxes between 2017-2023 in North-East Greenland.

Results: We showed that full and core home range sizes (estimated by means of Autocorrelated Kernel Density Estimates), distance travelled and proportion of active time stayed constant throughout the summer. Conversely, travelling speed showed intraseasonal variations. This metric had a hump-shaped distribution, peaking in mid-July, with males and non-breeding foxes moving faster. Site-specific patterns were also identified, with foxes having smaller territories in the two most productive sites.

Conclusion: Our study provides novel insights into how predators adjust their space use and behaviour to intraseasonal variations in environmental conditions. Specifically, we show that different movement metrics show different intraseasonal patterns. We also underline the importance of considering small spatiotemporal scales to fully understand predators' spatial behaviour.

Keywords: Autocorrelated Kernel Density Estimate, GPS telemetry, Greenland, home range, Movement ecology, Spatiotemporal patterns, *Vulpes lagopus*

*Speaker

Innovative Use of Depth Data to Estimate Energy Intake and Expenditure in Adélie Penguins

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Energy governs species' life histories and pace of living, requiring individuals to make trade-offs. However, measuring energetic parameters in the wild is challenging, often resulting in data collected from heterogeneous sources. This complicates comprehensive analysis and hampers transferability within and across case studies. We present a novel framework, combining information obtained from eco-physiology and bio-logging techniques, to estimate both energy expended and acquired on 48 Adélie penguins (*Pygoscelis adeliae*) during the chick-rearing stage. We employ the machine learning algorithm random forest (RF) to predict accelerometry-estimated foraging behaviour using depth data (our proxy for energy acquisition). We also build a time-activity model calibrated with doubly labelled water data to estimate energy expenditure.

Using depth-derived time spent diving and amount of vertical movement in the sub-surface phase, we accurately predict energy expenditure ($R^2 = 0.70$). Movement metrics derived from depth data modelled with the RF algorithm were able to accurately (accuracy = 0.82) detect the same foraging behaviour predicted from accelerometry. The RF more accurately predicted accelerometry-estimated time spent foraging ($R^2 = 0.81$) compared to historical proxies like number of undulations ($R^2 = 0.51$) or dive bottom duration ($R^2 = 0.31$).

The proposed framework is accurate, reliable and simple to implement, enabling to couple energy intake and expenditure, which is crucial to further assess individual trade-offs. We provide universal guidelines for predicting these parameters based on widely used bio-logging technology in marine species. Our work allows us to revisit historical data, to study how long-term environmental changes affect animals' energetics.

Keywords: Foraging activity, time, depth recorders, energy expenditure, diving behaviour, marine predator, machine learning

*Speaker



BEHAVIOURAL ECOLOGY

Speaker

ALEX JORDAN

Independent Research Group Leader, The Max Planck
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**Diving into Darwin's Dreamponds to understand how
behaviour evolves**

Front-line defences against avian brood parasitism in a poorly studied cuckoo host: the European stonechat

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Coevolutionary arms race between avian brood parasites and their hosts leads to the evolution of defences and counter-defences aimed to maximize the efficiency of parasitism or decrease its costs. Front-line defences include a set of antiparasitic strategies to prevent the parasite from laying its egg at the host nest. Despite their potential importance as an anti-parasitic defence, front-line defences have received little attention in most brood parasite-host systems. In this experimental study, we investigated the existence of front-line defences in the European stonechat (*Saxicola rubicola*), one of the main hosts of the common cuckoo (*Cuculus canorus*) in Sierra Nevada (Spain). Previous studies have shown that stonechats do not reject parasite eggs, yet there is little information about the host response to brood parasite presence (increased risk of parasitism). We assessed the level of response (no response, alarm calls, mobbing and attack) of stonechats to parasite presence by exposing them to plaster models of wood pigeon (*Columba palumbus*) as a non-threatened control, sparrowhawks (*Accipiter nisus*) as a threatened control and cuckoos, during the laying stage. We found that stonechats reacted to the sparrowhawk with alarm calls, while they showed no clear reaction towards cuckoo or wood pigeon models. This suggests that stonechats might not consider the cuckoo as a threat, probably because of their recent coevolutionary history, although more research is needed to fully understand the apparent lack of response of stonechats to cuckoo presence.

Keywords: Brood parasitism, Front, Line defences, Common cuckoo, Stonechats

*Speaker

Is endoparasite infection in feral cattle modulated by social structure and behaviors?

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Endoparasite infections in ruminant populations are unevenly distributed, with 20% of the group members typically shedding around 80% of the parasites. Those individuals with more shedding may have higher susceptibility or greater exposure to endoparasites. However, how this relates to social behavior and herd structure is largely unknown. This study, on a unique feral crossbreed of *Bos taurus* and *Bos indicus* in Hong Kong, aimed to characterize high-shedding individuals within free-roaming herds.

We sampled 95 individuals (36 males, 59 females) from three herds over two consecutive seasons. We collected freshly voided feces from each individual and utilized McMaster's technique to identify and count nematode eggs, cestode eggs and protozoa oocysts. Social interactions were scored using all occurrence sampling and converted into individual rates based on number of observed hours per individual. We built the social hierarchy using dominance interactions, from which we obtained Elo-scores for each individuals. Social network centrality scores were obtained for each individual based on the number of grooming partners and strength of their nodes in allogrooming interactions.

In these three Hong Kong cattle herds, 10.5% to 26.31% (mean=17.17, SD=4.67) of individuals shed 80% of the herd's endoparasite eggs and oocysts. This was unrelated to the social structure of the group, with neither hierarchy's steepness (LMM, $p=0.51$) nor linearity (LMM, $p=0.86$) influencing the number of high-shedding individuals within a herd. High-shedding individuals were more involved in allogrooming (GLMM, $p=0.01$), but less in other affiliative interactions (GLMM, $p=0.05$). Sex (GLMM, $p=0.92$), dominance rank (GLMM, $p=0.48$), and centrality within the allogrooming social network (GLMM, $p=0.42$) did not identify these individuals, indicating that infections are related to social behaviors but not social preferences. Further analysis unearthed that high-shedding individuals performed more allogrooming (GLMM, $p=0.001$), but they received allogrooming (GLMM, $p=0.79$) and affiliation (GLMM, $p=0.94$) similarly to those that shed less.

Our results show a relationship between social behavior and endoparasite infections, regardless of social structure. Across all herds, we found that a small portion of the group members shed

*Speaker

most of the endoparasites, and these individuals performed more allogrooming, independent of their position in the social network. While social behaviors reflect endoparasite infection, they were not related to social preferences in these feral cattle. Our results may reflect the higher likeliness of ingesting parasites during allogrooming events, which has been demonstrated in rats and primates, but has been poorly explored in large ruminants. In parallel, highly infected individuals might be performing more allogrooming for their own benefits, such as mineral ingestion or social trading to obtain better access to resources and protection for infection. We suggest that targeted interventions for endoparasite control should consider social behaviors, particularly allogrooming, to identify high-shedding individuals.

Keywords: allogrooming, affiliation, dominance, social network

Repeated shifts in sensory weighting reflect patterns of neural investment and ecological divergence in *Heliconius* butterflies.

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Combining information across sensory modalities enables animals to orchestrate a wide range of complex behaviours. However, the relative importance animals place on one sensory modality over another is likely shaped by natural selection to meet the needs of the local sensory environment. In closely related species, divergence in sensory brain regions may enable behavioural changes, potentially contributing to local adaptation and speciation. For example, sister species *Heliconius erato* and *H. himera* are found in parapatry across an elevational gradient, exhibit divergent sensory brain regions and accompanying differences in sensory weighting between vision and olfaction. If such behavioural shifts are adaptive, a similar change in sensory weighting may occur in another species pair *Heliconius cydno* and *H. melpomene* which are isolated across a comparable environmental gradient from closed forest canopy to open forest edge. Notably, these species show a similar pattern of neural divergence associated with adaptations to contrasting sensory niches. Here, we investigate how *H. cydno* and *H. melpomene*, prioritize visual and olfactory information in a foraging experiment. We trained butterflies to associate a combination of visual and olfactory cues to a food reward and then presented the stimuli in conflict the rewarded colour combined with the unrewarded odour and *vice versa*. Our results reveal a significant divergence in sensory weighting, with *H. cydno* emphasizing visual cues over olfactory cues, while *H. melpomene* prioritizes olfaction. These differences align with their different investments in visual perception in their eyes and brains, adapted to contrasting sensory niches. Overall, our findings underscore how the sensory environment can drive divergence in brain composition, contributing to behavioural differences such as the weighting of sensory information even at early stages of species divergence.

Keywords: Multimodal, Sensory weighing, vision, olfaction, learning, *Heliconius*

*Speaker

How to cope with thermal stochasticity? Foraging strategies and underlying energetic requirements of thermal stress.

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Climate change is frequently conceived merely as a gradual rise in average temperatures, yet it also manifests through increased thermal stochasticity and the occurrence of extreme climatic events. The impacts of such unpredictable fluctuations on organisms remain largely unexplored, limiting our understanding of the ecological, behavioural and physiological implications of such stress. In particular, the sensitivity of foraging strategies could have large consequences across communities *via* trophic interactions. In this context, we investigated the effect of thermal stochasticity on an endangered freshwater fish, the Rhône apron (*Zingel asper*). Ninety-two aprons were divided into four groups. Three were acclimated to constant temperatures (with minimum, mean, and maximum values of 13°C, 18°C, and 23°C, respectively) while the fourth group experienced a stochastic thermal profile oscillating randomly between 13°C and 23°C, centered on a mean temperature of 18°C. We predicted a decline in foraging activity associated with increased energetic cost. We assessed this response by measuring functional response, spontaneous activity as the level of spatial occupation in the presence of preys, and standard metabolic rate (SMR) resulting from physiological stress due to disruption of the acclimation process. Under stable temperatures conditions, predation decreased with rising temperature, conversely to energetic expenditure. Under stochastic conditions, feeding competitiveness exhibited a marked decline but metabolic costs mirrored those of the group acclimated to 18°C. Differences in metabolic or foraging responses between thermal treatments were not reflected in fish activity levels. These findings highlight the relevance of assessing the multiscale effects of environmental variability in studying climate change. Furthermore, at ecosystems scale, the alteration of foraging behaviour suggests important consequences of stochasticity on trophic networks. At the organism's level, these results suggest that stress might alter the commonly presumed mechanistic link between underlying energetic needs and resource acquisition, and the mismatch between physiological requirements and foraging behaviour questions the persistence of species in the era of global change. Finally, the complexity of the responses to such stress raises questions about a potential misalignment of thermal optima across different biological traits.

