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**Wildlife Research and Conservation 2019**

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Edited by

Sarah Benhaiem, Anne Berger, Oliver Höner, Conny Landgraf, Vikoriia Radchuk

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Spotted hyenas (*Crocuta crocuta*) in the Ngorongoro Crater,  
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## CONTENTS

<b>FOREWORD</b> .....	4
<b>ORAL PRESENTATIONS</b>	
MAIN SESSION I: BEHAVIOUR, LIFE HISTORY AND PHENOTYPIC PLASTICITY .....	5
MAIN SESSION II: SOCIAL BEHAVIOUR AND MATING SYSTEMS .....	12
PARALLEL SESSION I: AN INTRODUCTION TO THE CTMMWEB R PACKAGE FOR MOVEMENT ANALYSIS .....	19
PARALLEL SESSION II: IMPORTANCE OF SOCIAL BEHAVIOUR AND APPLICATION OF SOCIAL NETWORKS ACROSS WILDLIFE BIOLOGY AND CONSERVATION .....	20
MAIN SESSION III: DEFAUNATION: SPECIES FUNCTIONAL EXTINCTIONS AND THEIR SOCIO-ECOLOGICAL CONSEQUENCES .....	25
PARALLEL SESSION III: SMART TAGS FOR SMART ANIMALS; BUT ARE WE BEING SMART ABOUT WHAT WE ARE DOING WITH THEM? .....	32
PARALLEL SESSION IV - PANEL DISCUSSION: DEFAUNATION – FROM CONSERVATION SCIENCE TO CONSERVATION ACTION .....	38
PARALLEL SESSION V: RECENT ADVANCES IN CAPTURE-RECAPTURE STUDIES WITH APPLICATIONS IN WILDLIFE RESEARCH AND CONSERVATION .....	40
PARALLEL SESSION VI: HUMAN-WILDLIFE INTERACTIONS: COMING FROM BOTH SIDES .....	47
MAIN SESSION IV: HORMONES, INDIVIDUAL PLASTICITY AND FITNESS .....	59
PARALLEL SESSION VII: SEXUAL CONFLICT AND ADAPTATION TO ENVIRONMENTAL CHANGE .....	68
MAIN SESSION V: CONSERVATION GENETICS.....	74
<b>POSTER PRESENTATIONS</b>	
ADVANCES IN GAMETE PRESERVATION FOR ASSISTED REPRODUCTION .....	79
BEHAVIOUR, LIFE HISTORY AND PHENOTYPIC PLASTICITY.....	83
SOCIAL BEHAVIOUR AND MATING SYSTEMS .....	107
DEFAUNATION: SPECIES FUNCTIONAL EXTINCTIONS AND THEIR SOCIO-ECOLOGICAL CONSEQUENCES .....	121
HUMAN-WILDLIFE INTERACTIONS: COMING FROM BOTH SIDES .....	123
SMART TAGS FOR SMART ANIMALS; BUT ARE WE BEING SMART ABOUT WHAT WE ARE DOING WITH THEM?.....	136
RECENT ADVANCES IN CAPTURE-RECAPTURE STUDIES WITH APPLICATIONS IN WILDLIFE RESEARCH AND CONSERVATION .....	142
HORMONES, INDIVIDUAL PLASTICITY AND FITNESS .....	147
CONSERVATION GENETICS .....	162
OPEN SESSION .....	184
<b>FURTHER EVENTS</b> .....	200

## FOREWORD

This volume contains the contributions to “Wildlife Research and Conservation 2019” (WRC2019). This conference is jointly organised by the Leibniz Institute for Zoo and Wildlife Research (Leibniz-IZW), the European Association of Zoos and Aquaria (EAZA) and WWF Germany. It is the successor of the “International Conference on Behaviour, Physiology and Genetics of Wildlife”. This series of meetings brings together specialists from different disciplines and covers a variety of topics such as research on ecology, behaviour, life history, ecophysiology, reproduction biology, wildlife conservation and conservation genetics. The conference has developed a tradition of fostering an exchange of ideas and methods between scientists working with free-ranging and captive animals. A particular aim of the conference is to introduce participants to new concepts, methods and techniques developed within one discipline that may be very useful to answer questions in another.

The first section of this volume contains the abstracts of all oral presentations, including the abstracts of invited plenary speakers, session organisers and submitted contributions. The second section contains the abstracts of all submitted poster presentations. Contributions were invited for the following topics:

- Advances in gamete preservation for assisted reproduction
- Behaviour, life history and phenotypic plasticity
- Social behaviour and mating systems
- Importance of social behaviour and application of social networks across wildlife biology and conservation
- Defaunation: species functional extinctions and their socio-ecological consequences
- Human-wildlife interactions: coming from both sides
- Smart tags for smart animals; but are we being smart about what we are doing with them?
- Recent advances in capture-recapture studies with applications in wildlife research and conservation
- Hormones, individual plasticity and fitness
- Conservation genetics
- Sexual conflict and adaptation to environmental change
- Open session

The abstracts in this volume are organised by session according to the scientific programme and were published as submitted.

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Berlin, September 2019

Sarah Benhaiem, Anne Berger, Oliver Höner, Conny Landgraf, Stefanie Lenz, Josepha Prügel, Vikoriia Radchuk, Steven Seet and Heribert Hofer

## **ORAL PRESENTATIONS**

### **MAIN SESSION I: BEHAVIOUR, LIFE HISTORY AND PHENOTYPIC PLASTICITY**

#### **The significance of developmental plasticity in dangerous environments**

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Predation is one of the most influential environmental factors affecting individual behaviour and life-histories. Potential prey feature a broad array of phenotypic adaptations to reduce the mortality risk and indirect costs of predation. This ranges from morphological defences and anti-predator behaviours to the evolution of a social lifestyle, in cases when group-living provides the best protection from predation. Phenotypic adjustments early in life by way of developmental plasticity can provide a powerful opportunity to mediate the costs of predation lifelong. To understand the role of developmental plasticity in dangerous environments we may ask (1) under which environmental conditions developmental plasticity is beneficial in response to predation, (2) by which pathways early-life predator experience may shape phenotypes, and (3) which type of phenotypic adjustments we should expect in dependence of environmental parameter variation. I will provide answers to these questions provided by experiments using various animal models. In particular, I will present results from cooperatively breeding cichlids, which reveal (i) that a risky early environment can shape life history trajectories and behaviours for life; (ii) these effects can be transmitted non-genetically across generations; and (iii) early-life environmental risk can shape the phenotype of young through different pathways, including through variation in parental investment in offspring quality, through behavioural interactions between parents and offspring, and by direct effects of exposure to danger. Using evidence from recent meta-analyses I will highlight that typically we lack the information about the environmental autocorrelation structure required to assess the adaptive value of developmental plasticity.

## Effects of aging on timing of hibernation and reproduction

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Small hibernators are long-lived for their size because seasonal dormancy greatly reduces predation risk. Thus, within a year, hibernators switch between states of contrasting mortality risk (active season versus hibernation), making them interesting species for testing the predictions of life-history theory. Accordingly, we hypothesized that, with advancing age and hence diminishing reproductive potential, hibernators should increasingly accept the higher predation risk associated with activity to increase the likelihood of current reproductive success. For edible dormice (*Glis glis*) we show that age strongly affects hibernation/activity patterns, and that this occurs via two pathways: (i) with increasing age, dormice are more likely to reproduce, which delays the onset of hibernation, and (ii) age directly advances emergence from hibernation in spring. We conclude that hibernation has to be viewed not merely as an energy saving strategy under harsh climatic conditions, but as an age-affected life-history trait that is flexibly used to maximize fitness.

## Impact of early-life stressors on performance and behaviour of cane toad tadpoles

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Exposure to environmental stressors during development affects behaviour, performance and morphology in a wide range of taxa, sometimes with long-term consequences (across life-stages and even passed on to subsequent generations). Such effects may be important in the context of invasion because invasive populations often are exposed to novel environmental stressors. Across their introduced range in Australia, cane toads (*Rhinella marina*) have low levels of genetic diversity; however, they exhibit substantial geographic variation, including in performance and behavioural traits, and have differences in plasticity on the range-edge as compared to the range-core. We explored a possible role for methylation of the genome in driving such differences, in a common-garden setting, using two methods known to demethylate DNA: exposure to i.) Zebularine and ii.) cues from cannibalistic conspecifics. We measured performance and behavioural responses in 23 clutches of toads from the range-core and range-edge. Over a three-day trial of 5-8-day old tadpoles, swimming performance was unaffected by Zebularine or geographic origin. However, Zebularine-treated tadpoles gained more weight than controls, and tadpoles from the range-core (but not the range-edge) developed faster in response to Zebularine. Seventeen-day old tadpoles from the range-core had higher mortality rates than those from the range-edge but this was mitigated by exposure to Zebularine. Further, alarm-cue exposed tadpoles from both regions had higher mortality rates by day 17 than unexposed tadpoles, except for those also exposed to Zebularine. Range-edge (but not range-core) tadpoles reduced their feeding and increase their swimming rates following alarm cue exposure (i.e. higher behavioural plasticity). Overall, treatments that demethylate DNA accelerated larval development, and affected mortality rates and tadpole behaviour. These patterns were complex with respect to population age, and different demethylation methods had opposing effects on mortality, suggesting that the effect of DNA demethylation is both context and agent specific.



## Maternal investment strategies of a cooperatively breeding forest specialist in degraded cloud forest fragments

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In many tropical areas one of the main drivers of biodiversity loss is the degradation and fragmentation of pristine habitats. Different species cope differently with environmental stressors and some survive better than others. In cooperatively breeding species, subordinates provide extra care and/or protect a brood against predators. Breeding females of these species can apply multiple pre- and post-hatching strategies to optimize the trade-off between current and future reproduction. Such female behavioural plasticity may buffer natural variation in critical resources and thus in habitat quality. For instance, investment in offspring can be increased under harsh conditions, or alternatively, decreased when times are benign to benefit the breeding female. To what extent human-induced environmental change may trigger plastic maternal strategies in cooperative breeders, however, remains unclear. We study how habitat fragmentation affects breeding behavior, i.e. egg investment and nestling provisioning, and reproductive success, i.e. fledging success, of wild populations of Placid Greenbuls (*Phyllastrephus placidus*) - a forest specialist bird species that breeds in the cloud forest remnants of the Taita Hills of Kenya that are part of the Eastern Afromontane Biodiversity Hotspot. We study different populations of greenbuls that live in forest fragments varying in habitat size and quality ranging from large, undisturbed to small degraded patches. We hypothesize that females adjust their investment in eggs and nestlings depending on number of helpers and habitat quality. Thereby cooperative breeding may mitigate the negative effects of habitat degradation.

## **Does it pay to be smart? Cognition and fitness in wild grey mouse lemurs, *Microcebus murinus***

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The fact that neither all species nor all individuals within a given species exhibit the same, unlimited cognitive abilities indicates the existence of proximate constraints and evolutionary trade-offs involving the underlying traits. However, the magnitude and sources of inter-individual variation in cognitive abilities remain poorly known; primarily because only a few studies have linked variation in cognitive abilities to micro-evolutionary processes and fitness outcomes. We tested 90 wild grey mouse lemurs (*Microcebus murinus*) in four cognitive tests, a novel problem-solving, string-pulling and inhibitory control task and a spatial memory test, that showed high variation in the wild primate population. We investigated individual characteristics potentially influencing animals' performance, including sex, age, personality and energetic state, and linked cognitive abilities with monthly survival in the wild. We found that performance in one cognitive task was generally a weak predictor of performance in any other task, providing no evidence for the existence of a general factor explaining cognitive performance in wild grey mouse lemurs. Performance in problem solving efficiency was positively related to longevity. However, performance in string-pulling and inhibitory control were negatively related to longevity, whereas performance in spatial memory was not linked to longevity. Hence, our results highlight the need to expand links between cognition and fitness within study species by investigating multiple cognitive abilities addressing fitness-related behaviours in different contexts and various fitness outcomes simultaneously. This will help to detect the complex relationships between cognition and fitness and broaden our understanding how cognition evolved.

## **Effects of external energy reserves on overwintering strategies in common hamsters**

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Common hamsters (*Cricetus cricetus*) are facultative hibernators showing high individual variation in hibernation patterns and the extent of metabolic suppression during torpor, which could be related to food store availability and/or quality. In free-ranging Common hamsters food hoarding behaviour was much more pronounced in females compared to males. This difference was reflected in delayed hibernation onset and less time spent in torpor in female hamsters. In field studies, however, the information on the quantity and quality of food stores is lacking. We therefore manipulated food stores in hamsters kept in constant condition chambers and additionally provided focal individuals with high-quality food supplements in the field. Body temperature was recorded with subcutaneously implanted data loggers. In the first experiment female hamsters had either access to unlimited food reserves for hoarding or received only daily portions and could not build up food stores. Almost all females without food hoards hibernated whereas less than half of the other group showed deep torpor bouts. Food stores enriched with sunflower seeds strongly reduced the time spent in deep torpor compared to standard rodent pellets. In free-ranging hamsters, however the effects of food supplements differed between the sexes. Males hibernated significantly shorter and at higher body temperatures than unsupplemented individuals and substantially gained body mass over winter while the others lost mass. In females hibernation patterns and body mass changes did not differ between individuals with and without food supplements, but supplemented females emerged from their hibernacula about three weeks earlier in spring. Early emerging females preceded the others in mating indicating a longer breeding season and accordingly more litters. Thus, despite different responses to food supplements positive effects on reproductive success can be assumed in both sexes.