Keywords: thermal stochasticity, foraging, metabolic rate, ectotherm, freshwater fish

*Speaker

Two is too many: does being a single parent reduce the risk of predation?

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Offspring predation is one of the main drivers of reproductive failure in species reproducing in nest, burrow or den. This selective pressure promotes the evolution of passive defense strategies based on nest concealment or limited activity at nest. A frequently cited verbal model proposed by Alexander Skutch (1949) predict that parental activity at nest should decrease as a response to an increasing predation risk. This has then been repeatedly invoked to explain the evolution of uniparental care strategy. The rationale is that a nest of biparental species is more conspicuous than the one of a uniparental species because regular change-over between the parents induce more activity (successive take-off and arrival, vocal display during nest relief). The biparental nest would thus be more easily spotted by predators. Surprisingly, this verbal model has never been rigorously tested. Our aim was to assess the idea that predation pressure can favour the evolution of uniparental strategy over the biparental one. In a wide range of parameters, despite higher instantaneous risk of nest detection, biparental care strategy is a sensible strategy to mitigate predation risk because it allows for longer recess and less frequent movement at nest. Even extraordinarily conspicuous nest activity in the biparental strategy is not sufficient to explain the evolution of the uniparental strategy. We have also calibrated the model's parameter (frequency of nest departure, arrival and change-over) on eight shorebird species from a genus of Arctic ground nesting birds known for their diversity of parental care strategies. All uniparental species were predicted to be biparental under the sole assumption of nest conspicuousness. This result illustrate that the predation risk alone is not a sufficient driver for the evolution of uniparental care strategy in these species. More generally, without completely dismissing this hypothesis in some ecological contexts, we advocate greater caution when invoking the Skutch hypothesis to justify the evolution of uniparental over biparental care.

Keywords: parental care, nest predation, Skutch hypothesis, uniparental strategy, biparental strategy

*Speaker

What can baboons tell us about the evolution of language? A multi-modal approach to intentionality and flexibility in animal communication

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Intentionality and flexibility have been claimed to be hallmarks of human language but are also found in great ape gestural communication, leading to the hypothesis that some cognitive traits needed for human language evolved in the great ape lineage. However, there is preliminary evidence of intentionality and flexibility in monkey gestures and in other modalities of communication. These traits may thus be present in a broader range of systems, but the identification and coding of communicative signals is time-consuming, preventing comprehensive wider investigation. Furthermore, studies outside great apes are mainly in captivity and use different definitions of intentionality and flexibility, impeding cross-species and cross-modality comparisons. As a result, understanding the origin of intentional and flexible communication is difficult with the available evidence. This study takes a novel approach by implementing machine learning tools to automatise extraction of wild chacma baboon (*Papio ursinus*) multi-modal (gestural and vocal) communication data from videos to investigate its intentionality and flexibility. The behavioural markers that will be used to test intentionality are associated to two conditions that have to be met for communication to be considered intentional. The first condition is that an individual that communicates intentionally needs to have volitional control over their communication. An example of a behavioural marker that would be indicative of the first condition being met would be baboons consistently using contact or audible gestures rather than visual ones when the recipient is not paying attention to them, and thus unable to perceive purely visual signals. The second condition for intentional communication is that emitters need to aim to achieve a goal with their communication, which is normally a change in the behaviour of the recipient (i.e. a response from the recipient). An example of markers indicative of the second condition being fulfilled would be baboons consistently signalling for longer periods of time when they receive no response from the recipient or an incongruent one, since this would suggest they are using the signal to achieve a goal (i.e. a congruent response). Flexibility is investigated through the links between signals and responses or meanings. Note that the responses are indicative of the meaning of a signal but are not the meaning themselves. Instead, the meaning is the broader information that the signal carries. Flexible communication systems are those in which each signal can have multiple meanings and the same meaning

*Speaker

can be expressed through different signals; in great apes, the interpersonal (sex and age) and behavioural contexts disambiguate the meaning of signals. To test intentionality and flexibility beyond great ape gestural communication we collected 580 hours of video footage of 131 focal individuals of all age and sex classes from two groups of wild chacma baboons at the Tsaobis Baboon Project (Namibia). The present study uses wild chacma baboons as a model to develop techniques and a framework to facilitate cross-species and cross-modality studies of intentional and flexible communication and to better understand whether these cognitive traits suggested to be prerequisites for language evolution emerged before the great ape lineage.

Keywords: Communication, Intentionality, Flexibility, Language evolution, Primates, Machine learning, Gestures, Multimodal communication

Multiple factors affect the evolution of song diversity and composition in weaverbirds

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Within an evolutionary perspective, signals are expected to be shaped by both sexual and non-sexual social interactions, and to be constrained by living habitats and phylogenetic history, but there is a debate on the relative importance of these factors. In general, while birds' songs exhibit variations in syllable diversity, they also demonstrate consistencies in syllable composition, thus sharing specific syllable structures across species. Song diversity, notably, has been explored almost exclusively through the lens of sexual selection, providing mixed results. Here, we assessed the potential role of sexual selection, social organization, habitat characteristics, and phylogenetic history in driving the evolution of song diversity and composition's similarity in weaverbirds (Aves: Ploceidae). We used comparative methods to quantify the relationship between within-song repertoire size and song composition with respect to mating system, colony size, habitat openness, and phylogenetic proximity. As expected, species from larger colonies presented more song diversity and had similar song composition, however polygamous species presented less song diversity than monogamous species. Our results also suggest that sociality is a stronger driver of song diversity and composition than mating system, and reinforce the idea that it is important to have a multifaceted approach when studying bird song evolution.

Keywords: Birdsong, repertoire size, acoustic feature, sexual selection, sociality, comparative analysis, weaverbirds

*Speaker

Mesotocin influences social behavior among unrelated Siberian jays

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During the last decades there is more and more evidence for neuropeptides, such as mesotocin (avian homologue of oxytocin; MT *herein*), playing an essential role in governing social interactions and behavioral processes, such as parental care, affiliation, and mating. However, most studies linking MT concentrations in birds and their behavioral governance used controlled captive experiments and invasive methods, providing little insights about the effects of MT in natural conditions. Here, we first analyzed plasma samples from 232 wild Siberian jays (*Perisoreus infaustus*) caught in Sweden. We then also validated our observational study by experimentally administering MT intranasally in 48 individuals. For both approaches, we added behavioral observations. In dominant individuals (i.e. breeders) MT levels correlated negatively with the expression of aggressive behavior, while in subordinates MT correlates negatively with the received aggressive behaviors. We were able to replicate these findings with the experimental MT manipulation. Overall, these findings confirm the central role of MT has in shaping social behavior and affiliation in birds.

Keywords: Mesotocin, Avian oxytocin, neuropeptide, Corvid, social behavior

*Speaker

When warning comes at a cost: determinants of hissing sounds and associated water loss in a venomous snake

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Predation risk is a significant selective pressure. To minimize predation, prey species have developed a range of defensive behavior including warning signals. Defensive strategies are variable among species in relation with habitat, or predator type. They can also vary within species for example among populations or among sexes. Better understanding this diversity and sources of variation is a major question in ecology. Although advantageous, these defensive warning may also induce significant costs to the emitter. In this study, we investigated hissing behaviors which is the most widespread warning sound in vertebrates involving respiratory apparatus. We examined the determinant of hissing as well as physiological costs in a large venomous snake, the sand viper (*Vipera ammodytes*). We first used a neutral arena and applied standardized stimulation to measure the acoustic characteristics of warning hisses. Then, we used open flow respirometry to quantify changes in respiratory gas exchanges (oxygen consumption and evaporative water loss) during defensive responses. We first demonstrate significant sex difference in behaviors, with males being more likely to engage in sound warnings. Acoustic analyses reveal that expirations generated the strongest signals when compared to inhalation but did not differ between sexes. Second, we found that defensive hissing strongly increased metabolic rate and evaporative water loss, and this response was more pronounced in males. Metabolic and water loss were closely related to the duration of hisses. Overall, our results indicate that respiratory-based warning sounds induce significant physiological costs and may alter water balance. The higher responsiveness in males likely reflects a contrasted ecology (reproductive nomadism, higher dispersion) and enhanced risk exposure. Ongoing climatic changes and drought events may interfere with the expression of defensive behavior and alter prey-predators relationship.

Keywords: defense, predation risk, trade off, hydroregulation

*Speaker

Awake and hungry: Artificial light at night alters the behaviour of nestlings and parents collared flycatchers

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Daily biological rhythms across taxa are primarily driven by light cue. The introduction of artificial light at night (ALAN) induced by increasing urbanization can significantly alter behaviour, with potentially negative consequences for wildlife worldwide. However, so far, most of studies have focused on the effects of light pollution in laboratory and captive animals, thus, our understanding of the direct effects of ALAN on wild population is surprisingly limited. In particular, night-time lighting poses a threat to circadian activity patterns and in consequence can affect fitness and development of animals. We experimentally introduced ALAN to nest boxes on the island of Gotland, Sweden occupied by collared flycatchers (*Ficedula albicollis*), birds affected by ALAN in real life during their migrations. To compare the behaviour of parents and offspring exposed to ALAN with control ones (in natural dark conditions), we video recorded the activity in the nests, invariably starting at day 8 after hatching, for 24h. Our analysis showed that nestlings exposed to ALAN were more active overall (movements within nest cup) and begged for food more at night compared to the control ones. Additionally, parents of ALAN broods accelerated the onset of their feeding activity in the morning and ceased to feed later in the evening compared to control parents. We will also present changes in other parental behaviours such as feeding rate and time spent in the nest. These results point to the underlying behavioural mechanism allowing to comprehend the impact of ALAN on early life history traits generated by the daily activity disruptions.

Keywords: Artificial light at night, behaviour, begging, circadian rhythm, bird, nestling

*Speaker

Talking to the elephants: Do the acoustic parameters of keepers' voices change according the context?

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Humans and non-human species are linked to special relationship for centuries. It is particularly true when we talk about the bond between humans and house pets that are often considered as family members. It has been also established that humans use a Pet-directed speech (PDS) with similarities shared with Infant-directed speech (IDS). The use of PDS by humans during repeated interactions with their pets could lead to the establishment of a specific bond and may influence the way animals will react. Moreover, there is a growing interest in the topic of human interaction and relationship with non-human animals, to a broader range of animal species such as farm animals particularly with regard of population welfare and management. However, it exists a lot of different settings where human interaction with non-human animals can occur as it is the case in zoos and only few studies explored the relationship between our species and wild origin non-domesticated animals, such as elephants in this context. Elephants have long been used as working animals whilst at the same time being revered and are now ambassadors for conservation in zoos. In captivity such as in zoos, elephants interact daily and closely with the keepers who provide them with an appropriate and reliable source of information on their environment and feeding resources and the human-animal relationship could have an effect on their welfare. As far as elephants are concerned, it has been recognized that they are able to distinguish between humans on the basis of their ethnic origin, sex and age using olfactory cues and vocal cues. Thus, recognition of keepers seems important for captive elephants and interaction quality may impact the learning performance or at least draw the attention, as shown in other species. Different communication modalities are used by the carers to interact with the elephants, including vocal modality. In addition, keepers may interact in an informal way with elephants all along the day saying hello, ask how they are feeling today and so on. Thus, vocal signals seem to be important in the relationship between keepers and elephants as it is for the interaction between humans and pets. To fulfill the gap around the inter-species relationship and communication systems between humans and animals, we focused our research on the acoustic parameters of the keepers' voices when they speak to captive Asian elephants in three European zoos. The aim was to compare the acoustic features of the voice when keepers addressed elephants vs. an adult human. We studied keepers' vocal interaction with elephants across two main conditions: (a) standardized condition (specific sentences) and (b) spontaneous conditions (including random speech and surnames). Results demonstrated that zookeepers, regardless of gender and interaction conditions, would address elephants using a PDS-type vocal register (high pitch, wide fluctuation in intonation, etc.). This highlight the specific relationship that both zookeepers and elephants share.

*Speaker

Keywords: Elephant directed speech, Human Animal relationship, Elephants

First results from telemetric monitoring of Yellow-bellied toad (*Bombina variegata*) in forest landscape

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Amphibians are among the most endangered taxa in the world with 41% of threatened species. In France (metropolitan) almost a quarter are registered in the threatened species list. The Yellow-bellied toad (*Bombina variegata*) isn't an exception to these trends on amphibians. It's considered "vulnerable" in France and it's one of the species with the highest protection status.

The target population at the edge of the specie's north-western range, which is also the last of the Ardennes department, is studied since the early 2000s. The capture-recapture monitoring between 2008 and 2023 showed a 95% population decline in 15 years, with only about twenty remaining adults last years.

Based on this observation, a supplementation program was envisaged. However, this type of project requires prior studies on habitat, biology, eco-ethology (...) of the species in its environment to extend knowledge as much as possible for the program to be effective. In the case of Yellow-bellied toad, there are lacking knowledge on its utilization of aquatic and terrestrial habitats during and outside the breeding season.

Several methods are available to study habitat use by a species. The one that provides the most data and the most precision is GPS tracking. For now, this method can only be used on animals that can support the weight of the equipment and is therefore unsuitable for small amphibians. So, the radiotracking with very light transmitters is a good way to obtain information on localization of individuals and gives an idea of habitat use at a given moment.

External VHF transmitters were initially fitted to individuals between September and October 2023, with the aim to describe the type of lair used by the Yellow-bellied toad for overwintering. This monitoring enabled us to obtain initial results on the temporary terrestrial hiding places used, but not on overwintering sites because early autumn was very summer-like. These results will be refined with a new monitoring in autumn 2024. This first phase has above all enabled us to adapt the method and define limit points for outfitting the individuals.

Another survey is also planned for spring-summer 2024. The first results will be presented at the conference. We believe we'll be able to demonstrate that the Yellow-bellied toad regularly uses terrestrial hiding places even during the breeding season and especially in very dry weather. We would also like to observe the movement patterns of individuals, if possible distinguishing males

*Speaker

and females, during breeding and egg-laying episodes. Finally, weather permitting, we would like to gain a better understanding of the use of alternative aquatic and terrestrial habitats during periods of severe drought, when the ponds normally used are dry.

Keywords: Yellow bellied toad, radiotracking, habitat use

Sensory drive in the era of artificial intelligence: new tools for new experiments

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Sensory drive describes how animal communication signals and preferences evolve as adaptations to local environments. Classical approaches to testing this hypothesis focus on preference for one component or feature of a signal, such as colour. We use artificial intelligence (AI) to overcome the limits of a one-trait paradigm. With three unique studies conducted in *Etheostoma*, a diverse genus of freshwater fish, we demonstrate (1) how AI can generate new holistic phenotypes without focusing on a single feature, (2) how AI algorithms can be used to determine how similar two stimuli appear to the eye of *Etheostoma*, and (3) how artificial neural networks can represent the brain as an agent of selection. These studies represent three different applications of AI that test predictions of sensory drive and "processing bias," asking whether sexual signals in *Etheostoma* mimic the underlying patterns of their habitat and whether the fish prefer these patterns. We illustrate how AI can be leveraged to test predictions of sensory drive further while overcoming some of its limitations, here the one-trait approach, thereby demonstrating its generalisability.

Keywords: sensory drive, artificial intelligence, *Etheostoma*, sexual selection

*Speaker

Why and how to study birds' musicality : creation of a music for birds

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Music is not only an art form, but also a means of communicating information and emotions. In animals, the effects of music on behaviour remain largely unknown. However, researchers have been able to show a certain sensitivity to music in different species. Several components are necessary to be able to speak of musicality: the creation of periodic motor patterns, the perception of the beat, and the production of movement to this rhythm. In chimpanzees, however, the data show that at least the last component is missing. It is interesting to look at musicality in other animals that seem to have these three components, such as songbirds belonging to the oscine group and psittacines. Musicality is therefore a trait that is more present in birds than in the great apes, which are phylogenetically closer to us, suggesting an evolutionary origin and a convergent one at that, between different groups. Moreover, if birds are sensitive to music, then it could, as in humans, have effects on their behaviour, and more specifically on social interaction. By promoting the cohesion of social groups, these effects could represent an adaptive advantage that would explain the evolution of musicality in both groups. It is this hypothesis that we will examine here by studying three bird species: canaries (*Serinus canaria*) and zebra finches (*Taeniopygia guttata*), which are songbirds of the order Oscines, and calopsite parakeets (*Nymphicus hollandicus*). While we have seen that music has a significant impact on human social behaviour, we now need to determine whether the same is true for other animals, in this case birds. We are therefore going to carry out several behavioural observation experiments under different musical and social conditions. Until now, the music used for animals has been music created for human and human's studies. However, perceptive capacities and sensitivities vary from one species to another. It was important to use stimuli adapted to our species. To achieve this, we have created music that is tailor-made for our species. The songs we created are based on the physiological properties of each species, such as heart rate, audible frequency spectrum and vocalizes ranges. This approach will enable us to investigate the phylogenetic origins of musicality and the selective pressures that led to its spread. It will also help us to better understand the proximal relationship between music and social behaviour in humans and other species, in particular by studying the conditions under which music influences interactions.

Keywords: Musicality, Evolution, Social bonding hypothesis

*Speaker

Vocal performance and territoriality in females: a field study in European robins.

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Vocal communication plays a key role in social interactions in many animal species. In songbirds, vocal signals can serve to attract sexual partners and to defend a territory against rivals. Birdsong can be an honest signal of individual quality and/or motivation, through several acoustic parameters. Indeed, birdsong is subject to vocal production limits, and birds producing songs that closely approach these limits are said to reach a high vocal performance. Studies across multiple species have shown that males can modify their vocal performance in response to a territorial intrusion by a conspecific. Vocal performance is often measured by the speed at which an individual is able to change its song frequency. However, we know very little about variation in vocal performance of females. Indeed, female birdsong used to be considered as rare and there is a historical research bias towards investigating male song. However, female song is widespread and comparing it with male song can help better understand functions of vocal signals. The European robin (*Erithacus rubecula*) provides an excellent model for studying vocal performance. After the breeding season, males and females separate and both of them establish and defend exclusive individual territories throughout winter. Territorial intrusion in this context therefore constitutes an ideal experimental condition to compare male and female song in reaction to territorial intrusion. I will present the results of an experimental field study addressing the variation of vocal performance in relation to aggressive motivation, in female and male robins. Individuals of both sexes were recorded in two contexts: during a simulated territorial intrusion (by broadcasting the playback of an unfamiliar territorial song on their territory) and in a spontaneous context (without any intruder). Similar selection pressures are thought to apply on males and females in this species during winter, as both sexes defend their territory. They are thus expected to similarly increase their vocal performance in the context of territorial intrusion. Such results could suggest that similar selection pressures apply to individuals of both sexes in this winter context, which supports the theory that oscine song outside the breeding season may have evolved under social competition, rather than sexual competition.

Keywords: Acoustic communication, female birdsong, vocal performance, European robin, playback

*Speaker

Who participates in the construction and maintenance of a common good in social species?

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Many animal species transform their physical environment by building structures, forming what is called animal architectures. These structures, ubiquitous and diverse are widespread throughout phylogeny. In social species, these structures are shared and called "common good" because all individuals using them benefit. But who take care of the commons is poorly known in non-eusocial species. To answer this question I use sociable weavers (*Philetairus socius*) in my master. Sociable weavers are small colonial cooperatively breeding passerine endemic to southern Africa. They build one of the largest nests in the animal kingdom. These nests are used by all members of the group to roost and breed throughout the year. Using ca four years of observations of nest building behavior in the wild, encompassing over 3410 communal building events by 292 individuals (120 females and 172 males) across three colonies of birds, the aim is to elucidate how sex, age and kinship influence building behavior of the communal parts of the nest. With Generalized Linear Mixed Models (GLMM), I will (i) identify who are the individuals building at least once per day of observation; (ii) explore who are the individuals building the most per day; and (iii) determine if changes in individual attributes (i.e., age, averaged relatedness to the group) is associated with changes in the individuals' building behavior. The results of this study will be presented here, and they will shed light on the potential evolutionary factors driving the evolutive of animal architecture.