## **Individual variation in invasive predator behaviour: consequences for conservation management**

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Individual variation has been identified in a broad range of taxa and traits as key to understanding ecological, evolutionary and conservation outcomes. However, there remains limited information on such variation in invasive species, yet these species are critical threats to a wide range of biota, and among-individual differences can have important consequences for determining variation in the impacts and fitness of invaders in novel environments. In addition, understanding such impacts would benefit conservation efforts by providing key insights to guide management actions addressing this global problem. Using a natural experiment across invaded islands within the Hauraki Gulf, NZ, we determined the extent and covariance of individual variation across behavioural and dietary traits in two invasive rat species in the wild. We investigated how competition (between rat species) and predation threat (by invasive cats where present) modulate invasive individuals' behavior. We found substantial among-individual behavioural differences within and between species and island communities. However, relationships between behavioural traits and diet were complex, potentially mediated by density-dependent effects. These results enable the identification of trait combinations that produce disproportionate effects on native biota, and have important implications for the theoretical understanding of the individual invasive niche. They also highlight how applied management efforts can be enhanced through targeting those individuals that pose the greatest potential risks, so maximising conservation benefits.

## **MAIN SESSION II: SOCIAL BEHAVIOUR AND MATING SYSTEMS**

### **Kinship dynamics and the evolution of family life histories**

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Kin selection theory provides a very general framework to understand the evolution of social behaviour and mating systems. This theory is inherently static in approach, typically assuming fixed costs and benefits, and fixed degrees of relatedness between social partners. But in family-dwelling animals, all of these terms are subject to change over an individual's lifetime, as some group members disperse away from their group, and others die and are replaced. Here I discuss recent models of kinship dynamics which examine how these changes in the social environment influence selection on social traits across the lifespan. I show how these models can be used to explain the evolution of post-reproductive lifespans in humans and some toothed whales, and offer new insights into patterns of aggression in social carnivores and primates. Models incorporating kinship dynamics are a step toward a more general, social life history theory, capable of explaining the evolution and dynamics of family life.

## **Fitness benefits of male-male sociality in wild guinea baboons (*Papio papio*)**

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Multi-male associations and male–male bonds can result in important fitness benefits in numerous mammalian species. The adaptive value of these relationships is often attributed to coalitionary support, which aids in rank ascension and female defence, but may also be related to female choice. Guinea baboons, which live in a nested multilevel society with parties formed from units composed of a primary male, associated females and, often, secondary males, represent an ideal model to test the adaptive value of male–male sociality. Males are philopatric, maintain high levels of spatial tolerance, form affiliative relationships, and support each other in coalitions. Rates of aggression between males are surprisingly low, male hierarchy is unclear, and takeovers rare, with females playing an active role in inter-sexual relationships. Given that rank ascension and female defence appear unlikely in this type of society, it may also be that males with strong social ties are more attractive to females and thereby sire more offspring. Using social behaviour, genetic relatedness, and paternity of 24 adolescent and adult males, we investigated the features and adaptive benefits of male–male sociality in wild Guinea baboons. Male–male affiliative relationships were differentiated and preferred partners were stable over time, indicating males form strong social bonds. Although strongly bonded males revealed a higher degree of relatedness on average, bonds were not restricted to kin and kinship did not guarantee stronger social bonds. Dyads with stronger bonds were more likely to support each other in coalitions, however, contrary to our predictions, male–male sociality had no positive effect on the number of associated females or sired offspring. Instead, males with stronger bonds had significantly lower numbers of associated females. As influential components in their social dynamics, male Guinea baboons must balance number of associated females with time invested in male social bonds.

## **Reproductive costs and secondary dispersal in female western lowland gorillas**

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Individual effort to maximize reproductive success leads to conflicts and compromises between the sexes in group-living mammals. Females utilize counterstrategies such as dispersal to minimize the costs of male reproductive strategies including infanticide. Secondary dispersal by breeding females is rare among group-living mammals and when it occurs, it is believed to be a mate choice strategy that may minimize infant mortality. In this study, we assess factors of feeding competition and male competitive ability potentially influencing female reproductive success and dispersal patterns in western gorillas using a 20-year observation period at the Mbeli clearing in Northern Republic of Congo.

We found that females suffer reproductive costs of higher offspring mortality when with males near the end of their tenure. When female transferred, they experienced a five months delay in breeding and lower birth rates of surviving offspring after multiple transfers. In line with these findings, we found that females are more likely to stay with a male in the beginning of his tenure than transfer and more likely to disperse away from silverbacks closer to the end of their tenure. There was no effects of feeding competition linked with the size of the group.

The breeding delay does not represent a substantial cost if females can leave a male at the end of his tenure for a more competitive male earlier in his tenure allowing females to lower infant mortality and increase their future reproductive success. This study exemplifies that although female secondary dispersal entails costs, it may be an effective counterstrategy to mitigate the effects of male-male competition and sexual coercion.

## Local variation in adult sex ratios structures dispersal decisions in a primate

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Optimal individual reproductive strategies should be sensitive to the relative proportion of competitors to mates. For group-living mammals, this information is particularly pertinent during dispersal events. The adult sex ratio (ASR), i.e. the proportion of males in the adult population, is a key demographic trait that provides this information, but it remains poorly known whether this information on neighboring groups is used by dispersing individuals to inform their dispersal decisions. Here, we present 25 years of long-term demographic data on dispersal patterns in a Malagasy primate (Verreaux's sifaka, *Propithecus verreauxi*) to examine whether dispersing adult males and females take local ASR variation into account. This question is interesting because this species has bisexual dispersal, male-biased average ASRs and the most pronounced male reproductive skew reported for any primate species. We analyzed data on 206 observed and suspected adult dispersal events in a population of individually-marked Verreaux's sifakas living in a study population in Kirindy Forest, Madagascar. Preliminary analyses indicate that dispersing males left groups with male-biased ASR and targeted a group with even or female-biased ASR in the vast majority of cases. In females, the opposite pattern is indicated. Our study therefore suggests that these primates have the cognitive abilities to assess local ASR variation, and that they use it to structure their dispersal decisions.



## **Collective movement and multi-level social structure of a vulturine guineafowl society**

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Animal societies that consist of stable social groups can also organize into higher levels communities. However, such group-level fission-fusion dynamics have rarely been described or studied in detail, but raise questions about what social or ecological factors determine when groups fuse or fission. We studied a population of vulturine guineafowl that have highly-overlapping home-ranges by deploying high-resolution GPS tags on 129 individuals and by marking over 900 with colour-bands, allowing for individual identification in the field. Vulturine guineafowl live in stable groups, and by GPS tracking each of the 19 groups in our study area we found that their composition determined collective movement, with evidence for an optimal group size. GPS tracks further revealed that groups overnight in communal roosts together with other groups. We therefore tested whether home-range overlap predicts inter-group social networks (roost sharing) or if groups have specific ‘preferences’ for other groups. Lastly, movement and social dynamics are affected by changing ecological conditions across seasons and thus we tested whether seasonality predicts inter-group contact. Together, our study provides a unique perspective linking intra-group collective dynamics to population-level social structure across ecological conditions.

## **Modelling sociality in carnivores**

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Many theories have been put forward to explain grouping behaviour in carnivores, yet there is little consensus as to the underlying mechanisms that influence the tendency of animals to form groups or to act socially. Traditionally two selection pressures have been postulated; avoidance of predation and a widening of the resources that can be exploited. Much of the work investigating sociality has focussed on these as individual processes without consideration of the underlying demography influencing resource use and predator avoidance.

Sociality is likely to be driven by multiple processes. Here we create a conceptual model of the processes and their interactions that lead to sociality in carnivores. We use multivariate models coupled with Structural Equation Models and Bayesian Belief Networks to investigate the roles of demography and other processes in determining sociality in mammalian carnivores. Using data combining morphological and life history traits, habitat, diet, space use and distribution patterns we test these conceptual models investigating the drivers of sociality within and between carnivore species. Understanding sociality and grouping behaviours provides information that will be useful to inform conservation and management of carnivore populations, many of which are under threat and are of cultural and ecological significance.

## **Social interactions hinder the growth of a high-density mountain gorilla subpopulation**

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Density-dependent processes, such as food competition, predation, or disease, negatively affect the growth of wild populations. The mountain gorilla (*Gorilla beringei beringei*) is the only nonhuman great ape that is growing in number, passing 1000 individuals in two isolated forest fragments. Fifty years of demographical data and 18 years of group movement data from the Virunga population unveiled new mechanisms linking density to population growth. In the absence of predation and food shortage, social factors have emerged as key forces regulating the study subpopulation of 115 gorillas in recent years. The continued growth of three stable social groups with up to 65 individuals and nine mature males led to a series of group fission events and emigrations of adult males (solitary males) aiming at establishing their own group. These events resulted in a rapid increase in the density of social groups with high instability and solitary males, whereas the overall individual density declined. This social reorganization triggered a cascade of behavioral changes: larger group home-range overlaps caused a five-fold increase in annual interactions between social units (groups and solitary males) with frequent female transfers, which in turn was responsible for a nearly five-fold elevation of infanticide and several cases of lethal fights among mature male. Consequently, the annual population growth rate decreased from 4% to 2% within 10 years. These findings highlight the complex relationship between population density, mainly on group-level rather than individual-level, and growth in social species, which has important implications for the conservation management of fragmented populations of social mammals, especially for disease control.

**PARALLEL SESSION I: AN INTRODUCTION TO THE CTMMWEB R PACKAGE FOR MOVEMENT ANALYSIS**

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Modern, high-resolution animal tracking datasets are both increasingly available and invariably autocorrelated. Continuous-time movement models can naturally accommodate the rich autocorrelation structure of such datasets, and thus provide a solid foundation for model-based statistical inference. Until recently, however, these methods have been relatively inaccessible to practicing ecologists due their highly technical nature. In this workshop, I will introduce the `ctmmweb` movement analysis package, which allows users to perform a suite of sophisticated analyses based on continuous-time movement models via a point-and-click graphical user interface. `ctmmweb` can either be used as a cloud-hosted webapp, or can be installed locally on a user's computer. I will walk participants through a detailed analysis including variograms and visual diagnostics, properly accounting for telemetry error, movement model fitting and selection, autocorrelated kernel density home range estimation, home range overlap analysis, occurrence distribution estimation and path reconstruction, and scale-free estimation of speed and distance traveled. I will conclude by demonstrating how `ctmmweb` can record analysis sessions to facilitate reproducible research, and can also produce publication quality graphics.

**PARALLEL SESSION II: IMPORTANCE OF SOCIAL BEHAVIOUR AND APPLICATION OF SOCIAL NETWORKS ACROSS WILDLIFE BIOLOGY AND CONSERVATION**

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Social environments, including the number and strength of relationships as well as indirect connections, have profound impacts on individuals' fitness. There is increasing awareness that these environments, often measured using social network analysis tools, can be affected by social disturbances, including group instability and demographic changes. This is relevant because social structure also directly modulates many population-level processes, such as disease transmission. We will discuss recent insights into the impact of social disturbances on group functionality, and the implications of network dynamics arising from social disturbances on population-level processes. The symposium will span empirical studies and social network theory, with the aim of highlighting areas in which social network analysis could give us insights into more effective conservation actions.

## **Disease implications of animal social systems and network structure**

PRATHA SAH

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Socially complex species that live in large groups are traditionally considered to have elevated risks of disease transmission. Beyond group size, it is being increasingly recognized that the dynamics of infection spread largely depends on the organization of contacts occurring in host populations. Consequently, network theory has emerged as a powerful tool as it provides a framework for incorporating host contact patterns into models of infectious disease spread. Comparing empirical networks has however proven to be challenging, and limited knowledge about the host-pathogen system has resulted in underutilization of network analytic approaches in wildlife epidemiology. Here, I address these challenges by utilizing an extensive empirical dataset of more than 600 animal social network of 47 species. Meta-analysis of this dataset reveals that only a few features of network structure distinguish different social systems and that the network organization in social species may not provide general protection against pathogens of various transmission potential. These findings offer new perspectives on the debate about the disease costs of group living by evaluating how social organization strategies mediate pathogen pressures.

### Supporting papers:

- Sah, Pratha, Jose David Mendez, and Shweta Bansal (2019). A multi-species repository of social networks. *Scientific Data*, 6(1), 44.
- Sah Pratha, Janet Mann and Shweta Bansal (2018). Disease implications of animal social network structure: a synthesis across social systems. *Journal of Animal Ecology*, 87(3), 546-558
- Sah, Pratha, Stephan T. Leu, Paul C. Cross, Peter J. Hudson and Shweta Bansal. Unraveling the disease consequences and mechanisms of modular structure in animal social networks. *Proceedings of the National Academy of Sciences*, 114(16), 4165- 4170.