Keywords: Animal architecture, Common good, Kin selection, Nest building behavior, Sexual selection, Sociality

*Speaker



ECOTOXICOLOGY & ECOPHYSIOLOGY

Speaker

OLIVIER CHASTEL

CNRS Director of Research, CEBC, ECOPHY team

**Endocrine disrupting chemicals in birds : from
physiology to demography**

Effects of mercury on mitochondrial traits and individual fitness in a wild population of European dippers (*Cinclus cinclus*)

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Mercury is both naturally present in the earth's crust and added to the environment by geogenic processes and anthropogenic activities. Its ability to travel long distances, bioaccumulate in food chains, and toxicity to individuals has inspired much research into the mechanisms and thresholds for adverse effects on individuals. Interestingly, mercury is soluble in both water and fat, rendering aquatic bird species particularly vulnerable, from a cellular level all the way to population level. For example, mitochondria are fundamental organelles in eukaryotes responsible for converting food into cellular energy which can then be used for growth in nestlings and reproduction and maintenance in adults. Mitochondria also produce reactive oxygen species (ROS) as a waste product which can lead to oxidative stress. Because published literature has suggested mercury can disrupt mitochondrial function, one hypothesis is that mercury contamination alters the mitochondrial efficiency of energy transduction, as well as increasing ROS production and oxidative stress. All together, this could account for the frequently reported negative effects in natural populations of bird species. For my PhD project, I will investigate individual variation in exposure to mercury, the consequences of exposure to mercury on fitness, and whether these fitness consequences are driven by mercury induced changes in mitochondrial function in a population of European dippers (*Cinclus cinclus*) in France. This population of dippers has been monitored from 2014 to present, with biometric data, reproductive data, and biological samples collected annually. Dippers are an excellent study species as they remain loyal to their territories each year and do not migrate, closely tying them to their aquatic habitats where they forage. I will show preliminary results on individual variation in exposure to mercury measured in feathers, indicating that mercury concentrations are highly repeatable in territories. I will also show preliminary results exploring the fitness consequences from exposure to mercury on growth, reproduction, and survival. By measuring mitochondrial traits with minimally invasive methods using red blood cells, I will gain new insights on the cascading effects of mercury on mitochondrial traits and fitness in dippers. Finally, in support of this project, I am currently conducting a meta-analysis to explore published literature for the effects of mercury and other chemical pollutants on oxidative stress in wild and experimental studies.

*Speaker

Keywords: bird, mercury, mitochondria, reactive oxygen species, reproduction, survival, growth

Inter-specific variation of pesticide effect on European wild pollinators

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Pollination is an essential ecosystem service that ensures the sustainability of wild plant communities and improves crop yields. It is estimated that insects provide pollination services worth 153 billion dollars a year worldwide and 14 billion dollars a year in the European Union (i.e. 10% of agricultural production). However, in the current context of the Anthropocene, human activities are causing a massive extinction of biodiversity across the globe, affecting many pollinators such as bees and lepidopterans (butterflies and moths). Among the causes of this decline, the use of plant protection chemicals is a major factor. However, current test standards are based mainly on a few bee species, such as the honey bee *Apis mellifera*, virtually excluding wild pollinators. Wild pollinating insects are very diverse, therefore the development of new protocols is a first essential step to assess their sensitivity to pesticides. To this end, several species of wild bees (*Bombus terrestris*, *Bombus hypnorum*, *Andrena vaga* and *Colletes hederæ*) and wild lepidopterans (*Aglais urticae*, *Macroglossum stellatarum*, *Papilio machaon*, *Saturnia pavonia*, *Maniola jurtina*) were selected to cover a large part of pollinators' taxonomic range, reflecting a wide range of morphological traits and life histories. Initially, LD50s measurements were carried out on a model species belonging to each of these groups: *Bombus terrestris* and *Aglais urticae*. By adapting these results and developing new protocols, we then tested the effect of acute and chronic exposure of all pollinator species to the main categories of pesticides (insecticide, fungicide, herbicide), alone or in mixtures, to assess and compare their sensitivity to these products at each stage of their life cycle (juvenile and adult). Measures of survival were accompanied by measures of fitness-associated morphological, behavioural and physiological traits.

Keywords: Wild pollinators, Bees, Lepidoptera, Pesticides, LD50, Survival.

*Speaker

Effects of a heatwave on cardiac mitochondrial respiration of a freshwater fish: the Rhône apron

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Nowadays, global warming is a real issue and is accompanied by an increase in extreme climate events such as heatwaves. The first to be impacted by these phenomena are ectotherms, as environmental temperature is a key driver of their body temperature that drastically influences rates of biochemical and physiological reactions, such as energy production. In aerobic conditions, cellular energy is mainly produced by mitochondria through oxidative phosphorylation. In this context, the aim of our study was to elucidate the effects of an acute thermal stress, mimicking an environmental heat wave (HW) on mitochondrial bioenergetics of fish hearts. We chose to study cardiac mitochondria as the heart plays a central role in metabolism and is greatly solicited during acute thermal stress. Indeed, it is suspected to be the first organ to fail in fish exposed to high temperatures.

To investigate this question, we had the opportunity to study an endemic and critically endangered species to the Rhône basin in France, the Rhône apron (IUCN red list). Its population decline may partly be due to the negative impacts of global warming, particularly because of the large fluctuations in environmental temperature on its metabolism.

The fish went through a heatwave, characterised by an increase of temperature from 13°C to 18°C (1°C/hour) for 5 days, followed by a decrease from 18°C to 13°C (1°C/hour) for 5 days and measures were made at different timelines; 1h, 24h and 96h during the heatwave and at the same times during the decrease. Mitochondrial respiration rate associated to phosphorylating state (ATP production, OXPPOS), basal state (without ATP production, LEAK) and uncoupled state (FCCP) were measured at 13°C and 18°C in heart homogenates for each individual using high-resolution oxygraphs (OROBOROS). Fluxes were divided by COX respiration as a proxy of mitochondrial content in the homogenates. We found that OXPPOS in complexes I + II was decreased 24 hours into the heatwave and returned to its original level 1 hour into the decrease. LEAK and uncoupled respiration (FCCP) values followed the same pattern. This can be considered as an adaptative response of the fish to acute stress and once they are acclimated to the stress, mitochondrial respiration returns to its original level. There was also an effect of

*Speaker

assay temperature; OXPHOS and LEAK respiration of complexes I + II and uncoupled respiration tended to be higher at 13°C than at 18°C, excluding the possibility of a Q10 effect and suggesting that the mitochondria of these fish are less efficient at producing energy at higher temperatures, which could partly explain their status as an endangered species.

Keywords: fish, mitochondria, oxidative phosphorylation, heart, bioenergetics, temperature, acute heat stress

Physiological determinants of individual quality in penguin species: relating on-land and at-sea performances

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Populations are now increasingly acknowledged to be constituted of individuals that can substantially differ in multiple traits, either behavioral or physiological, and consistently exhibit different fitness outcome. These differences can arise from different strategies in resolving energetic trade-offs, which depend on both intrinsic (genetic) and extrinsic (environment) conditions both affecting the physiological state of individuals. Especially, corticosterone – considered the principal hormonal mediator of allostasis – plays a central part in the resolution of such trade-offs by affecting energy allocation to different functions. Recent studies have shown a role for corticosterone in parental care in seabirds, principally via positive correlation with foraging effort and provisioning. However, higher levels of corticosterone have also been associated with increased physiological costs, for example in the form of increased oxidative stress or modification in H/L ratio.

Here, we investigated the relationship between various physiological traits, foraging performances and markers of breeding success in two colonial penguin species, the king (*Aptenodytes patagonicus*) and macaroni penguins (*Eudyptes chrysolophus*). King penguins are long distance, pelagic foragers and deep divers while macaroni penguins are smaller with moderate diving performances. The study was performed on king penguins breeding in Baie du marin colony (20,000 pairs, Crozet islands) and macaroni penguins in Cap Cotter colony (sub-colony studied:1000 pairs, Kerguelen archipelago).

Based on the corticosterone-adaptation hypothesis, we expected birds with higher endogenous corticosterone levels to also exhibit enhanced foraging effort and breeding success (chick growth and survival). We also expected "high quality" birds (*i.e.*, birds with higher breeding success) to either exhibit reduced physiological costs or to be able to cope with these costs.

Keywords: penguins, performance, individual quality, foraging, physiology

*Speaker

Radioactive contamination in the Fukushima region impacts the energetic metabolism of tree frogs

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Major nuclear accidents, such as Chernobyl (1986) and Fukushima (2011), have led to significant radioactive releases into the environment, resulting in chronic exposure over several generations for the fauna inhabiting these areas. Several studies have shown that chronic and low-dose exposure to ionizing radiation (IR) can affect the energy metabolism of various species. For example, a study on tree frogs (*Hyla orientalis*) living in contaminated areas near Chernobyl showed alterations in energy metabolism through transcriptomics analysis 30 years after the nuclear accident, a result corroborated by other studies on fish and rodents. Since metabolism plays a crucial role in allocating energy among major biological functions of the organism, such as survival, growth, reproduction, and maintenance, it is essential to assess whether these molecular signatures are reflected at the physiological level.

The objective of this study is to investigate the effects of radiocontamination in Fukushima Prefecture on the energy metabolism of a tree frog, *Dryophytes japonicus*, thirteen years after the Fukushima nuclear accident.

To achieve this, we examined in *D. japonicus* the impact of a gradient of radiocontamination on the activity of several enzymes involved in aerobic and anaerobic pathways of energy metabolism, notably citrate synthase and cytochrome c oxidase associated with aerobic metabolism, and lactate dehydrogenase linked to anaerobic metabolism. These activities were measured in the thoracic muscles and liver of male tree frogs collected during the breeding season. In the thoracic muscles, which are used extensively in male tree frogs during the breeding season to produce calls and thus attract females, the activities of citrate synthase and lactate dehydrogenase increased with the dose of ionizing radiation absorbed by the tree frogs.

This suggests an adjustment of both aerobic and anaerobic metabolic pathways to cope with the increased energy demands during the breeding season and compensate for the energy costs associated with the received dose. In the liver, an organ involved in detoxification, aerobic metabolism decreases with dose likely caused by mitochondria damage. Anaerobic metabolism is boosted to compensate for the loss of energy production. There was no significant dose-related impact on cytochrome c oxidase activity for both tissues, thus, the mitochondrial volume does

*Speaker

not appear to be affected by radiation dose.