## **Effect of early-life social experience on the development of individual social behaviour in ravens (*Corvus corax*)**

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In social species, the number and quality of relationships in which individuals are involved can have strong effects on their health, survival or reproductive success. In those systems, we can expect strong selective pressures on the cognitive and behavioural traits allowing individuals to better navigate their social environment, along with substantial inter-individual variation, because of heritable phenotypic differences but also in response to environmental conditions. In this regard, the early social environment - e.g., rearing conditions, quantity and quality of parental care - was found to affect the development of social competences and ultimately the expression of individual social behaviour in a diverse range of species. This was notably corroborated by the negative effects of early social deprivations, later altering individuals' social behaviour e.g., increased aggressiveness, lower propensity to associate with others. However, to date, the dynamics of environmental influences on the development of social behaviour has been hardly investigated, and little is known about the long-term effects of early life experiences. In particular, social experience has been typically viewed as a by-product of mother-offspring interactions, whereas the potential contribution of other peer interactions has received limited attention. In ravens, a highly social monogamous corvid species, we currently examine how early-life social experience shapes the expression of individual social behaviour in later life stages. To do so, we manipulate brood size of breeding pairs in our captive colony, to investigate how variations in upbringing conditions affect the patterns of interactions experienced by juveniles within their family unit (with their parents and siblings), and later modulate the way they interact with other peers i.e., nature, frequencies and distribution of social interactions. Preliminary results of the first year of study will be presented.

## Using social networks to identify the effects of environmental disturbances

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Anthropogenic activities such as recreational activities can disrupt the social dynamics of wildlife which can constitute a conservation problem. However, we are just beginning to understand how human activities can shape animal societies. Disturbance events can affect the social structure of a group, and thus generate a cost if changes in social interactions affect group-level outcomes. The effect of disturbances on social dynamics can be quantified using analytical approaches such as network theory. In this study, we experimentally induced disturbance by splitting replicated groups of zebra finches (*Taeniopygia guttata*) that had lived in stable colonies, to investigate the effects of social instability on social structure and group-level performance (foraging efficiency). We found that disturbance affected the social dynamics of the colonies. After a disturbance event, the average group size while foraging was smaller, and the social network structure of the colonies changed relative to the pre-treatment period. These changes subsequently reduced the efficiency of groups at foraging on ephemeral resources. Importantly, our results show that a single disturbance event can impact social dynamics and group performance, and that a sustained period of social instability can cause long-lasting effects and thus affect the resilience and stability of animal societies. Together, this suggests that social dynamics are sensitive to environmental disturbances, thus highlighting the necessity to better understand the factors that affect group stability and resilience, and its implications for wildlife conservation strategies.



## **Animal social network theory & wildlife conservation**

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Conservation and management of highly social and territorial species bring along their own specific challenges. Aggressive interactions, social fragmentation, social instability and disease transmission can heavily impact the viability of threatened and reintroduced populations. These conservation threats are not always simply density-related, but can strongly depend on the specific social structure and composition of a population. Indeed, recent studies have shown that social network structure can predict or influence population-level processes and individual fitness components, yet the logical role and formal application of animal social network theory for conservation have not been well articulated. Here, I will therefore outline how certain animal social network metrics might be used for understanding, predicting and potentially manipulating group and population-level dynamics of threatened and reintroduced species. Additionally, I will highlight and discuss recent applications of social network theory in conservation contexts. The primary aim of this talk is to stimulate the design of new practical tools and theory in this field and to inspire novel behavioural research and collaborations.

Supporting paper:

Snijders L, Blumstein DT, Stanley CR and Franks DW (2017) Animal Social Network Theory Can Help Wildlife Conservation. *Trends in Ecology and Evolution* 32: 567-577.

**MAIN SESSION III: DEFAUNATION: SPECIES FUNCTIONAL EXTINCTIONS AND THEIR SOCIO-ECOLOGICAL CONSEQUENCES**

**Defaunation: species functional extinctions and their socio-ecological consequences**

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Wildlife is hunted for food, trophies (most often skins, teeth, antlers and horns), medicines and other traditional uses (most hard and soft body parts) and as pets (especially primates, birds and reptiles). Individuals hunt tropical forest wildlife primarily to eat or sell it. In tropical rainforests worldwide, hundreds of species are hunted and consumed. In terms of weight and numbers, however, mammals make up the bulk of the trade. Wild meat is primary source of protein for the majority of forest families, but is consumed regularly in cities primarily as a luxury. In isolated communities, wild meat is often the most tradable item, in terms both of value-to-weight ratio and transportability. Considerable evidence indicates that commercial hunting has been growing in importance for some time with increasing numbers of hunters currently either earning or supplementing their incomes with the sale of meat. Such commerce increases the amount of hunting and reduces the sustainability of numerous wildlife species. While vulnerability varies among species and localities, uncontrolled exploitation could bring about marked wildlife population declines, and eventually the extinction of a number of hunted species. Coupled with threats from habitat loss and deforestation, global extinctions of the most sensitive species, such as primates, are likely as an accumulation of local disappearances. This may result in long-term changes in tropical forest dynamics through the loss of seed dispersers and 'ecosystem engineers' such as large forest mammals. The role of the wild meat consumption and trade is reviewed, and data presented on the impacts of overhunting in tropical rainforests. Data on how wild meat consumption and food security are linked are also shown. Better governance towards a more sustainable wild meat sector will ensure continuity of wildlife as well as safeguard the needs of people who use it.

## Getting the big picture: landscape-scale surveys to assess defaunation and target conservation efforts in Southeast Asia

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Both habitat degradation and unsustainable hunting have caused the widespread loss of larger vertebrate species (defaunation) across the world's tropical regions. Both defaunation drivers result in impoverished and homogenized faunal communities, often with unknown consequences for ecosystem services and functioning. To develop effective conservation strategies using limited conservation resources, it is imperative to understand (1) how these threats impact tropical faunal communities at regional scales, and (2) species distribution within select sites to prioritize areas for targeted conservation interventions. Because defaunation often occurs over large areas, it is important that standardized sampling approaches to assess defaunation are also carried out at appropriate spatial scales. We conducted landscape-scale surveys in two tropical Southeast Asian biodiversity hotspots facing different anthropogenic pressures (Malaysian Borneo: habitat degradation, Vietnam and Laos: unsustainable hunting). Each study area includes multiple study sites and spans more than 1,000 surveyed km<sup>2</sup> of tropical rainforest. We use a defaunation index and community occupancy models to assess the impact of different anthropogenic threats on species' functional extinction and species' occurrence at each site. Functional extinction rates were significantly higher in the hunted compared to the degraded landscape, and most species pairs found in both landscapes showed lower occupancy in the hunted sites. Our results suggest that unsustainable hunting may be a more severe short-term threat to tropical faunal communities than habitat degradation, and at a regional level, we call on conservation stakeholders to focus as much on poaching as on habitat preservation. Within the hunted landscape, we also used the results of our community occupancy models to predict species distributions across the individual study sites. We mapped species richness for threatened and endemic mammals to identify specific areas for targeted anti-poaching efforts. Together, our regional and site-level surveys highlight the advantages of using landscape-scale datasets to set conservation priorities in tropical biodiversity hotspots.

## Linkages between national economy and hunting offtake of the blue duiker on Bioko Island, Equatorial Guinea

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Wild meat in cities in the Afrotropics is a luxury item for which consumers will pay significant prices. Changes in household wealth can directly affect purchasing power, thus demand for wild meat may fluctuate according to changing economic circumstances. In Bioko Island, Equatorial Guinea, a large number of species are actively hunted to supply the country's capital, Malabo. We assessed daily hunting offtake of the blue duiker (*Philantomba monticola*), the most hunted and consumed species in the island, in a key hunting community during two different economic periods. The first period covered a phase of rapid national economic growth (August 2010-September 2013, 33 months) whilst the second included a time of recession caused by the drop in oil prices (November 2017-January 2019, 15 months). We employed three different measures of hunter offtake (catch per hunter -CC-, catch per hunting day -CD-, and catch per unit effort -CPUE-) to determine whether there was any indication of overexploitation during the first period and possible recovery in the second. The number of duikers shot or snared across the first period, significantly declined for the three measures between 40-60%. By contrast, in the second period two of the three hunting measures increased during the second period, Only CC was significant with values almost reaching original levels. The CD reached half of the original levels but CPUE remained constant. The immature-to-adult ratio significantly increased during the first period, while in the second period this measure significantly decreased. We suggest that these trends indicate an important decline in the population during the first period, but the possible recovery in the second. Our study provides an example on how fluctuations in the national economy can affect the intensity of hunting to supply urban markets.

## **Habitat selection in small-sized mammals along a defaunation gradient**

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Defaunation is characterized by the rapid loss of large-sized mammals in many areas where these species naturally occur. However, little is known about how surviving smaller mammal species adapt their ranging behaviour in response to the extinction of large species. Here, we evaluated habitat use by small mammal species in three sites (Ngouleminanga, Palestine, and Ndengue) representing a gradient of defaunation in the northern sector of the Dja Landscape (Cameroon). In each site, mammal abundance and habitat use data were collected along five transects (maximum length of 6km) in July and August 2017. The overall index of abundance of large mammals was 1.349, 7.719, and 18.492 in Ngouleminanga, Palestine, and Ndengue, respectively. In Palestine, where an intermediate level of large mammal depletion was noted, small mammals colonised a large array of habitat types compared to other sites. It is suggested that the extinction of large-sized mammals may result in competitive release and modifications of the ranging patterns and ecological niches of small mammals.

## **Impact of anthropogenic threat on forest elephants, people and the ecosystem**

THOMAS BREUER

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Poaching continues to lead to dramatic declines of forest elephant populations (*Loxodonta cyclotis*). While forest elephants show remarkable differences to their savanna counterparts, the long-term consequences of declines or local extirpation of these mega-gardeners has alarming consequences for the habitat they are residing. Here, I examine the potential repercussions of these threats and the related consequences for forest elephants. First, I briefly summarize our current knowledge about the demography and population recovery of forest elephants. Next I discuss the long-term effects of poaching and other anthropogenic threats for Central Africa's forest elephants. While forest elephant social organization is less known than those of savannah elephants, the close evolutionary history of these species suggests that they will respond to anthropogenic threats in broadly similar ways. The loss of older, experienced individuals in an elephant population disrupts ecological, social, and population parameters. Severe reduction of forest elephant populations within Central Africa's forests can alter plant communities and ecosystem functions. Poaching, habitat alterations, and human population increase are probably compressing forest elephants into protected areas and increasing human–elephant conflict, which negatively affects their conservation. We encourage conservationists to look beyond documenting forest elephant population decline and address the causes of these declines when developing conservation strategies. We suggest assessing the effectiveness of the existing protected-area networks for landscape connectivity in light of current industrial and infrastructure development. Longitudinal assessments of the effects of landscape changes on forest elephant sociality and behavior are also needed. I finalize the presentation by identifying important research topic that could substantially contribute to an improved understanding of forest elephants and will help to improve survival in a rapidly changing environment in the Congo Basin.

## **Defaunation and the role of traditional ecological knowledge for the conservation of tropical forest fauna**

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Deforestation and habitat loss, forest degradation and unsustainable hunting for subsistence and commercial purposes threaten forest fauna across the tropics. An increasing number of studies show that defaunation affects the ecological integrity, resilience and carbon storage potential of tropical forest ecosystems. However, defaunation is closely linked to social actors who make decisions on forest resource use and hunting of forest fauna. Thus, understanding how people make those decisions and to what extent local and traditional ecological knowledge can play a role to counteract defaunation and to support a more sustainable forest use in the future is of uttermost importance.

Nonetheless, global forest governance at present is mainly concerned with preserving tree cover and forests are being reduced to their carbon content. Despite the rhetoric of environmental co-benefits, biodiversity is treated as a rather empty concept and not as a functional component of forests. The local interactions between forest dwelling communities who harvest forest fauna is rarely considered in national forest policies or global forest governance. This omission of people and fauna and their interactions threatens the long-term effectiveness and equity of global and local efforts to protect and sustainably manage tropical forests. I present insights from an ongoing research project on defaunation and hunting practices in the Colombian Amazon where worldviews and local management practices differ substantially from nationally mandated as well as western scientific view of resource management of tropical forests and fauna.

## **Assessing risk in conservation translocation of species**

MARK W. SCHWARTZ, AVIV KARAOSOV-OLSON

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As changing climates, invasive species, and environmental degradation threaten species, one management option is to actively move at-risk species to new locations in order to protect populations. Various called assisted migration, managed relocation or assisted colonization, these actions are increasingly occurring beyond experimental cases. To responsibly respond to requests to translocate species on behalf of their conservation, resource managers require a framework to adequately assess risk. Working with the U.S. National Park Service, we have created a risk assessment tool to evaluate the potential adverse impacts of moving species into novel locations. This risk assessment is divided into four areas that include two attributes of risk to the translocated species: the risk of extinction lacking action, and the risk of adverse impacts to remnant populations through translocation. The other two aspects of risk include risks to recipient ecosystems in the form of risks to species, communities and ecosystem functions within the recipient ecosystem, but also assessing the risk of damage created by unexpected establishment and spread of the translocated species. We designed this risk assessment workbook with consultation of National Park resource managers in an effort to create a workbook tool that is both thorough and usable. We review both the process for creating this decision-support tool as well as the product we created.



**PARALLEL SESSION III: SMART TAGS FOR SMART ANIMALS; BUT ARE WE BEING SMART ABOUT WHAT WE ARE DOING WITH THEM?**

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The advances made in the solid-state electronics industry over the last few years have been remarkable and have catalysed the animal tag industry to create ever more sophisticated miniature devices, recording (and often even transmitting) multiple parameters simultaneously. In turn, this has led to a proliferation of animal tag-based studies, many of which have led to changes in the way we understand wild animals. But are we being smart about the way we conduct these studies? Many issues are important in this, including; deleterious tag effects, the ethics of tag attachment, smart sensor combinations, sampling rates, resolution, trade-off between transmission and storing technology, analytical techniques and the biological meaning of our results. This session will take a critical look at some of our practices in the broadest sense, highlighting exciting aspects for the future as well as examining how we might improve what we do.

Abstract written by Prof. Rory Wilson (Swansea University, Wales, UK)

## Modest means will take us a long way

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We suggest that the use of loggers to learn about animal ecology and behaviour can often be enhanced with relatively modest means. Progress is especially feasible by better a) acquiring and describing contextual information, b) visual data exploration with multi-variate displays and c) integrative modelling. These research activities are relevant for both state-of-the-art and older data sets, and are largely independent of the future progress in sensor technology. Moreover, they are providing the groundwork required for other research steps. At the same time, progress is warranted as some lingering constraints will increasingly hinder research progress when not resolved. Examples for each of the activities are provided by case studies and evidence for our claims is based on these case studies as well as recent literature.

Contextual information refers to (both transient and more stationary) environmental data as well as interaction with other organisms. We illustrate with studies on central placed foragers and long distance migration how this type of information can be acquired from (sometimes unexpected) external sources, complementary animal-borne sensors, but also through visual observation in the field. Matching spatio-temporal resolution and uncertainty of the contextual information with the resolution of the logging data is crucial. We explain a method to help finding an adequate match. It remains challenging to structure and curate contextual information - we list key problems and propose possible solutions.

The use of exploratory visualisation to check and interpret logger data is commonplace in our field. However, only few research teams have optimized these visualisations to provide linked views of multivariate data with flexible switching across scales and to smoothly browse and annotate truly large data sets. Yet these properties are crucial for to make progress. Using case studies on time budget analyses during migratory movement and the interpretation of accelerometer data to determine different types of bird flight, we illustrate both the power and necessity of such visualisation tools. We show what it takes to develop appropriate tools.

Integrative modelling is the use of a model to describe the contemporary understanding of a system. In the context of logging, integrative models can be used for purposes of clear communication, preparation for fieldwork and experimental design, or even sensor design. Typically, these are agent-based models which are parameter rich, require lots of input data, and contain some process descriptions and parameter values that are just best guesses. Even though the construction, evaluation and interpretation of a suitable integrative model for a study system is a considerable task, one can start with a very simple version and already have valuable output from the start. We illustrate how a simple model for forager behaviour provided interesting research hypotheses which will be tested in the field, how optimal sensor sampling frequency can be established by model-evaluation, and how observation models can be specified to provide insight in the actual information content of the measurements for the system under study.

Finally, we highlight how the three research activities that were discussed here relate to other important steps in ecological and behavioural research and provide an important infrastructure for better use and re-use of logger data to advance our research.

## How to plan a bio-logging study with high ethical standards?

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As technology is moving forward, and bio-logging devices are getting smaller and more affordable, the study of animal behaviour takes a new turn. There is however, a mismatch between tag miniaturization and relative tag mass experienced by tagged animals. This has two main reasons: (i) smaller species get equipped, (ii) more sensors are used to obtain more parameters and / or the duration of the deployment is increased resulting in larger batteries. While we are enthusiastic about the new avenues bio-logging has to offer, we advocate for thoroughly planned studies and encourage scientists to take into account more than rules of thumb based on relatively arbitrary proportions of a species' body mass. Equipping an animal can have profound consequences both on animals' welfare, and on the robustness of the results. Several studies have shown that bio-loggers can negatively influence species' survival, growth, reproductive success and behaviour. It is therefore essential to keep a scientific approach when designing new studies and to 'tag wisely'. We propose a general overview of the crucial steps to design such studies by going through three examples in different ecological contexts. We suggest to adapt the 3R rules originally developed to improve laboratory animal welfare. To avoid unnecessary tagging of new individuals, we strongly encourage collaborations and data exchange prior conducting new studies (*Replace*). Such an approach also allows preliminary analysis, which will sharpen the overall question and help defining the technical requirement of the new study. In light of this, a thorough risk assessment for tagging the study species is needed according to its biology and its ecology (*Refine*). We end by highlighting the importance of interoperability, and data sharing in this field, in order to limit our impact on the study species (*Reduce*) but also to increase the value of our research.

## **The position matters: Handicaps of bio-tagging in wild living Northern Bald Ibises *Geronticus eremita***

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A migratory population of Northern Bald Ibises (*Geronticus eremita*; *NBI*) is currently reintroduced in Europe, in the course of a LIFE+ project (LIFE NBI). GPS-tagging of the whole population is essential at this stage of the reintroduction, for overall monitoring and management reasons. Different types of devices are in use, fixed either on the lower or upper back of the birds.

Since 2016, we observed more than 30 birds with an opacity of the cornea in one eye, with varying intensity. Probably as deterioration of these observations two birds developed more severe changes like cataract, synechia, iridogenesis, and uveitis up to blindness. No infectious causative agent could be found in any of these birds despite thorough examinations. We found a strong correlative relationship between one-eye opacity and GPS-tagging. Only birds with solar powered GPS-device on the upper back were affected by the eye-impairment. We also found that birds with a lower degree of opacity recovered fast after removing their tags or change their position to the lower back, what supports the hypothesis of a causal relationship. Since birds sleep with the head on the back and one eye placed close to the device, the most parsimonious explanation for the symptomatic is a permanent slight irritation of one eye during resting and sleeping.

This position on the upper back seems to be also disadvantageous in another context. A preliminary study with free flying NBIs indicate impairing aerodynamic effects of devices, particularly if they are placed at the upper back of the bird. We discuss potentially far-reaching implications of these preliminary results for bio-tagging of birds and describe further topic-related investigations.

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## **Effects of bio-loggers on behaviour and corticosterone metabolites of Northern Bald Ibises (*Geronticus eremita*)**

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During the past decades avian studies have been profiting from the development of miniature electronic devices which can be attached to birds and allow long-term and long-range monitoring. However, for ethical reasons and in order to ensure data quality it is necessary to identify potential effects of tagging. In the present study, we investigated the influence of GPS-transmitters on behaviour (i.e. locomotion, foraging, general comfort behaviour, dorsal comfort behaviour between the wings, social interactions) and excreted corticosterone metabolites in a semi-feral, free flying and individually marked colony of Northern Bald Ibis (*Geronticus eremita*), an endangered bird species. We included 24 individuals, which were randomly assigned to three experimental groups: (1) logger group, birds were equipped with GPS transmitters mounted via harness and experienced handling procedure, (2) handling group, birds only experienced handling procedure without the harness, (3) control group, birds were neither equipped with GPS transmitters nor experienced handling procedure. No behavioural differences were found between the tagged individuals and the handling as well as unhandled control groups. However, individuals equipped with a transmitter excreted significantly more corticosterone metabolites one month after tagging. Our results suggest that at least over the time of our investigation GPS-transmitters did not measurably affect behaviour in the Northern Bald Ibis. However, they affected the hypothalamic-pituitary-adrenal reactivity calling for long-term studies; for instance, investigating potential effects on reproductive success. As the Northern Bald Ibis is listed as endangered, evaluating possible adverse effects of bio-logging is also relevant for potential conservation and reintroduction projects.

## Advanced instrumentation and analytics for wildlife protection

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Illegal harvesting of wildlife is one of the world's most profitable criminal industries, rating fourth-largest after trade in drugs, humans and arms. It is currently a top threat to many iconic species, e.g. elephants, pangolins, tigers and rhinos (poached for their ivory, scales, bones and horn, respectively), with cascading effects on other species. Solutions to global demand, corruption and trafficking are far-off, whilst current anti-poaching practices fail to prevent the population decline of endangered species. One of the keys to successful wildlife protection is the acquisition of a timely warning in case of a poacher intrusion, so that preventive action can be taken. Animal sentinels could be central to this pursuit, as the evolution of anti-predator traits has resulted in prey animals that are adept in identifying and responding to perceived threats. Especially species that are abundant in the vicinity of poached species, yet no targets themselves, could provide a timely cue that a poacher is *en route*. Here we use advanced technology to track, in real-time, the movements of 130 animals of 4 herbivore species through an African savanna, and show that their behavioural signatures indicate the presence of a poacher. Of 80 experimentally staged poacher intrusions, our trained machine learning algorithms were able to detect and localize the intruders with 86% accuracy, exclusively using movement data of non-targeted prey species. We thus provide proof of concept that insight into the movement ecology of sentinel animals and advancements in distributed wireless sensor networks can be combined to produce an early warning system against poachers. Apart from advancing our understanding of reactive responses of prey animals to human-induced disturbances, our findings thus have important ramifications for wildlife protection, nature conservation and possibly other areas where sentinel animals can assist human interests through providing a timely warning.

## PARALLEL SESSION IV – PANEL DISCUSSION: DEFAUNATION – FROM CONSERVATION SCIENCE TO CONSERVATION ACTION

STEFAN ZIEGLER<sup>1</sup>, ARNULF KÖHNCKE<sup>1</sup>, ANDREAS WILTING<sup>2</sup>

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<sup>2</sup>Leibniz Institute for Zoo and Wildlife Research, Berlin, GERMANY

### The Panel:

**Prof. John Fa** (Manchester Metropolitan University, UK and Center for International Forestry Research, INDONESIA): One of the leading scientists surrounding the exploitation of bushmeat in South America and Central Africa; did a number of field studies on consumptive use of wild animals in Central Africa, published numerous scientific papers on bushmeat consumption, sustainable use of bushmeat, role of bushmeat in terms of malnutrition of children, bushmeat as source of zoonotic diseases (e.g., ebola).

**Andrew Tilker** (Leibniz Institute for Zoo and Wildlife Research, GERMANY): Tropical ecologist with a focus on ecology and conservation of endangered mammal species, extensive fieldwork experience in Vietnam and Laos, interest in using robust survey methods to inform conservation strategies, especially in areas subjected to increasing levels of hunting-driven defaunation.

**Frank Barsch** (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, GERMANY): Biologist by training, spent several years as development worker in Botswana, focusing on species conservation, Community-Based Natural Resources (CBNRM) and sustainable trade issues. He worked for WWF and TRAFFIC on similar tasks, joined the BMU species protection team about 10 years ago in the area of CITES and Illegal Wildlife Trade. He now is in the BMU Division for international Cooperation on Biodiversity, being responsible e.g. for biodiversity projects of the International Climate Initiative (IKI) of BMU.

**Martin Bostroem** (KfW Development Bank, GERMANY): Agricultural Engineer/Economist, started his career at FAO, spent 4 years as expert for rural development for GIZ in Tunisia. Since 2000 project manager in KfW / Frankfurt. Since 2006 mainly responsible for projects in the field of sustainable resource management with a focus on protected areas in the Congo Basin and (since 2014) in Madagascar.

### Facilitator:

**Marion Junkersdorf** (World Wide Fund for Nature, GERMANY): Marion Junkersdorf has been with WWF since 2003, her field is the organization of WWF's political communication. She holds the Diploma in Translation and is in charge of event management with growing numbers of events and guests out of the realms of politics, media, industry and civil society. She ensures that all political communication is clear and professional, and she makes sure that all political WWF events go by the same high standard and quality.

### Abstract:

In the 1990s, the term of “empty forest” was first mentioned to describe the extirpation of forest mammalian diversity. There is no doubt that hunting poses a major threat to the persistence of wildlife throughout the tropics. Hunting pressure is obviously triggered by environmental variables and anthropogenic pressure, and it seems that many protected areas are located in high-risk areas. In 2000, John Robinson & Liz Bennett, in their seminal book ‘Hunting for Sustainability’, invoked an image of the slippery concept of sustainability

by comparing it to Lewis Carroll's 'snark', an imagery animal difficult to track down. Almost two decades later, we are probably just as far away from tracking down the fabled animal. In other words, our understanding of the sustainability of hunting in the tropics is still incomplete. But, although we do know much about who hunts and why, as witnessed by the large number of studies that have been published on hunting in the tropics, our understanding of how much is extracted is still sketchy. Knowing where extraction of wild meat occurs is a prime importance in understanding how to tackle the problem of overexploitation of wildlife. After all, bushmeat extraction, which has no doubt increased substantially during recent decades, is perhaps the most pervasive threat to biodiversity in tropical forests worldwide. In recent years, the magnitude of the global illegal wildlife trade has increased significantly, and several new studies indicate that unsustainable hunting may be a greater threat to tropical biodiversity than deforestation. Defaunation has myriad ecological and socio-economic consequences. The disappearance of large vertebrate species, for example, can degrade ecosystem services, change evolutionary trajectories, and even impact human health. This panel discussion will provide a platform for scientists, conservation practitioners, and the donor community to take a critical look at how current conservation strategies can be strengthened to deal with this global challenge. The discussion will focus on ways to integrate findings from recent scientific studies into conservation actions that can effectively address the defaunation crisis.