To further explore these results, we will evaluate the ecological consequences of potential modifications in animal physiology related to the production of secondary sexual signals of the tree frogs (such as calling), which are highly energy-consuming.

Keywords: tree frog, energy metabolism, Fukushima, radioactivity

Mismatched and everchanging temperature effects on song learning in zebra finches

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Current climate change is known to increase the unpredictability of environmental conditions. The impact of variable abiotic conditions on animal fitness is still poorly understood, especially regarding mating behaviour. Songbirds are a good subject for this topic, as their singing performance can be influenced by various factors. During my PhD, I investigated the effect of temperature variability on song learning and production in captive zebra finches. Males developed in either stable or variable temperatures, and experienced a mismatch in thermal conditions between different developmental stages (i.e., pre-hatching phase, development and adulthood). I then recorded adult males to analyse their song quality and learning performance. The most important finding is that the consequences of a temperature mismatch depend on its timing. When the mismatch occurred after hatching, it had no effect on song learning, and variable temperatures had a rather positive impact on song production. On the other hand, when the mismatch happened after independence, it led to poorer copies of the father's song, and variable temperatures tended to impair song quality. Taken together, those results show the vulnerability of some cognitive traits to suboptimal conditions at particular life stages.

Keywords: zebra finch, temperature variability, mismatch, song learning, climate change

*Speaker

Who's coming home? The relationships of chick growth and telomere length with adult return probability to the natal colony in black-legged kittiwakes (*Rissa tridactyla*)

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In wild animals, individuals have heterogenous phenotypic traits, and this heterogeneity may have fitness implications and may reflect individual quality. Recent studies showed that individual quality could be quantified by the length of telomeres, the non-coding DNA sequences protecting the ends of chromosomes. Telomeres are usually shortened over time, and their shortening can be accelerated by costly life-history events and environmental stress. In adults, shorter telomeres are often associated with lower survival, lower reproductive success and thus lower individual quality. However, few studies have connected adult individual quality to the telomere length during early-life development, when telomere shortening is among the fastest in an individual's lifetime. To fill this gap, we investigated the effects of developmental conditions on the growth and telomere length of black-legged kittiwake (*Rissa tridactyla*) chicks and in turn the relationships between these chicks' traits and their return probability to the natal colony within five years. Although developmental conditions did not directly affect telomere length, we found that in broods of two, larger chicks tend to have shorter telomeres. In the contrary of many previous studies showing shorter telomeres associated with lower individual quality, we found that chicks with shorter telomeres were more likely to return to the natal colony within five years. This suggests that these chicks survived to reach their reproductive age and that shorter telomeres may reflect better development and individual quality in this species as the survival of seabirds in their first year of life is in general very low. These findings add to the evidence showing that early-life telomere dynamics are intrinsically connected with individual quality and future performance. Therefore, developmental conditions and telomere dynamics in early life are crucial factors to consider when studying how telomere length may predict the individual quality of wild animals.

Keywords: telomere, seabird, individual quality, developmental condition

*Speaker

HotKing: a study of thermal stress in king penguins breeding on land.

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Polar and subpolar endotherms, adapted to cold climates, could be particularly sensitive to heat stress in a context of global warming. Indeed, species physiologically adapted to cold environments have a narrow thermoneutral zone, and specific reproductive constraints can limit the use of thermos-dissipative behaviors. During reproduction on land, king penguins are bound to a small territory to incubate and protect their egg or chick, without being able to access water for several days to several weeks. The study of king penguins during reproduction on land in Crozet archipelago allowed to highlight complex relationships between behavioral indicators of heat stress (panting, wing stretching, exposure of the brooding pouch), body temperature and a panel of 4 climatic parameters (air temperature, solar radiation, wind speed and relative humidity), depending on sex and reproductive stage. Interactions between climatic parameters, as for example high solar radiation combined with low wind speed, predicted heat stress occurrence better than air temperature alone. Our results highlight the necessity to go beyond the use of the sole Tair parameter to model heat stress in wild animals. In addition, we explored the effect of heat stress on other non-thermoregulatory behaviors, such as aggressiveness towards conspecifics, which increased with air temperature during incubation, and could exacerbate the deleterious effects of heat stress. Ultimately, the penguins' response to heat could have important consequences in terms of population dynamics (egg/chick abandonment), especially if heat waves increase in frequency and intensity in the future.

Keywords: Heat stress, Polar birds, Thermoregulation, Climate change

*Speaker

Sub-clinical effects of blood parasite co-infections in Namibian cheetahs (*Acinonyx jubatus*)

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Co-infection by parasites is ubiquitous in wild animal populations. Pathogen (co-)infections can affect individual health and fitness and have the potential to influence population dynamics. However, these infections often remain sub-clinical, and their effects are therefore unknown or overlooked. To better understand the potential underlying costs and effects associated with long-term co-infections, we characterized inflammatory and biochemical parameters in free-ranging Namibian cheetahs (*Acinonyx jubatus*) in a long-term, cross-sectional study (n = 194). This cheetah population harbours a consistent pool of co-infecting vector-borne pathogens (VBP), including bacteria (*Rickettsia* spp., Anaplasmataceae), protozoans (*Babesia* spp., *Hepatozoon* sp.) and filaria (in particular *Acanthocheilonema* spp.). The inflammatory response was characterized by the levels of proinflammatory cytokines (IL-1 β and TNF- α), an acute phase protein (SAA), as well as markers of macrophage activity (neopterin) and oxidative stress (reactive oxidative metabolites and antioxidant capacity) in serum or plasma. Serum biochemical markers were chosen to cover liver and kidney function and muscle health (AP, ALT, GLDH, GGT, total bilirubin, bile acids, AST, CK, LDH, total protein, urea, creatinine). We investigated the relationships between the co-infecting pathogens, inflammatory and biochemical profiles, life-history parameters and environmental factors. Our results suggest that life-history parameters, such as age and sex are more important determinants of the described immunological and physiological measures than the parasite community in the animals. We discuss the importance of the measured parameters in wildlife health monitoring and what long-term effects the VBP infections can have on the genetically constrained cheetah population.

Keywords: Parasite infection, inflammation, *Acinonyx jubatus*, sub, clinical infections

*Speaker

Exposure to PFAS and egg patterning in an arctic seabird

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Environmental pollution affects all ecosystems, and the Arctic is no exception. Arctic top predators, such as seabirds, at a high trophic level and generally long-lived, are particularly contaminated. But the effects of certain contaminants, such as PFAS (per-polyfluoroalkyl components, also called ‘forever chemicals’), are still poorly documented. Some studies showed that PFAS can have negative effects on survival and reproduction, can disturb some physiological mechanisms, and can be transferred to the egg from the mother. Seabird eggs show many in-traspecific variations in colour, maculation and shape. Several hypotheses have been suggested to explain this variation. One of them is that these patterns may reflect the quality of the female, since the two main pigments involved in egg patterning are also involved in the immune system and in the oxidative balance. Other studies have shown that some contaminants can affect the appearance of eggs, but the effect of PFAS has never been investigated so far. Our study tested association between PFAS levels and parameters derived from measurements and egg picture analyses, in an arctic population of black-legged kittiwakes (*Rissa tridactyla*) located in Svalbard. We found that females with higher PFAS levels produced greener and brighter eggs with a more intensive colour and with more spots. In addition, PFAS levels were negatively correlated with shell thickness. We proposed several hypotheses to explain these associations as well as for the potential consequences at the individual and population levels.

Keywords: Arctic, marine birds, PFAS, eggs, image analysis

*Speaker

Do pesticides exposure influence the intestinal microbiota of a wild raptor, the Montagu's harrier?

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Diverse microbial communities composed of microorganisms inhabit vertebrates' body, with the vast majority living in the gut and coming from the diet. This microbiota offers several physiological functions (e.g., nutrient absorption, immunity regulation), and represent a crucial bridge between environmental conditions and host health. Recent studies have notably demonstrated that certain pesticides could affect the composition and functions of the intestinal microbiota, reducing microbial richness for instance with possible consequences on host's health (e.g., intestinal dysbiosis). Research on the toxicity of pesticides on the microbiota is mainly carried out in humans, due to the link with several diseases. In other species such as birds, whose intestinal morphology is fundamentally distinct from that of mammals, it remains largely unknown, with only a few studies on model species in captivity (e.g., poultry, Japanese quails). Despite current concerns about the decline of specialist birds in agricultural lands, due to, among other things, pesticide use, wild birds remain ignored. The present study investigated the interactions between pesticide load (104 compounds searched) and the microbiota in a raptor living in a rural environment, the Montagu's harrier (*Circus pygargus*). We focused on chicks, whose levels of pesticide contamination and microbial colonization mainly come from their diet after hatching. The data used came from 22 individuals (11 males, 11 females) in 13 nests sampled in 2022, and allowed us to evaluate: i) the number of pesticides detected, their concentrations and the total sum of these concentrations in the blood, ii) the community composition and diversity of the microbiota from cloacal samples. Our results first showed that the composition and diversity of the intestinal microbiota were different between males and females. We also observed a higher level of contamination in individuals with high body condition compared to those with low body condition. Finally, we found that the contamination level was associated with a decrease in the species diversity of the microbiota, as well as changes in its taxonomic composition. The strength of these relationships, however, depended on the variable studied. Thus, our results highlighted differences in intestinal microbiota and pesticide contamination between individuals according to their phenotypic characteristics, as well as an effect of exposure to a cocktail of pesticides on the microbial communities of a wild raptor.

*Speaker

Keywords: *Circus pygargus*, Chemicals, Chicks, Microbial communities

The effect of the anxiolytic pharmaceutical oxazepam on territoriality in a social cichlid fish

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Pharmaceutical pollution has the potential to deleteriously affect animals exposed in the wild by altering their natural expressions of behaviour. However, most previous studies on the behavioural effects of pharmaceutical exposures in animals have focused on simplistic behavioural endpoints quantified within socially and ecologically unrealistic environments. We therefore studied the effects of a common psychoactive pharmaceutical (oxazepam) on a range of behaviours in a highly social, group-living cichlid fish, *Neolamprologus multifasciatus*. Using chronic, one-month long, laboratory exposures, we tracked how exposed and unexposed adults formed social groups and interacted with one another, defended territories, and utilized resources in their test environments. In a first-of-its-kind application in the field of behavioural ecotoxicology, we also employed neural network algorithms to quantify behaviour. We found that exposure to low concentration of oxazepam affected both females and males by reducing their homeranges. For both sexes the high treatment did not have any impact on the size of the territory and was not different from the control group. Exposed females did not experience a significant change in body condition over the course of the different treatments, compared with males, who experienced weight loss in both the low and high oxazepam treatments. I will present results on how the pharmaceutical treatments influenced social interactions, space-use, competition, and growth in our study fish, with reference to how long-term exposures might affect the social dynamics of exposed animals in the wild. I will also discuss how ecotoxicological studies can benefit from considering more naturalistic social and ecological environments.