**PARALLEL SESSION V: RECENT ADVANCES IN CAPTURE-RECAPTURE STUDIES WITH APPLICATIONS IN WILDLIFE RESEARCH AND CONSERVATION**

OLIVIER GIMENEZ<sup>1</sup>, LUCILE MARESCOT<sup>2</sup>

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Studying wildlife populations is challenging because not all individuals can be captured, identified and monitored exhaustively and continuously. Capture-recapture methods (CR) are a powerful tool to study individual life-history and behavioral traits and connect them to the dynamic of free-ranging populations. CR is also key to evolutionary demography through the inference of demographic parameters and establishment of causal assumptions between biological processes and environment, while accounting for individual heterogeneity and imperfect detection. In this session, recent applications of CR methods are presented, including the study of trade-offs between reproduction and survival, dominance and parental care, foraging and anti-predation vigilance, resistance and tolerance to pathogens, providing a better understanding of changes in population size and composition, inter-specific interactions and coevolution as well as insights for conservation

## **Capture-recapture - Ecological questions, methods**

OLIVIER GIMENEZ

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In this talk, we review recent advances in capture-recapture over the period 2009-2019. Using bibliometrics and textual analyses, we analyse the content of > 5000 scientific papers. We go through the ecological questions that capture-recapture allows to address as well as the recent methods that have been developed. Based on our review, we eventually discuss the future of capture-recapture.

## **Studying the fitness costs of infection when health status is uncertain for some individuals: a case study of canine distemper virus infection in Serengeti spotted hyenas**

LUCILE MARESCOT

CNRS, Biostatistics, FRANCE; Lucile.marescot@cefe.cnrs.fr

The extent to which the fitness costs of infection are mediated by key life-history traits such as age or social status is still unclear. Within populations, individual heterogeneity in the outcome of infection is the result of two successive processes; the degree of contact with the pathogen (exposure) and the immune response to infection. In social mammals, because individuals holding high social status typically interact more frequently with group members, they should be more often in contact with infected individuals than those of low social status. However, since individuals with a high social status often have priority of access to resources, they have a greater opportunity to strengthen their immune system and to recover from infection. Such health-related costs and benefits of sociality have rarely been quantified in wild animal populations, possibly because of the difficulty to assign infection states. Recently, there has been an upsurge in statistical methods to account for uncertainty in the detectability and assignment of individual infection states. Such uncertainty can be treated as a hidden Markov process in Multi-Event Capture-Recapture (MECR) models, which allow disentangling the relative importance of individual exposure and resource allocation to immune processes. Using such an approach, our study provides the first quantification of the demographic impact of a virulent Canine Distemper Virus (CDV) outbreak in a free-ranging population of spotted hyenas monitored continuously since 1987 in the Serengeti National Park, in Tanzania. Our results provides evidence for fitness costs of infection for juveniles, particularly those with low social status and showed that high-ranking females were likely to contribute to population recovery after the CDV outbreak. Such recent advances in capture-recapture studies provide insights for the study of disease transmission and persistence in social mammals.

## **Uncovering population dynamic, habitat use, and life-history trade-offs in bats and birds using capture recapture models**

ANTICA CULINA

Netherlands Institute of Ecology, Wageningen, THE NETHERLANDS

Wild populations and the biological processes happening in them are often difficult to study because animals are usually observed in discrete-time periods rather than continuously. Multi-event capture models are a powerful tool to study these processes when only a partial and sometimes biased information on the individuals are available. In this talk, I will showcase a diverse use of multi-event framework for addressing questions on the interface between conservation, population ecology and evolutionary ecology. In the first case study, we look into survival rates of three bat species, and study these in relation to sex, age, and climate. The second case study aims at determining the most important roosting areas for three bat species, and the most important landscape characteristic that make a roost attractive. In the third case study, we look into life history trade-offs between survival and reproduction in long-lived, income breeders. The final case study examines a demographic process of divorce in populations of three species of birds, and its previously neglected consequences for survival of individuals.

## **Impact of climate and fisheries on seabird demography**

CHRISTOPHE BARBRAUD

CEBC-CNRS, FRANCE

Seabirds are among the most threatened bird families of the world. Estimating the impact of climate change and human activities on seabird populations remains a challenge and a priority for their conservation. Fisheries and other anthropogenic activities may act simultaneously with climate on population dynamics, and demographic information is often incomplete. Population surveys, capture-recapture, demographic and population modeling provide useful tools to investigate the effects of climate and human activities on seabird populations. I first illustrate how state-space models based on population surveys can give insights on the way seabird populations are regulated by climate, density dependence and fisheries. I then present several case studies to show how the underlying demographic and ecological processes involved can be revealed by capture-mark-recapture analyses combining climate data, fisheries data and behavioral data. There is also a growing concern for an impact of new stressors linked to human activities on seabird demography, such as contaminants. Matrix population models and integrated population models including multiple demographic parameters can allow estimating the combined effects of several environmental drivers on the population dynamics and their relative importance. Finally, I show how demographic modelling and ecological knowledge can be used for seabird conservation.

## Studying foraging strategies by multievent capture-recapture models

ANA SANZ-AGUILAR

University of Balearic Islands, SPAIN

Populations of species typically considered trophic generalists may include specialised individuals. Optimal foraging theory states that individuals should feed on those resources most valuable to them. This, however, may vary according to individual differences in detecting or processing resources, different optimization criteria, and competitive abilities. White storks (*Ciconia ciconia*) are trophic generalists at the population level. Their European population recovery has been attributed to increased wintering in Southern Europe (rather than Africa) where they feed upon new anthropogenic food subsidies: predictable dumps and less predictable and more difficult to detect but abundant invasive *Procambarus clarkii* crayfishes in ricefields. We studied the foraging strategies of resident and wintering storks in SW Spain in ricefields and dumps, predicting that more experience in the study area (residents vs. immigrants, old vs. young) would increase crayfish specialisation. We developed the first multievent capture-recapture model to evaluate behavioural consistency, analysing 3,042 observations of 1,684 banded storks. There were more specialists among residents (72%) than immigrants (40%). All resident specialists foraged in ricefields, and ricefield use increased with individual age. On the other hand, immigrants specialised on either dumps (24%) or ricefields (16%) but the majority were generalists (60%). Our results provide empirical evidence of high individual foraging consistency within a generalist species and a differential resource selection by individuals of different ages and origins probably related to their previous experience in the foraging area. The use of multievent capture-recapture modelling has proven useful for studying inter-individual variability in behavior.

## **Challenges and promises of large-scale spatial capture recapture**

PIERRE DUPONT, CYRIL MILLERET

Norwegian University of Life Sciences, NORWAY

Population monitoring and abundance estimations are essential for wildlife conservation and management. Non-invasive methods, such as non-invasive genetic sampling (NGS), are now routinely used to survey populations. In the last few years, many studies demonstrated that NGS, in combination with spatial capture-recapture models, can provide robust population density estimates. However, monitoring large carnivores at the population scale is challenging, as individuals are elusive and have large space requirements. In addition to the logistic and financial challenges of maintaining long-term and large-scale population monitoring, new analytical methods are necessary to overcome the computational challenges associated with the analysis of such large data sets. Using the example of the long-term monitoring of wolverines, bears, and wolves in Scandinavia, we showcase recent and potential advances in SCR.

**PARALLEL SESSION VI: HUMAN-WILDLIFE INTERACTIONS: COMING FROM BOTH SIDES**

LYSANNE SNIJDERS<sup>1</sup>, TANJA STRAKA<sup>2</sup>, SOPHIA KOCHALSKI<sup>3</sup>, MAARTEN JACOBS<sup>4</sup>

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Co-existence between people and wildlife: What does it mean for humans but also for wildlife? With humans increasingly moving into habitats of wildlife and wildlife returning into previously used habitats, landscapes are getting more and more shared and interactions between humans and wildlife are unavoidable. How do we currently deal with these situations and how do we want to deal with them in the future? What management strategies exist beyond the extremes of lethal control or doing nothing, and should these be preferred? In this session, researchers and practitioners share their experiences and lessons learnt, followed by a panel discussion to explore perspectives from 'both sides' together and to set (new) research priorities.



## **The hard problem of conservation: Doing good is not good enough**

MAARTEN JACOBS

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Conservation is a social challenge. Naturally, biological and ecological challenges do exist. These are the soft problems of conservation. Soft does neither mean easy nor imply that required knowledge-production is easy. Soft means that these challenges are focussed and well-understood. And by extension, solutions in terms of adequate technical interventions are conceivable. The hard problem of conservation is to get it done in societies with a diversity of people. Conservation practices imply working with people with different livelihoods, desires, and perspectives on what is good and bad. The Oostvaardersplassen case, a fenced conservation area in The Netherlands, illustrates the ethical dimension of the hard problem. Public outcry frequently occurred as a substantial amount of large herbivores is starving at the end of the winter due to lack of edible vegetation. The tension between conservationists and segments of the public has built up over the years to become explosive in 2018 as conservationists even received death threats. Conservation managers believed starving was acceptable as being part of nature, and by natural selection contributing to fit populations. Many citizens believed starving was unacceptable as it implies suffering of animals. Becoming each other's enemies, both sides in this pressing conflict have failed to recognize common ground. Both sides care a great deal about animals and both sides feel strongly ethically motivated. However, conservationists project their ethics onto the level of populations, while citizens project their ethics onto individual animals. Thus, a second order difference became a first order conflict. The case teaches us that accepting diversity and identifying common ground are crucial. This does not necessarily lead to a solution, but softens the hard problem to open the way to explore potential solutions. Differences in ethical perspectives are probably the heart of the hard problem. Conservationists need to face this challenge.

## **A compassionate conservation perspective on the conflict between protecting ecosystems and species rather than individuals, and possible solutions**

DROR BEN-AMI

Compassionate Conservation Middle East, Tel Aviv University, ISRAEL

The need to protect ecosystems from change, safeguard certain wildlife species from harm by other species, and manage human-wildlife conflicts, coupled with a disregard for the individual wild animal, has given rise to conservation management practices that cause significant harm, in the form of death and pain, to wildlife by humans. For example, non-native wildlife are routinely shot and poisoned to dilute their numbers and the supposed impact on native wildlife and ecosystems; emergent (“irruptive”) species are killed to lessen their impact on other wildlife; human-wildlife conflict in agricultural and urban contexts is usually resolved by killing wildlife; and, trophy hunting is supported by many conservationists as sustainable conservation.

There is also a growing animal protection movement, including animal welfare and animal rights, that recognises and elevates the sentience and intrinsic value of individual animals. Vegan/vegetarian populations are increasing globally. There are political parties that support animal rights. Thus, all spheres of human activity including social, economic, medical, and environmental activities, need to consider the rights of animals. Increasingly, the conservation and animal rights movement are in conflict. Both represent strong well-founded ethical positions that clash when either certain conservation measures are taken like culling populations that are too large for their environment or opposing the killing of a potentially harmful non-native species. Who’s right? What should the conservation biologist do?

Interestingly, there are indications that the animal protection ethic is also broadly accepted in relation to wildlife. A recent survey of the general population in the US, and conservators and hunters, showed that 69% to 87% of the different groups acknowledge the intrinsic value of individual wild animals. Thus, the non-anthropocentric view is pervasive and suggests that there should be a common ground between various conservation stake-holder groups.

Although there is no comprehensive remedy, compassionate conservation strives to resolve conflicts between conservation and animal protection by merging conservation and animal protection for improved conservation outcomes by adhering to simple guideline of conservation action: First, do no harm; that is, in the medical sense. Second, individual wild animals are important; they have intrinsic value and are often a repository of information and important for social stability. Third, wild animals should be de-categorized because the categorization of animals shapes our attitudes towards them, for example, ‘pest’, ‘feral’, ‘invasive’. Fourth, we should strive for peaceful co-existence with wildlife, by sharing space with nature and minimizing conflict between humans and wildlife.

## **Inverse relationships between wildlife conservation, tourism development and human growth: The case of Ngorongoro Conservation Area, Tanzania**

FREDDY MANONGI

Conservator, Ngorongoro Conservation Area Authority, TANZANIA

Ngorongoro Conservation Area was established in 1959 as a multiple land use model where humans were allowed to reside inside the conservation area. Since its inception on 1959 conflicts between conservation, tourism and human development in NCA have reached a critical point where any strategic investment in human development has corresponding negative consequences on wildlife conservation, tourism development and management, and vice versa.

Recent studies clearly indicate waning relationships between the people of NCA and the Authority resulting from weakening human conditions of the people of the NCA due to water shortages, income poverty, problem animals, food insecurity, poor health and worsened education conditions in the area. Results also show that there seems to be a converse relationship between achieving optimal outcomes of conservation and tourism and worsening conditions of the people of the NCA based on established national and global standards of human development. More efforts to conserve biodiversity and cultural heritage seem to adversely restrain or confine human development conditions thus render the multiple use model unsuitable and unsustainable in a tropical landscape dominated by wildlife.