Keywords: ecotoxicology, social behaviour, cichlid fish, oxazepam, *Neolamprologus multifasciatus*, territoriality, sex specific effects

*Speaker

Can the pollutant-fitness relationships be associated to the gut microbiome in free-ranging mammals?

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Freshwater ecosystems shelter one-third of vertebrate species, yet they are among the most threatened worldwide. Industrialisation is responsible of the release of tons of compounds in the environment, which have become imbedded in food webs. Pharmaceutical residues are considered as emerging pollutants and have been revealed in aquatic ecosystems and organisms. There is however little data on the non-therapeutic effects of pharmaceutical pollution. The alarm about these chemicals is based primarily on the fact that they are all biologically active at low doses, and they can act on physiological systems conserved across taxa. Hence, all of them could cause health effects on non-target species. The gut microbiome plays a crucial role in host health, it contributes to the development of an immune response, to metabolic processes and can influence the host behaviour. Recent insights have suggested that most diseases could be linked in some way to an alteration of the gut microbiome. However, no studies so far have investigated the impact of pharmaceutical residues on wildlife's gut microbiome and its effect on disease susceptibility. Top predators of aquatic ecosystems such as mustelids are considered as keystone sentinel species for the study of pollutant effects on wildlife. Mustelids are also considered as a reservoir species to zoonotic disease as they are exposed to diverse types of pathogens that can be passed from and to domestic animals. In this study, we investigated pharmaceutical pollution exposure in an invasive species in France, the American mink (*Neovison vison*); we determined whether pollutant exposure could be related to a specific gut microbiota composition, and tested if individuals with high concentrations of pollutants were more likely to develop infections.

Keywords: Pharmaceuticals, environmental pollutants, Microbiome, Metabolomics, Mustelids

*Speaker

Dealing with pesticide exposure as a long-lived vertebrate: the case of a freshwater turtle species in three regions of metropolitan France

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Wetlands are among the most threatened ecosystems on the planet. Among the different factors involved in the decline of biodiversity, pollution plays an important role. Despite their increasing use, little is known about the fate and effects of pesticides in wild populations, notably reptiles. Freshwater turtles, though, constitute key species for ecotoxicological studies as they provide a comprehensive picture of the local contamination. We worked on the European pond turtle (*Emys orbicularis*) a species with high potential for pesticide exposure whose populations are declining. From 2018 to 2023, we conducted longitudinal and transversal studies and sampled 15 populations of *E. orbicularis* in three regions of France. We obtained 719 blood samples from 568 individuals and we assessed the levels of 40 pesticides in LC-MS/MS. We also evaluated the contamination pathways by sampling water, soil, and crayfish (one of the main prey of *E. orbicularis*) and by using POCIS. During the three-year longitudinal study on two populations in the Camargue, we detected 24 plasmatic pesticides. We showed that the site of capture and its hydrology was one of the main factors explaining pesticide occurrences and levels, alongside the day of capture, with an increase of both of these variables across the season of capture. However, the frequency of detection was low except for bentazone, an herbicide widely used in rice growing, one of the region's most important crops. Thanks to the longitudinal monitoring, we recaptured 116 individuals over two or three years, and we showed that bentazone levels varied at the intra-individual level over the years. Regarding the transversal study, we analyzed 311 blood samples from 15 populations of the Camargue (n=6), the Nouvelle-Aquitaine (n=7),

*Speaker

and the Brenne (n=2). The populations from the Camargue exhibited higher levels of pesticides compared to the other regions and we confirmed that the effect of the site of capture was the main explicative factor in this region. In Nouvelle-Aquitaine and Brenne, pesticides were poorly detected in the plasma despite being quantified in water samples, especially in Nouvelle-Aquitaine. Analyses are currently underway to measure the effects of pesticide exposure on various biological parameters (AChE, oxidative stress, biochemical blood test) that we hypothesize to be disrupted in populations living in the most contaminated sites. These analyses will be processed at the time of the congress. Together, our results suggest that this species responds quickly to environmental pesticide contamination. We also call for attention to bentazone, a widely and heavily used herbicide worldwide, especially in Mediterranean deltas that harbor many endangered species.

Keywords: Reptile, blood, bentazone, water contamination, biological effects

Seasonality and long term effects of methylmercury exposure on songbird brain: neurogenesis and myelination do not tell the same story.

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Organisms regularly adjust their physiology and neurology to respond to predictable seasonal variation, but environmental contaminants may disrupt such adjustments. For example, in the brain, neurogenesis and myelination are known to vary across seasons and are impacted by methylmercury (MeHg) exposure in humans. MeHg is a neurotoxic contaminant, concerning due to its ubiquity and biomagnification along food chains. Although songbirds are good indicators of environmental pollution and important models of adult neuroplasticity, it is unknown whether MeHg exposure may negatively impact the adult bird's neurology across seasons through carry-over effects. To evaluate this question we performed two experiments where captive song sparrows (*Melospiza melodia*) were exposed to environmentally-relevant dietary levels of MeHg (0.19 and 0.22 ppm MeHgCl w.w. respectively) during 3 months in the summer and winter season respectively, and then kept for post-exposure observations during the following season. We stained the brain of these birds for the presence of doublecortin (DCX), a marker for neurogenesis, and for myelin basic protein (MBP), a marker of axons myelination. In both experiments, birds exposed to MeHg exhibited a significant reduction of DCX expression in the song-control area HVC, both immediately after exposure and after MeHg clearance. This suggests consistent neuroplasticity disruption of seasonal plasticity. However, we found no effect of MeHg on myelination of the HVC-RA tract, but we observed a difference in MBP expression across seasons during the summer experiment. This indicates some protection of this protein structure against MeHg deleterious effects. Overall, songbirds may suffer acute negative effects of MeHg on their song control system neurogenesis, which may strongly impact their singing abilities and thus their breeding success. This study deepens our understanding on MeHg effects in songbirds' brain, but more studies are required on this contaminant long term effects.

Keywords: methylmercury, avian brain, seasonal transition, neurogenesis, myelination

*Speaker

Hg and PFAS contamination in seabirds: a multispecies and multisite study in metropolitan France

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Pollutants such as mercury (Hg) and perfluoroalkyl substances (PFAS), a group of man-made chemicals, require urgent monitoring across large geographical ranges. As apex predators, seabirds are good bioindicators for marine pollution, but Hg and PFAS contamination in seabirds from France is still understudied. Hg and 14 PFAS were analyzed in the blood of chicks of nine seabird species from 33 sites in France. Mean Hg concentrations ranged from 0.1 ± 0.1 to $2.9 \pm 1.3 \mu\text{g g}^{-1}$ dry weight in herring and great black-backed gulls, respectively. Hg concentrations were mainly driven by trophic position and were uniform along the French Atlantic coast. Most chicks exhibited low Hg concentrations, with 74% categorized at no risk, according to established toxicity thresholds. 2 to 11 PFAS were quantified per individual and 10 PFAS were detected in more than 70% of individuals. Perfluorooctanesulfonic acid (PFOS), the dominant PFAS, was detected in all individuals, and ranged from 21.4 ± 13.5 to $77.4 \pm 21.8 \text{ ng g}^{-1}$ wet weight

*Speaker

in herring gulls and Scopoli's shearwaters, respectively. Relations between PFAS and trophic ecology are currently being investigated but seem to be species and compound specific. Overall, chicks appear to be at low risk from Hg, while 88% of chicks were above the lowest PFOS concentrations reported to have sublethal effects. The impairments reported in seabirds with Hg and PFAS burdens considered harmless call for further studies on the impact of these pollutants.

Keywords: blood, chick, stable isotopes, Atlantic, Mediterranean Sea

Can organic farming reduce birds' exposure to pesticides?

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The intensification of agriculture has led to the homogenisation of agricultural landscapes, the loss and fragmentation of habitats and the heavy contamination of the environment by a wide range of pesticides. In parallel, a significant decline in biodiversity has been observed for all the taxa monitored, and specifically for farmland birds, mainly explained by the pesticide use. One of the solutions to limit this decline would be to adopt an alternative model of agriculture with organic farming (OF). Indeed, contrary to conventional farming (CF), crops in organic farming employ nature-based methods and the use of synthetic pesticides is banned. The aims of this study are therefore to investigate the contamination patterns of wild farmland passerine and to compare the pesticide exposure in organic farming environments vs. in conventional farming environments. Five species of passerine birds were captured in 10 hedgerows surrounded by organic farming crops (n=101) and 10 hedgerows surrounded by conventional farming crops (n=106) in the Long-Term Socio-Ecological Research Zone Atelier Plaine & Val de Sèvre in France. Bird trapping was carried out during the breeding season, when birds remain in a same area, and we detected the presence and quantified 104 pesticide residues in the blood (recent exposure) of each bird. Even if we found at least one molecule in each bird, our results show a contrasting pesticide exposure between species. Indeed, among the 5 tested species, the circl bunting (*Emberiza circlus*) shows the highest exposure to all pesticide classes (insecticides, herbicides, fungicides), while the Eurasian blackcap (*Sylvia atricapilla*) shows the lowest exposure, with a high proportion of insecticides. Moreover, some molecules seem to be specific to certain species: for example, the bifenthrin is found in all circl buntings, and sulcotrion is found in all common blackbirds, but not in other species. Our results may imply that the species ecology such as the feeding ecology may have a wide significance in these differences of the contamination patterns between species. We also found a high inter-individual variability in molecule concentrations, which may be due to several factors like individual abilities to detoxify for instance. Finally, we didn't find any difference in pesticide exposure between organic and conventional sites (statistical analysis in progress), which may indicate a persistent contamination of all environments by pesticides, even those in organic farming, contaminated by pesticides from neighbouring conventional crops. Such findings in birds may suggest a similar pesticide exposure in other species, including humans, with potentially significant implications for their health (under the 'One Health' concept).