## **Understanding Maasai and large carnivore relationships in Ngorongoro Conservation Area, Tanzania**

ARJUN DHEER, TANJA STRAKA, OLIVER HÖNER

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Local communities hold the key to wildlife persistence given that their support is crucial to the long-term success of wildlife conservation and management outcomes. Therefore, understanding what people think and feel in relation to wildlife in their surroundings/area is essential to establish how best to promote coexistence. In areas that support both large carnivores and pastoralist communities, human-carnivore conflict is a pressing issue due to human and livestock population growth and concurrent attacks by carnivores on livestock. In this study, 100 members of Maasai tribe, a semi-nomadic pastoralist community in Ngorongoro Conservation Area, Tanzania, were surveyed in structured interviews with closed questions. We assessed a subset of wildlife value orientations as well as emotions and attitudes of the Maasai towards the three carnivore species: spotted hyenas (*Crocuta crocuta*), lions (*Panthera leo*), and leopards (*Panthera pardus*). In addition, we collected demographic data and information on annual livestock loss to the three carnivore species and disease and drought. Using this social science framework, we determined the underlying factors determining the attitudes of Maasai in the Ngorongoro Conservation Area towards large carnivores and their management. In addition, we assessed total monetary loss incurred by carnivores in comparison to disease and drought in order to understand the main cause of livestock loss. This information might be useful to inform decision makers when working together with Maasai and other pastoralist communities in sub-Saharan Africa and other regions.

## **Human-kangaroo interactions in suburban ecosystems: An emerging challenge for managers, people and kangaroos**

CATHERINE A. HERBERT, MAQUEL E. BRANDIMARTI, FABIOLA R.O. SILVA, AARON SMITH, GEORGIA THOMAS, HOLLY R. COPE, DEREK SPIELMAN, RACHAEL GRAY

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Australia is one of the most urbanised nations in the world; up to 90% of the human population live in urban areas and 85% live within 50km of the coast. The human population is concentrated along the east coast, overlapping with the range of one of the most abundant herbivores in Australia, the eastern grey kangaroo (*Macropus giganteus*), which has an estimated population of over 10million individuals. Given these figures, it is surprising that human-kangaroo conflict has not received more attention in peri-urban areas to date. However, that is about to change. Regional areas along the east coast are rapidly urbanising. Former agricultural land, a preferred habitat of kangaroos, is being converted to residential estates at an unprecedented rate, combined with large transport infrastructure projects. The end result is fragmentation and isolation of kangaroo populations along the coast. We studied kangaroo populations dynamics, movement patterns and health at four coastal peri-urban sites. Kangaroos in these areas have small home ranges (females =  $8.1 \pm 1.2\text{Ha}$ ,  $n=20$ ; Males =  $12.6 \pm 4.2\text{Ha}$ ,  $n=10$ ), and at some sites their core activity areas overlap entirely with residential properties. Conflict is frequently reported at these sites, with kangaroo attacks on people generating fear and promoting a culture where land-owners exclude kangaroos from their property using fencing. When this is coupled with a reluctance to cross major roads, kangaroo populations are faced with diminishing habitat, isolation and unsustainable population densities. In some isolated peri-urban reserves kangaroo population densities exceed  $500/\text{km}^2$  and are associated with widespread ill-health, including poor body condition, nutritional stress, non-regenerative anaemia and high levels of parasitism. There are no winners at present. Successful co-existence in the future will, at a minimum, require policy changes which necessitate the inclusion of kangaroo management plans as part of infrastructure development applications in high risk areas.

## **Social hubs of an unsocial cat: Cause and solution for the human-cheetah conflict**

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Cheetahs naturally occur at low densities, which makes it unlikely for two individuals to meet by chance. With GPS data of >200 collared cheetahs (*Acinonyx jubatus*) we investigated their socio-spatial organisation. We detected a striking intraspecific communication network consisting of a regular pattern of communication hubs within the landscape. Each of these hubs was owned by territorial cheetah(s) which maintained numerous marking sites within the hubs. These marking sites were regularly visited by non-territorial males, which oscillated between two or three hubs, and irregularly by females. This spatial pattern was stable over consecutive cheetah generations. This is a unique system within mammalian species and offers exciting further research questions in understanding territoriality, mate choice, intraspecific communication and providing a key to mitigate human-cheetah conflicts. Namibia hosts one of the worldwide largest free-ranging cheetah populations. Most cheetahs roam on farmland where they come in conflict with livestock farmers. We showed that regular visitations of the communication hubs by various cheetah individuals created local 'hotspots' of cheetah density in these hubs and thereby increased the local predation risk for livestock animals. Shifting the cattle breeding herds away from these hotspots during the calving season drastically reduced losses. This is because cheetahs retained their spatial distribution pattern and preyed on naturally occurring prey species. Our approach of exploiting research insights of the socio-biology of conflict species to promote coexistence between humans and predators opens a promising area to develop solutions also in other conflict species with non-homogenous space use.

## Why are the wild fish in the seasonal irrigation channels?

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Taurus Mountain ranges stretch along the entire Southern Mediterranean coast of Turkey and beyond, towards the Eastern regions of Turkey. Large and small, numerous streams of the Taurus Mountains are the source of rich and lush landscape of the lower Mediterranean coastal regions. This environment of abundant flora and fauna has also been home to many agrarian settlements for centuries. Particularly, with the rising population, changing life styles and the increasing variety of usages of natural resources in the recent years, the pressure on the wealth of environment is alarmingly on rise. As a result, the region is subject to many forms of human-wildlife conflicts, irrigation being a significant one.

Local rural communities irrigate their gardens and fields with the traditional flood irrigation methods. With this method water is simply diverted into man-made trenches that are connected to the natural stream beds in their upper elevations. Water flows through the trenches via gravity along the banks until it reaches villages, gardens and fields. With this gravity based 'free-flow flooding' method vast number of migrating fish is misguided into dead-end trenches and eventually to the fields as the 'sink holes' of their aquatic habitats. Many fish in this habitat are *potamodromous* who migrate upstream to spawn then the juvenile migrate back to the larger body of water in the lower streams. Such diversions of irrigations interfere with the juvenile fish migration and direct them to the sink holes. Hence, "Why are the wild fish in the seasonal irrigation channels?" becomes a big question. In an attempt to respond to this question, first an innovative technical solution was implemented in the field which failed. In the second term however, not only the technical dimension was improved but it was also supported by a social dimension. This work specifically concentrates on the potentials of human dimensions of habitat conflict resolution.

## **Reverse NIMBYism: Human-human conflict resulting from human-wildlife conflict**

BEN KLINKENBERG

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NIMBYism (“not in my backyard”-ism) can block reintroduction through a lack of or reduced support towards reintroduction of species from those who live within the reintroduction area. Reverse NIMBYism is the concept of those outside of the reintroduction area have a lack of knowledge or ignorance to human-wildlife conflicts created by the reintroduction of species. This creates human-human conflicts over management of reintroduced species and can lead to unsuccessful or unsupported reintroductions. This study examines how reverse NIMBYism has created conflicts surrounding wild boar and other reintroductions in the Forest of Dean, UK.

Wild boar (*Sus scrofa*) were reintroduced into the Forest of Dean 20 years ago with approximately 1500 wild boar in the Forest of Dean currently. Data were collected from interviews and questionnaires completed by those who use and are local to the Forest of Dean. Data revealed those living within the Forest of Dean conflict with those outside the Forest of Dean over the reintroduction and management of wild boar. This has been aggravated due to those within the Forest of Dean feeling that those outside do not understand or care for the issues with wild boar because those outside of the area are not experiencing those issues. This conflict is escalated by outside organisations profiting from the reintroduction of wild boar despite locals suffering damages.

These issues have created further conflict over the reintroduction of Eurasian beaver (*Castor fiber*) and potential reintroduction of European pine marten (*Martes martes*) in the Forest of Dean. These conflicts can be resolved through (1) initial discussion between conservationists and locals, (2) the provision of funds to mitigate negative effects of species reintroduction at the start of the reintroduction and (3) giving more weight to local life, opinions, and knowledge when studying the feasibility of reintroducing a species into an area.



## **Analysis of conflict reduction strategies in Iran; Case study: Kharvana district, East Azerbaijan province**

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Nowadays population growth and increasing human activities in the natural environments lead to encroachment human activities in wildlife habitats, which increase human-wildlife conflicts, especially with carnivores. The investment of livestock owners and natural conservationists for mitigating these inconsistencies is vital. There is more evidence of an increasing trend in the complaints reported by Kharvana herders on wolf damages. This study aimed to capture people attitudes about wolves and investigate the familiarity and feasibility of five nonlethal methods for reducing the wolf depredation on small livestock (goat and sheep) in the region of interest. To conduct this study, 15% of the herders in each village from Kharvana were selected for interviews. The herdsmen who possessed the big number of livestock and had been for a long time in herd activity were subjected to interview. We totally analyzed survey responses from 77 Kharvana-based herdsmen. Surprisingly, the results of the study indicated that although the majority of survey respondents reported an insufficient current level of protection and had a high desire to eliminate and kill wolves, there was a notable number of responses that were neither agree nor disagree of having experienced negative impacts from wolves. We found that there is a perceived feasibility of implementing all five strategies in areas where are used as wintering feeding sites which called Geshlag compared to areas are allowed to be grazed during warm part of the year called Yeylag. The use of herd dogs (median rank = 1) was the most and significantly locally-feasible conflict reduction strategies (Friedman  $X^2(4) = 169.4$ ,  $P < 0.0001$ ) for inclusion in conflict reduction programs which have already being used in the Kharvana area by the most herdsmen.

## **Community led conservation in the Littoral Region, Cameroon: Five years experiences with the “Club des Amis des Gorilles” to save Ebo Gorilla**

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The Ebo forest is under threat due to over hunting and land occupation. Our main goal with this study consisted to assess whether empowering communities conservation initiatives can effectively contribute to preserve natural resources in the Ebo ecosystem. We did a literature review and apply questionnaire to villagers and stakeholders to appreciate the impacts of the Community association baptized “*Club des Amis des Gorilles*” (CAG) in wildlife preservation within the Ebo landscape. These groups were initiated in three closest villages to the Ebo gorilla habitat with objectives to undertake various conservation activities that include: the environmental/education/sensitization of the population, wildlife survey, and the promotion of small-scale livelihoods activities for their members. As results, these groups are legal association gathering volunteer that committed themselves for conservation. After 5 years of existence, CAG have increased people attention about the Ebo biodiversity. 80% of villagers acknowledged their pride for Ebo gorilla and other wildlife thanks to CAG. This study confirmed that, Ebo gorilla live in sub-mountain mature forest with dense herbaceous undergrowth and open canopy. Much of the gorilla are mature referring to their nest diameters. They mostly sleep on a ground herbaceous nest dominated by Zingiberaceae or fence species. Hunting is the main threat for gorilla in this forest. CAG received 1800 \$US from this NGO-EFRP and the fund helps to implement some micro-projects that contributed to improve life condition in the community.

We conclude that communities association can play a great role in biodiversity conservation in this region. However to ensure a long term conservation program in this ecosystem, we propose to increasing households incomes with substantial livelihood activities and the promotion of ecotourism in the region, which no doubt will lead to the improvement of community welfare.

## **Prioritising communities to enable an environment for coexistence with carnivores: Case studies from Kenya and India**

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The loss of large mammal populations has been widely discussed within the literature. Although significant attention is given to the illegal wildlife trade and habitat loss, conflict between people and wildlife is an increasingly serious challenge, particularly in landscapes with large carnivore populations. Here, we discuss the Born Free Foundation's prioritisation of community-level interventions in order to achieve coexistence with lions in Amboseli National Park, Kenya and tigers in the Satpuda Landscape, India. Amboseli is a stronghold for the lion population of Kenya, which has seen major declines in the last twenty years to approximately 2,000 individuals today. Similarly, the Satpuda Landscape offers perhaps the best hope for India's remaining 2,229 wild tigers. However, both landscapes are heavily populated and carnivore depredation of livestock and attacks on people are a considerable problem for local communities. As a result, both lions and tigers are subject to retaliatory killings. The attitudes and actions of local communities become critical for safeguarding wild carnivores. Born Free's compassionate conservation approach aims to reduce human-wildlife conflict by implementing community-level measures that serve to prevent, mitigate or respond to conflict events. These initiatives are compatible with traditional ways of life, improve health and wellbeing of local communities and enable an environment and the capacity for coexistence. We present the successes of the 'Predator Proof Boma' project in Amboseli, where the lion population has quadrupled since 2010, and discuss our approaches in achieving coexistence with tigers in the vast, complex and human-dominated Satpuda Landscape. Experiences and lessons learnt during a combined 24 years of managing human-carnivore conflict at these two sites suggest that human behaviour change is key to achieving coexistence and that the involvement of the local people living within carnivore habitat is crucial in conservation programmes.

## **MAIN SESSION IV: HORMONES, INDIVIDUAL PLASTICITY AND FITNESS**

### **Hormones, individual plasticity and fitness**

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In natural settings, individuals are continuously exposed to changes in environmental and social conditions. Hormones are signals that mediate adjustments in behavioral and physiological phenotypes to such fluctuations in the environment. However, it is still unclear why individuals vary substantially in hormone concentrations when exposed to similar environmental stimuli and whether certain endocrine phenotypes gain higher fitness benefits than others. Recent work has shown that genetic components explain some of the among-individual variation in steroid hormone concentrations, though heritability estimates were low for baseline hormone concentrations in undisturbed individuals. Hormone concentrations also change in response to stimuli, thereby mediating important phenotypic adjustments. Plasticity in hormone concentrations rather than absolute levels may therefore be more repeatable and more strongly tied to fitness. We study individual variation in absolute and plastic components of hormones in wild great tits (*Parus major*), focusing on the metabolic hormone corticosterone (the main glucocorticoid of birds). At low baseline concentrations, glucocorticoid hormones facilitate adjustments in metabolic physiology and regulate behavior. In our previous work absolute concentrations of baseline corticosterone were correlated with nestling provisioning rates and reproductive success in great tits. However, the direction of the relationship with reproductive success depended on the season in which individuals were sampled, suggesting that seasonal plasticity is important for the relationship with fitness. Our current work utilizes a reaction norm approach to analyze a multi-year dataset on wild great tits. First, we investigate whether individuals differ consistently in absolute concentrations and plastic changes of baseline corticosterone. Second, we analyze environmental and internal factors that explain variations in absolute and plastic components of baseline corticosterone. Finally, we ask whether components of individual hormonal phenotypes are related to fitness. Our work aims at improving our understanding of the evolutionary processes that shape hormonal phenotypes.

## Physiology in a long-lived seabird: What can we learn from a longitudinal study?

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To understand individual variation in physiology, ecologists have focussed on the roles of life-history trade-offs and environmental variation; however, longitudinal studies that span the lifetimes of animals are scarce. Such studies are especially important since trait expression is often affected by viability selection and ontogenetic processes, both of which can affect trade-off resolution. Therefore, we analysed longitudinal individual-based data related to several axes of physiology, including innate immune parameters and hormone levels. These data were collected as part of an exceptionally detailed multi-decade study of the common tern (*Sterna hirundo*), a long-lived seabird. We evaluated how these parameters varied with age by assessing the roles of both within-individual change and selective (dis)appearance, and we assessed to what extent these parameters were correlated with each other and with fitness components in order to identify potential trade-offs.

## **Temporal organization of male sexual behaviour in lizards: Why is necessary to follow time series in the studies of hormonal control**

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In vertebrates, male sexual behaviour (MSB) is largely controlled by gonadal androgens, however, the mechanism of this control is believed to vary among species. During immediate activation MSB is tightly correlated with circulating levels of androgens, while the organization of MSB by a hormonal event at a specific developmental period, early in ontogeny or during puberty, has been postulated in other lineages. We put forward an alternative concept of “temporal organization”. Under temporal organization longer exposure to circulating androgens is needed for the onset of MSB, which can continue for a long time after the levels of these hormones drop. We tested this concept through long-term monitoring of MSB in females and castrated males of the leopard gecko (*Eublepharis macularius*) in response to experimental changes in testosterone levels. Several weeks of elevated testosterone levels were needed for the full expression of MSB in both treatment groups and MSB diminished only slowly and gradually after the supplementation of exogenous testosterone ended. Moreover, despite receiving the same application of the hormone both the progressive onset and the cessation of MSB were significantly slower in experimental females than in castrated males. We suggest that the concept of temporal organization of MSB can parsimoniously explain several earlier discrepancies and debatable conclusions on the apparent variability in the hormonal control of MSB in vertebrates, which were based on behavioural testing at a few subjectively selected time points. We conclude that long-term and continuous behavioural testing after hormonal manipulations is needed to understand the regulation of MSB in vertebrates.

## **Assessment of a remote delivery approach for fertility control in eastern grey kangaroos**

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One of the greatest challenges in wildlife management is the design of population control and management methods that are successful, safe and humane for application in different species. The management of peri-urban eastern grey kangaroos (*Macropus giganteus*) is often influenced by social and political factors. Since lethal methods may be seen as unethical by members of the public, or are logistically impossible due to the proximity to residential areas, new technologies have emerged which aim to reduce or manage kangaroo populations by controlling their fertility. Suprelorin<sup>®</sup> implants, containing the gonadotropin-releasing hormone (GnRH) agonist deslorelin, are a safe, reversible and effective method of contraception in a range of species. This study investigated the contraceptive efficacy of Suprelorin<sup>®</sup> implants in eastern grey kangaroos at three peri-urban sites. At each site, two mechanisms of delivery were compared: subcutaneous injection of immobilised animals versus remote delivery. Contraceptive success was monitored for 12-18 months by conducting pouch observations and re-capturing a subset of treated females for hormonal competence testing (GnRH challenge). Contraceptive success rates and longevity were reduced in the remote delivery treatment groups, but this reduced efficacy is likely to be counteracted by significant increases in the efficiency of treatment at these peri-urban sites. The study also aimed to assess changes in behaviour pre- and post-treatment and pain responses to the delivery method by means of focal animal observations recorded for two days pre-treatment and two days post-treatment at one site. This second research aim established that contraceptive implants could be remotely delivered to kangaroos without causing an appreciable pain response post-treatment, providing an efficient and safe alternative to animal capture. The outcomes of this research will be discussed within the context of the potential contribution of this approach towards a humane and publicly acceptable management option for overabundant kangaroo populations in peri-urban areas.

## **Proximate predictors of variation in egg rejection behavior by avian brood parasite hosts**

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The rejection of parasitic eggs by hosts of avian brood parasites is one of the most common and effective defenses against parasitism. Despite its adaptive significance, egg rejection shows substantial inter- and intra-specific variation: some species and individuals are more likely to remove or abandon parasitic eggs than others. Understanding variation in egg rejection requires that we study variation in parental motivation to care for eggs, and that we consider the cognitive and sensory contexts of the parasitized nests. Here we asked if life-history and physiological factors known to be linked to motivation and perception explained variation in rejection of model eggs by American Robin *Turdus migratorius* females. We found that the probability of egg rejection was negatively related to the clutch size at the time of parasitism: females with fewer eggs were more likely to reject the model eggs. Females with greater mass and higher corticosterone levels were less likely to reject eggs and egg rejection probability was negatively related to progress of the incubation. Our data suggest that proximate predictors of an individual's egg rejection behavior include both the components of the nest's perceptual environment (the ratio of foreign vs. own eggs) as well as contributors to maternal motivation towards eggs (endocrine and temporal factors). However, much of the variation in robin's responses to model eggs remained unexplained. Future experiments should aim to resolve the uncertainty about the causal roles of these and other factors in egg rejection behaviors across the diverse host species of avian brood parasites.



## **Testosterone may promote sex trait size only under conditions of intrasexual competition: The dark ventral patch in red deer**

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Testosterone promotes the development of sex traits. However, sex traits entail costs, so it is expected that selection favour the modulation of trait development according to a cost-benefit balance. When the proportion of rivals in the population is high, probably the costs of producing sex traits may increase but also the associated benefits. Here we explore the relationship between faecal testosterone and a sex trait size in two populational conditions of intra-sexual competition. Our model species is the Iberian red deer and the sex trait is the dark ventral patch that some males exhibit during the rutting season. Our results showed that the positive relationship between testosterone and dark ventral patch depended on the male-male competition situation, so that individuals with high levels of faecal testosterone only developed the trait in populations where the operational sex ratio was high (high proportion of rival males), and this relationship was especially consistent in adult males, probably because they are more likely to get benefit returns from trait investment. This result reinforces the idea that the effect of testosterone in promoting the development of sex traits (and its associated costs) may be mediated by the intra-sexual competition level in the population.

## **It's the brain, not the gonad, *Oida!* – Hormones and mating system differences in coucals**

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Testis size predicts mating systems, suggesting that steroid hormones such as testosterone may be important proximate factors regulating mating decisions. Indeed, comparative data suggest that seasonal patterns of circulating testosterone are related to mating systems and testosterone manipulations affect mating decisions in some species.

The black coucal (*Centropus grillii*) is the only altricial bird with strong female competition for territories and obligate male-only care for offspring. Territorial aggression of females is modulated by progesterone and females have a higher sensitivity for testosterone in a part of their brain that regulates social behaviour. Hence, sex steroids seem to play a role in the regulation of the sex-role reversed behaviour of this species. Here, I ask if the steroid profiles of female and male black coucals differ from those of white-browed coucals (*C. superciliosus*), a closely related species with conventional sex roles. In this species, females and males form pairs and jointly defend a territory with both parents raising the offspring. Based on the previous findings I predicted female black coucals to express higher levels of testosterone and lower levels of progesterone than female white-browed coucals. Further male black coucals should express higher levels of testosterone than male white-browed coucals during the mating phase, because there is intense competition for fertilizing females in black coucals, but not in white-browed coucals. During parenting, I predicted low levels of testosterone in males of both species, but particularly so in black coucals, because testosterone has been shown to inhibit paternal care – and that would be fatal in a species with male-only care. Unlike predicted, though, sex steroid levels of both sexes were similar between the two species regardless of breeding stage. Thus, the solution to proximate factors regulating differences in mating strategies of coucals seems to lie in the brain, and not in the gonads!

## **Eco-evolutionary physiology of environmental stress: Corticosterone as a driver of adaptive divergence in moor frogs (*Rana arvalis*) along an acidification gradient**

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Physiological responses, as immediate reactions to abiotic and biotic environmental variation, are crucial mechanism of phenotypic plasticity and can affect evolution at ecological time scales. This is of particular relevance under the multitude of human induced environmental changes. An individual reacts to environmental stressors by releasing stress hormones, which enable energy mobilization to various stress responses. We investigate whether the stress hormone corticosterone (CORT) is a key mediator of adaptation to human induced acidification in the moor frog (*Rana arvalis*). *R. arvalis* shows adaptive divergence in several key fitness traits (e.g. embryonic acid tolerance, larval life-histories and predator defences) along an acidification gradient in Southwest-Sweden. To test for among population divergence in CORT, we reared tadpoles at benign (pH 7.5) and stressful (pH 4.2) conditions and compared CORT profiles across different developmental stages. We found that populations differ in their CORT profiles, indicating genetic divergence in physiological stress responses that might drive the previously observed morphological and developmental divergence. Our study highlights the need to understand the evolution of physiological responses in natural populations exposed to stressful environments.

## **Negative feedback regulation of the HPA axis – a meaningful status measure for conservation?**

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Individual fitness, and ultimately population viability, are determined by how well animals cope with the manifold challenges of life. Across vertebrates, glucocorticoid hormones are important regulators of allostasis. Baseline glucocorticoids vary with predictable changes in life-history stages, and increase to stress-induced levels in response to unpredictable challenges. Negative feedback then terminates the stress response.

More and more ecologists and conservationists measure glucocorticoids in wildlife to infer the health status of individuals and populations. We are, though, far from a sound understanding what causes individual and population-level variation in glucocorticoids, and how these affect fitness and population viabilities.

A very basic, yet unanswered question in this context is if and how body condition is reflected in glucocorticoid profiles. Birds on migration offer an excellent opportunity to examine how different aspect of the glucocorticoid physiology vary with body condition. At a stop-over site in the Mediterranean Sea we measured corticosterone (the main glucocorticoid in birds) at baseline and stress-induced levels, and after experimentally inducing maximum negative feedback with dexamethasone in 4 species of migrating songbirds: common redstarts, garden warblers, whitethroats and whinchats.

Neither baseline, nor stress-induced corticosterone were related to body condition in any of the 4 species. The strength of negative corticosterone feedback, however, strongly correlated with the amount of energy reserves, an effect that was consistent across all species. Together with former studies indicating negative feedback as a predictor of survival, this result calls for further investigation of negative feedback as underappreciated aspect of glucocorticoid physiology, and its possible applications in conservation action.

**PARALLEL SESSION VII: SEXUAL CONFLICT AND ADAPTATION TO ENVIRONMENTAL CHANGE**

**Evolution of post-copulatory characters in vesper bats**

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In the male never-ending quest for a higher Darwinian fitness and the resulting commitment to increase chance of reproductive success, the competition with other males and the courtship of females may not stop with copulation. Indeed, when females mate with several males, sperm competition or cryptic female choice further exert selective pressures on post-copulatory traits. The strength of these pressures should increase with the duration of sexual receptivity and ultimately covary with, and shape these traits. Vesper bats (family: Vespertilionidae) are exceptional for the capacity of females to store sperm. As females may mate repeatedly with different males over several weeks and even months, selective pressures on post-copulatory characters are expected to be strong. However, the evolutionary consequences of this particular reproductive system remain elusive. Hence, we conducted an interspecific comparative study using more than 50 species worldwide distributed. We focused our analyses on the morphology of sperm cells and functional erected penises and on testes volumes. Data were obtained from the available literature and, for the most part, collected on the field. First, we analyzed the allometric scaling of these variables. Then, we investigated whether mating system and the duration of female sperm storage covary with these traits. Any phylogenetic signal was considered and controlled in our analyses. Results are discussed in the context of the evolutionary adaptations found within the particular reproductive system of vesper bats. This study highlights the potential of sexual selection to continue operating after copulation. Furthermore, since numerous bat species are endangered, a better understanding of their reproduction system and its mechanisms can help to optimize conservation strategies and population stabilizing measures.