Keywords: agriculture intensification, organic farming, farmland birds, pesticide exposure, passer-

*Speaker

ine birds



AGROECOLOGY

Speaker

THOMAS PERROT

Postdoctoral researcher at the Foundation for Biodiversity Research, hosted in the Resilience team at CEBC.

Agroecology: Opportunities & challenges

Impact of farming practices on the cultural evolution of Corn bunting songs (*Emberiza calandra*)

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Agricultural intensification has resulted in alarming decreases of multiple bird species populations living in farmlands. Pesticides are one of the causes of bird populations decimation associated with conventional agriculture. Although birds are not targeted by pesticides, most birds living in farmlands feed on contaminated plants and/or contaminated insects and macroinvertebrates, which can lead to bioaccumulation (i.e. accumulation of pollutants throughout an individual's life that can lead to intoxication). Thus, some pesticides have been shown to alter bird behaviours such as migration and their cognitive abilities. Vocal behaviour has also been found to be impaired by pesticides that modify singing activity, brain structures associated with singing and the songs themselves, by changing song timing and increasing song complexity. In addition, agricultural intensification can result in other types of pressures on bird populations, for example, through habitat fragmentation that can indirectly affect bird song cultural transmission, since they affect population size and connectivity. In addition, agricultural practices could also reduce food availability, impairing cognitive functions development. In our study, we investigate the impact of different farming practices on the cultural evolution (i.e. the evolution of behaviours that are acquired through social learning) of the dialects of Corn bunting (*Emberiza calandra*) songs, one of the most affected species by industrial farming in Europe. Birds that learn their songs typically show geographic gradual variation of their songs, meaning that the further two individuals are, the more different their song will be. However, in birds that have song dialects, like Corn buntings, each dialect occurs in a discrete area with clear borders and no gradual variation. Furthermore, recent findings showed that corn buntings within the same dialect area modify their songs from one year to another in an impressive consistent way, stressing the fact that they can learn songs along their life with great accuracy. This suggests the importance of song learning accuracy in the biology of this species, and therefore the potential serious consequences of learning disruption. We hypothesise that the different pressures that result from conventional agriculture act as stressors affecting early life cognitive abilities development needed for song learning in corn buntings. Therefore, we predict that in dialect areas affected by conventional agriculture Corn bunting song variation will be higher within each dialect than in those that are in organic farms, whose practices tend to have a less negative impact on the environment and potentially on bird song learning. To test this prediction, we recorded the songs of 750 individuals at 2 sites in France and 7 sites in the United Kingdom with different farming practices. We use Dynamic Time Warping analysis to quantify song similarity. The confirmation of our prediction would provide important insights into the mechanisms that link conventional agriculture and bird populations decrease. Given that bird songs have a key role in their reproductive success, the negative impact of conventional agriculture on bird songs cultural evolution should be considered as a key driver of the dramatic decrease of some bird populations in farmlands.

*Speaker

Keywords: Animal communication, Bird song dialect, Cultural evolution, Social learning, Agriculture, Pesticides, Ecotoxicology, Anthropogenic disturbance, Pollution

Spatio-Temporal variations of woodlice abundances in agroecosystems, using a citizen program

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Declines in biodiversity and biomass measured in European agrosystems for a wide range of taxa threaten ecosystem functioning and ecosystem services. Of particular concern, a recent empirical study highlighted that soil biota and associated ecosystem services provisioning are at stake in intensive agricultural fields. Little is known however on the determinants of woodlice abundance in agroecosystems, in spite of their critical - and complementary from Earthworms' - role in litter decomposition and thus contribution to soil fertility. Here, we address this gap in the literature using a nationwide dataset to investigate whether woodlice abundance in French agrosystems i) is associated to local or landscape variables, and ii) changed over the 2012-2022 period of our dataset. We relied on data from the citizen science program "Farming Biodiversity Observatory" in which farmers follow a standardised protocol to record abundance of woodlice and other soil taxa. Farmers provide local scale (conditions of observations, crop, field edges) information and the surrounding landscape (e.g. land use heterogeneity or proportion of hedgerows within 500 m) was characterized using a geographic information system. Results from our generalised linear mixed-effects model revealed significant effects at both local and landscape scales. Abundance varied between crop types and was lowest in vineyards. In addition, wood presence next to fields was associated with increased woodlice abundance. At the landscape scale, land-use heterogeneity and hedgerows were both positively associated with abundance. Most importantly, our model indicated a significant temporal decline in woodlice abundance. To our knowledge, this is the first study to investigate spatio-temporal variations in woodlice abundance at large scale. While our results point out a decline in woodlice abundance in French agroecosystems over the past ten years, restoring hedgerows and increasing land use heterogeneity could benefit woodlice populations. To prevent further losses and potential consequences for ecosystem functioning and services, future research should focus on identifying the causes of woodlice abundance erosion

Keywords: agroecosystems, biodiversity, citizen sciences, farmings practices, GLMM, landscape, woodlice

*Speaker

Flower visitors, pesticides, and landscapes: responses indicators to in natura effects of pesticides based on citizen science in France

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Lately, agricultural practices have intensified (landscape simplification, quantity and diversity of pesticides). Although pesticides antagonistic effects have been demonstrated under lab conditions for some flower visitors species, studies are lacking in natura effects, often encountered at sublethal doses and in cocktails. Here, we aim at developing indicators of responses of flower visitors to pesticides use on a national scale.

We used data from a monitoring scheme of flower visitors across France and related them to pesticides indicators derived from the French database on pesticide purchases: i) a total pesticide hazard ratio integrating quantity, toxicity and degradability of 269 active substances, and ii) the diversity of pesticides purchased locally. We also included covariables such as arable land proportion, landscape heterogeneity, weather conditions, etc. We assessed responses to pesticides for major flower visitors groups: bumblebees, solitary bees, hoverflies, butterflies, and beetles.

Preliminary results suggest a negative effect of pesticide diversity on bumblebees (cocktail effect). In landscapes mostly agricultural, solitary bees was negatively associated with the total hazard ratio.

We did not detect any pesticides effects on other groups' presence. Thus, next steps of this research are to assess responses at finer taxonomic resolutions and identify bioindicator species to pesticides and their cocktails.

Keywords: citizen science, community ecology, landscape ecology, pesticides, flower visitors

*Speaker

Preserved hedgerow landscapes enhance microclimatic quality and reptile diversity: insight from a military camp in western France

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The shift to industrial agriculture is responsible for major habitat degradation, homogenization and biodiversity decline. Traditional agricultural landscapes are composed of a mosaic of semi natural habitats, such as hedgerows, small woods and pastures, and provide important structural connectivity. These legacy landscapes have been profoundly degraded by the transition to mechanized agriculture in western Europe. Quantifying the amount of habitat loss as well as the quality of remaining habitat and microhabitat is important to improve land sharing strategies.

We studied farming landscape in Deux-Sèvres (western France), comparing an area (Avon military camp) where pastoral activities have been maintained since 1950, to the surrounding area exposed to practices intensification. We combined three approaches. First, we examined hedgerow linear loss in each area between 1950 and 2010. Second, we compared the hedgerow structure (width, height) and microclimatic conditions of 15 hedges in each area. Finally, we studied the occurrence of squamate reptiles in these hedges using occupancy models. While the hedgerow density was initially high (188,6 +- 2,2 m/ha), we detected a 73% loss in the area exposed to agricultural intensification between 1950 and 2010, compared to only 21% within the camp. Hedgerows were also thinner and shorter outside the military camp and offered lower wind protection resulting in altered microclimates. We found that species occurrence and richness were more important in the traditional landscape.

The structural quality of hedges is often neglected, despite its likely crucial role in supporting biodiversity. It has an impact on the microclimate, therefore on the availability of this habitat for species. Land-sharing strategies within degraded matrices must necessarily consider the quality of the remaining semi-natural habitats.

Keywords: farming, landscape, hedgerow, microclimate, microhabitat

*Speaker

Méthafaune project : Impact of intermediate energy crops on three species of cereal plains

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Methanization is designed to recover urban organic, industrial and agricultural waste by producing biogas and digestate, and is booming in France. While studies seem unanimous on its potential for reducing greenhouse gas emissions, knowledge is still missing on the impact of new agricultural practices linked to methanization on wildlife.

Introduction of intermediate energy crops in crop rotation leads to significant spatiotemporal changes in the landscapes. In fact, summer intermediate energy crops create a high plant cover that can be used as refuge by wildlife during periods where soils have little vertical cover under conventional cultivation. On the other hand, introduction of winter intermediate energy crops leads to very early mowing periods, coinciding with the reproduction period of some animal species, which could increase mortality.

Thus, we decided to investigate the impact of these new farming practices on cereal plains wildlife. To do this, GPS tracking, abundance estimates and mortality counts are carried out on roe deer (*Capreolus capreolus*), hare (*Lepus europeaus*) and partridge (*Perdix perdix*). Small mammal captures are also carried out to assess summer intermediate energy crops attractiveness for these species.

To this day, eight roe deer, thirteen partridges and two hares are tracked with GPS devices. Captures are still in progress and spatial data will enable us to identify the importance of different landscape features (crops types, height plant cover, crop surface) for these three species. First results will be presented at this symposium. Fifty hectares of rye (winter energy crops) have been prospected until now. Despite these crops being mown during the breeding season, no corpses or nests were found in any of the plots surveyed. A first session of small mammal captures seems to indicate that MethaniCouv (summer energy crops made up of sunflower, fox-tail millet, niger) is highly attractive to voles (*Microtus*) and field mice (*Apodemus*). A full year is still needed to accumulate data.

Méthafaune project is part of the multidisciplinary framework of the industrial chair on methanization in the Grand Est region (MERGE). The latter is itself conducted within the framework of the Zone Atelier Environnementale Rurale Argonne (ZARG) accredited by the CNRS, bringing together researchers and local players.

*Speaker

Keywords: Intermediate energy crops, Wildlife, Habitat selection, GPS tracking

Linking high resolution movement data of common noctule bats with their diet

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Intensive agriculture is considered one of the main drivers of insect decline. Predators of insects such as bats presumably have a particularly hard time finding sufficient food over agricultural land. Our current project follows up on a previous study, which showed that common noctule bats (*Nyctalus noctula*), a typical open-space foraging bat from Europe, rely on mobile sensory networks when hunting over insect-depleted agricultural land. We used the ATLAS tracking system, a reversed GPS approach that yield spatial positions at very high temporal and spatial resolution, to investigate the seasonal and individual variation in habitat use of common noctules when foraging above farmland. Additionally, we used meta-barcoding based on faecal pellets collected from maternity roosts to investigate their feeding behaviour.

We were specifically interested if common noctule bats adjust their foraging flexibly according to resource availability. We predict that their preferred foraging patches should vary a) across seasons, i.e., between spring and summer, and b) across years. We conducted comparative studies during two seasons (spring and summer) in three different years (2020, 2022 and 2023) of 179 common noctule bats in total from two nearby colony groups and 230 faecal samples. This study will help understanding the individual variations in the spatial behaviour of an open-space foraging bat and how this can be linked to trophic interactions on a landscape level.

Keywords: ATLAS tracking, movement ecology, metabarcoding, insect communities, *Nyctalus noctula*

*Speaker

Characterization of landscape factors affecting biodiversity in agricultural landscapes in order to promote the provision of multiple ecological functions

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Agricultural environments are experiencing a major decline in biodiversity, leading to the loss of the ecological functions (e.g. pollination, pest control, degradation of organic matter, etc.) performed by beneficial organisms that are essential to the functioning of agricultural ecosystems. It is assumed that the landscape surrounding the fields play a major role in the provision of ecological functions through the habitats and trophic resources it provides for populations of beneficial organisms.

The aim of this study is to understand which landscape factors support the simultaneous provision of a bunch of ecological functions within agricultural landscapes.

To answer this question, we used oilseed rape as a study model. It is an ideal model for studying the impact of the landscape on ecological functions because it is a crop that is particularly dependent on ecological functions. Indeed, oilseed rape is partially entomophilous, is known to have major pest problems. On the other hand, it is a crop known to shelter and provide resources for certain populations of beneficial organisms at landscape scale.

We measured 3 ecological functions in 108 oilseed rape fields: pollination (measured by the average number of seeds produced per oilseed rape branch), pest control (measured by weed seed and aphid predation rates) and organic matter recycling (measured by the initial decomposition rate and litter stabilisation factor). These measures of ecological functions were used to calculate a multifunctionality index (using the average method by summing the 5 standardised centred proxies) which reflects the level of simultaneous provision of all these functions.

The landscape variables studied are the amount of oilseed rape (%OSR), the amount of grassland (%Grassland), the amount of hedgerows (%Hedges) and the amount of organic farming (%OF) in the landscape adjacent to the fields studied. The statistical model used to study the effects of landscape variables on multifunctionality was programmed in R using the Siland package. This package produces statistical models evaluating the effects of landscape variables and the effect distances of these landscape variables by maximising likelihood.

Our results show that the amount of oilseed rape within a 368 m radius and the amount of grassland within a 378 m radius have a positive influence on the multifunctionality of the oilseed rape plots. The amount of hedgerow within a radius of 734 m has a negative influence on multifunctionality. No significant effect of the amount of organic farming on multifunctionality was

*Speaker

found with this model.

By understanding the factors that drive multifunctionality, we can support the design of agricultural landscapes in which ecological functions guarantee sufficient production to enable producers to secure their incomes, while at the same time meeting current environmental and biodiversity challenges.

Keywords: Agricultural landscape, Ecosystem functioning, Natural pest control, Pollination, Soil



HUMAN-NATURE CONFLICTS

Salvage logging and subsequent post-windthrow management leads to impoverished forest bird communities for two decades

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1. Post-disturbance forest management is known to impair biodiversity, but most studies focus on short-term effects of salvage-logging, without recognition of the long-term impact of collective silvicultural practices.
2. We tracked bird community succession in a temperate pine forest for 19 years after wind disturbance in managed (n=45) and unmanaged (n=32) windthrow areas, comparing it to nearby undisturbed forest (n=29).
3. Bird communities of unmanaged windthrow were consistently the richest in terms of bird diversity. They hosted comparable forest bird diversity to undisturbed stands throughout the study period as well as significant diversity of farmland birds.
4. . Managed and unmanaged windthrows followed distinct successional pathways and no signs of convergence were observed. However, bird communities of both types of windthrows became similar to undisturbed forest over time, as early-successional species were replaced by late-successional species. Nevertheless, bird communities of the two types of windthrows as well as undisturbed forest remained distinct until the end of the study.
5. *Synthesis and applications:* Restraining from any active post-windthrow management sets bird succession on a distinct pathway, leading to unique, complex and rich bird communities. We advocate viewing natural disturbances as cost-effective ecosystem restoration tools, provided no forest management is implemented.

Keywords: Secondary succession, salvage logging, wind, disturbance, spontaneous development

*Speaker

Forest patch vs Anthropogenic habitat: Comparing diet, activity budget and ranging patterns of bonnet macaques (*Macaca radiata*) in two different habitats in Southern Western Ghats

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There is a rapid conversion of wildlife habitats to anthropogenic areas globally. In the past few decades, a large area of forest has been lost/degraded in various biogeographic zones of India, including the Western Ghats. Due to this, Wild primates are being forced to become more dependent on anthropogenic habitats like plantations and agricultural areas. In order to better understand how macaques adapt to anthropogenic habitats, we examined the diet, activity budget and ranging patterns of two groups of bonnet macaques in a forest agricultural matrix at Wayanad, Kerala, India. One of the groups studied was a forest-dependent group (KV group) and the other was a plantation-dependent group (MTB group). The findings of research conducted on both groups during the post-monsoon season, the season with the least fruit availability in the study area, are presented here. KV group was studied from October 2021 to January 2021 and MTB from October 2022 to January 2022. Groups were followed five to ten days a month, usually from 8 AM to 6 PM. We employed 30-minute interval slow scan sampling method to collect data on activity budget and diet. Locations of the groups were recorded once in every 15 minutes throughout the period of observation. The home range estimations were done following kernel density estimation method. Intergroup differences in activity budget and consumption of different food types were tested by using the Mann-Whitney U test. There were significant differences in time spent on feeding, rest, aggression and affiliative interactions between the groups. The plantation-dependent group spent more time in affiliative interactions and aggression. Insects and fruit were the most consumed food type for the forest-dependent group and plantation-dependent group respectively. Plantation-dependent groups consumed fruits of 34 different plant species while the forest-dependent group consumed fruits of only 16 plant species. Plantation-dependent groups consumed significantly more anthropogenic food when compared to that of the forest-dependent group. The home range and core area for the forest-dependent group were large when compared to that of the plantation-dependent group and the average path length was smaller for the forest-dependent group when compared to that of the plantation dependent group. The forest-dependent group spent significantly less amount of time (10.24%) on the ground when compared to that of the plantation-dependent group (29.47 %). Groups residing in two distinct habitats demonstrated notable distinctions in their diet, activity budget and ranging patterns even though they inhabited neighboring home ranges. According to our research, macaques living in anthropogenic environments can take advantage of both natural and anthropogenic resources. However, since they spend so much time on the ground, they are also vulnerable to a range of anthropogenic threats.

*Speaker

Keywords: Primate behaviour, Bonnet macaque, Anthropogenic habitat, Southern Western Ghats

Exploring habitat selection and behaviour of Barbary macaques (*Macaca sylvanus*) in response to environmental factors in the context of human-wildlife conflict

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Habitat loss, modifications of land use and human population growth have led to increased proximity between wildlife and human resulting in potential conflicts when both species use the same resources. Understanding how wildlife selects its habitat and how organisms' movement can be altered by anthropized modifications can help design action to mitigate these conflicts. The Barbary macaque (*Macaca sylvanus*), an endangered primate species, is mainly forest-dependent. In Morocco due to change in agricultural and sylvo-pastoral practices, traditional common pastures at the edge of forest have been converted into crops and orchards. Since several years, farmers have frequently reported damage in their orchards because of Barbary macaques coming to feed.

The aim of this study is to investigate environmental factors driving movements and behaviours of Barbary macaques and to compare groups living in an undisturbed cedar-oak forest with those living at the edge of agricultural landscape. We hypothesize that the behaviour expressed by the group of macaques differed with respect to habitat selection especially when differences in human pressure and resources between habitats are high. In the agricultural site, food and water resources are more condensed and predictable than in the forest site where these resources are more dispersed. In addition, human presence and disturbance is higher in the agricultural site than in the forest site, especially around orchards and when cherries are ripe.

To test these hypotheses, we monitored daily movement (GPS position) and behaviour (scan sampling and focus) of two groups of Barbary macaques during nine months spread over different seasons in two different sites in the national park of Ifrane, Middle-Atlas (Morocco). We also monitored food availability performing weekly vegetation surveys during observation period and we mapped habitat characteristics. We analyzed habitat selection from GPS location data in relation to their behaviour and environment features such as food and water resources and anthropic pressure using Step Selection Function. We identified that factors influencing habitat selection varied among seasons and between the two sites. We believe that understanding

*Speaker

which factor is involved in habitat selection by Barbary macaques would help to inform effective management strategies. For example, if food is an important factor leading macaques to select orchards, protecting herbaceous plants in the forest to limit overgrazing by sheep would increase the food availability for macaques and could lead to a reduction of their time spent in orchards.

Keywords: movement, spatial and temporal variations

Urbanization and habitat productivity influencing niche structures and competition behaviours of avian communities.

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Human-driven habitat transformation, referred to as urbanization, has become a dominant force shaping ecosystem dynamics, usually causing wildlife habitat loss. Moreover, specialists are substituted by generalists along the urbanization gradients resulting in biotic homogenization driving the niche packing of the communities. According to the niche theory, more intense competition would be expected between species if they are more similar and be expected to be mediated by habitat productivity. In this study, we conducted a two-year-round experiment, adopting the transect method recording the behaviors in avian communities along urbanization gradients in 30 sites in Suzhou, China. Urbanization rate and productivity were quantified within a radius of a 1-kilometer circle of each site using satellite images. Results showed that niche overlap and competitive behaviours among avian assemblages significantly increased along urbanization gradients, supporting the niche theory. Productivity reduced the impact of urbanization on the competition intensity among avian communities.

Keywords: niche overlap, avian assemblages, competition intensity, habitat loss

*Speaker

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