## **Female reproductive synchrony and male reproductive skew in a seasonally-breeding baboon**

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Mating system diversity is linked to variation in the potential for males to monopolize reproductive access to females, influenced by the spatio-temporal distribution of fertile females. Compared to other large mammals, primates exhibit remarkable variation in reproductive strategies, suggesting they have been subject to varying combinations of sexual selection mechanisms. We looked at mating system variation among polygynandrous baboons (*Papio* spp), which are generally characterized by strong contest competition among males leading to high degrees of reproductive skew. The lesser-studied Kinda baboon, however, exhibits traits suggestive of weaker contest, and stronger indirect, competition among males. We assessed patterns of reproduction in a wild population of Kinda baboons in a seasonal environment in Zambia. Due to large group sizes and seasonal breeding, Kinda females exhibit higher degrees of reproductive synchrony in mating behaviour and hormonally-determined fertile-phases relative to other baboons. Male skew in mating success is low, which we predict leads to low skew in genetic reproductive success. Kinda baboons provide an excellent model to study how variation in the environment leads to intra-genus variation in mating system diversity.

## **Sex-specific telomere dynamics in relation to age and reproductive success in a long-lived seabird**

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Individuals in free-living animal populations generally differ substantially in reproductive success, lifespan and other fitness-related traits. The causes of such variation with respect to the individuals' state and whether this differs between the sexes is still poorly known. Telomeres – evolutionarily conserved DNA-protein structures at chromosome ends – are a candidate biomarker as short telomeres relate to reduced health and survival in birds as well as other organisms. In the framework of a long-term project we measured telomere length and dynamics in Cory's shearwaters (*Calonectris borealis*), a long-lived seabird to assess their relation to age, sex and reproduction. Our results show that female telomere length changed relatively little with age, whereas male telomere length declined significantly with age. Telomere shortening was three times higher within than between males, suggesting a lower survival probability of males with shorter telomeres. Past long-term reproductive success was sex-specifically reflected in age-corrected telomere length. While males with high fledgling production were characterised by shorter telomeres, successful females had longer telomeres. A manipulation of reproduction in a subset of birds revealed that not the males providing parental care, but those males that experimentally failed reproduction due to egg removal experienced higher telomere loss. We discuss these results in a life-history context.

## Effects of fragmentation in the social behaviour of the Cabrera vole: Insights from genetic non-invasive sampling

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Analysing how habitat fragmentation affects within-population processes of spatially structured populations is crucial to predict their ability to persist at local scales and beyond. In this study we assessed the relatedness, family groups and inbreeding in 20 local populations of the Iberian-endemic Cabrera vole from SW Portugal, based on genetic non-invasive sampling (gNIS). We detected a total of 101 individuals (between 1-12 individuals per patch), with mean relatedness per patch varying between -0.215-0.721. We found family groups in 16 out of 20 patches, with 12 family groups displaying genetic monogamy in 11 patches, but in 5 patches a consensus pedigree could not be achieved, with possible polygamous behaviour. The inbreeding risk was low for all patches (mean: -0.237). We explore how several habitat variables associated with fragmentation relate to the variations in the social and reproductive behaviour found within patches as well their genetic diversity indexes. The probability of monogamous behaviour is increased in low quality habitats and fragmented patches, while genetic diversity is higher in larger patches and in areas with more suitable habitat available. We discuss the utility of gNIS to evaluate within-population processes of species with metapopulation-like structure.



## Change in migratory behavior of bats revealed by stable isotopes

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During the Anthropocene, wildlife species have to adjust to various anthropogenic challenges in order to survive in an ever changing environment. Anthropogenic changes range from local levels such as landuse changes and fragmentation to ecosystem or even planetary levels such as global warming. Among the many species affected by anthropogenic challenges, migratory species are of particular concern because they depend on a series of habitats for their annual life cycle. Here, we studied if and how a European migratory bat species, the common noctule bat (*Nyctalus noctula*), changed migratory behavior over the past two decades. Several papers confirmed that starting from turn of the last century this species shifted its wintering areas to higher latitudes. Over a period of 12 years, we collected fur samples from migrating and hibernating common noctules in the Kharkiv area in the Ukraine to identify possible changes in the summer origin of juvenile and adult bats over time. Based on stable hydrogen isotope ratios in fur keratin ( $\delta^2\text{H}_f$ ), used a proxy for the geographical summer origin of individuals, we documented a decrease in the proportion of migratory individuals for both the migration and hibernation period, suggesting that over a period of more than a decade a significant proportion of the local population of common noctules stopped migrating, but instead remained in the Kharkiv area throughout the whole year. Our results shed light on the process of change in the migratory behavior of common noctule bats, most likely related to global warming, and the recent expansion of the wintering range of this species towards the north in Eastern Europe.

## **How urban parrots navigate and fly through the city centre: The cognitive challenges of adaptation**

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With the growth of human population, the urban areas are expanding across the world. Designed by and for humans, urbanisation constitutes the most severe land alteration that men impose on the environment, being mostly mineralised and dominated by exotic species. For those species, which adapt to these changes, the challenge is to navigate through the urban matrix to fulfil their biological needs. Here, we present pioneering work that aims to uncover the navigational and foraging decision making of sulphur-crested cockatoos (*Cacatua galerita*), a large social parrot that has successfully invaded or persisted in human-modified habitats across Australia. Using over 30,000 record data from the long term citizen science project 'Wing-tags' and 2 years of high frequency GPS data collected on 8 sulphur crested cockatoos, we study the factors influencing the species presence and movements across the city of Sydney. We identify the most influencing features on birds' movement and use landscape resistance models to compute the connectivity map of the urban environment. While birds' movements seem mainly restricted by large water surface features, their home ranges are strikingly small (95% kernel: 248 ha (+/- 107) in average) and only travel in average 5,956m (+/- 4,234m) per day. Building on these, we show how memory influence home range sizes when navigating across urban landscapes, and highlight its importance especially in the context of foraging on predictable resources. Our work represents a novel representation of the city from a bird point of view, and advances our understanding of how cognition can facilitate movements in the urban matrix leading to some species to coexist with humans in large cities. We suggest this is particularly important from a conservation aspect, as if efficiently manage, urban areas can be more permeable to wildlife and can be turned into refuges for a diversity of bird communities.

**MAIN SESSION V: CONSERVATION GENETICS**

**Genomic management of endangered species across the in situ/ex situ continuum and the role of biobanks**

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As the One Plan approach to conservation becomes embedded in endangered species management, it is becoming apparent that the genetic status of many in situ and ex situ populations of endangered species is a cause for profound concern. With many species retaining just a fraction of their historic genetic diversity in the present day, ex situ populations and biobanks are now seen as potentially vital sources of lost diversity, increasingly required to mitigate against genetic erosion. Increasingly, therefore, management of the world's most threatened gene-pools will require an integrated approach involving living and cryopreserved genomes and placing an emphasis on their careful deployment and management. Taking some examples from work in our laboratory and others, I will highlight the prospects and problems for the One Plan approach to genetic management, particularly focusing on an increasing role for biobanks in this field. I will draw attention to recent developments in zoological biobanking in Europe and elsewhere and how these biobanks may work together to widen the gene-pool available for management of endangered species and how, in combination with rapidly developing 'omics tools, the genetic health of endangered species may be transformed in the future.

## **Bridging the gaps between population genomics and conservation through the use of zoo samples**

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In recent years, genetic research has become an increasingly important part of zoo animal management and vice versa, zoo-led genetic research has become a vital part of genomic fundamental science. As an exemplar of this emerging trend, the European Endangered Species Programme (EEP) for chimpanzees constitutes a holistic approach in conservation genomics with mutual benefits to applied and fundamental science. Here, we present the development in the use of zoo samples with combined purposes for genomic diversity research and applied conservation efforts for the endangered chimpanzee, both *ex situ* and *in situ*.

The chronology for using zoo samples in chimpanzee genomics, spans from early attempts of using mitochondrial sequence data and microsatellite markers to resolve taxonomic disputes and identifying subspecies for establishment of captive breeding programmes, to whole genome exploration of the complex demographic history including ancient admixture with the species closest living relative, the bonobo.

While genetic management of zoo breeding programmes is limited to a few taxa, reduction in genomic sequencing costs and improved sample-sharing infrastructure (EAZA Biobank) has facilitated that more than ten genetic EEP programmes are currently underway. We predict that the use of zoo samples will likely increase in future research initiatives with synergetic benefits to the zoo community and fundamental science.

## **Mitochondria as a driving force for sex-specific fitness differences in ex-situ breeding populations**

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As the powerhouses of the cell, mitochondria can directly impact an individual's fitness in terms of its fertility and the process of aging. In general, mitochondrial DNA is exclusively transmitted via the mother, and as a result natural selection works in favor of females over males. One potential side-effect of this is the accumulation of male-harming mutations in the mitochondrial DNA, a process labelled "mother's curse", a phenomenon described in both humans, animal models and livestock. Here we provide empirical evidence on the presence of mtDNA-induced sex-specific differences in ex-situ population. We analyzed a total of sixteen EAZA Ex-situ Populations (EEPs) through their studbooks, with a focus on survival and fertility. While no significant differences were found in terms of fertility, our results indicate survival of males is affected in several mitochondrial lineages within the studbooks under study. Additionally, we found that some mitochondrial lineages were more beneficial for both sexes relative to other lineages of the same populations. These results are of interest in the revived debate on the maintenance of healthy ex-situ populations and safeguarding their genetic diversity for both ex-situ and in-situ conservation.

## Genomic assessment of zoo populations for conservation reintroductions

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Captive breeding programmes play an important role in species conservation. The growing move towards integrating *in-situ* and *ex-situ* conservation management under a one-plan approach requires sustainable and diverse zoo populations to act as sources for future reintroductions. Over the last two decades, genetic data has increasingly been used to improve and evaluate captive breeding programmes (Fienieg & Galbusera 2013). However, advances in DNA sequencing technologies have enabled a transition towards genome-scale analysis and researchers are now able to address broad-reaching biological questions with more power and precision than ever before. For example, it is now possible to precisely measure inbreeding in the absence of any pedigree information (Kardos et al. 2016) to uncover population structure that had previously gone undetected (Ogden et al. 2013) and to reconstruct both recent and historical population size fluctuations (Pujolar et al. 2017). This has the potential to transform conservation management programmes which rely on accurate measures of genetic diversity, inbreeding and demography. The scimitar-horned oryx (*Oryx dammah*) reintroduction programme provides an ideal opportunity to integrate genomic data from zoo populations into applied conservation. We have used whole-genome sequence data together with a chromosomal level genome assembly to develop a dataset of over one million high quality genomic markers in 20 scimitar-horned oryx individuals from three captive populations. This has enabled us to a) compare levels of genome-wide diversity with other mammalian species, b) uncover genetic structure among captive populations and c) infer individual inbreeding and demography using runs of homozygosity. We will examine these results in light of what we know about the history of scimitar-horned oryx and discuss the implications of these findings on the future management of other vulnerable species.

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## **Using ex situ population for establishment of wild population. How much genetic diversity is transferred during translocation? Case study of the European mink translocation to Hiiumaa Island in Estonia**

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European mink (*Mustela lutreola*) is one of the most endangered small carnivores in the world (in IUCN red list - critically endangered). The minks' decline is caused by over hunting in the past, habitat loss and competition with invasive American mink. Apart from the established Estonian island population, the species still survives in tiny fragments in Spain, France, Romania, Ukraine and Russia. Tallinn Zoo has been focusing on the species' captive breeding and conservation for 30 years. Translocation into Hiiumaa Island started in 2000. During 17 consecutive years (2000-2016) 597 minks were released there. Since 2017 the release has stopped as the wild population has been established on the island. Animals selected for the release with the aid of population management software were, according to the program, genetically least valuable as maintaining the genetic diversity of captive population was the priority. The aim of the study was to assess how much genetic diversity in the present *ex situ* population has been passed to the established wild population and if there is a need to vector missing genetic diversity into established wild population. Comparisons of the genetic diversity between the island and captive populations based on sample of 86 animals: 64 from captive population (collected in 2017, overall size 113 minks) and 22 from Hiiumaa Island (collected during 2014-2017). Fifteen DNA markers were used and they consisted of mitochondrial, microsatellite and nuclear markers. In conclusion, the island population's genetic base was found to be a bit less, but not drastically, diverse than the captive population. These results give a good starting point to monitor European mink genetic diversity and changes on the island in the future.

## POSTERS

### ADVANCES IN GAMETE PRESERVATION FOR ASSISTED REPRODUCTION

#### Cells survival after cryopreservation of dissociated testicular cells from three feline species

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Testicular cells can be cryopreserved for male germ line preservation and fertility restoration, we aimed to validate a cryopreservation protocol for testicular cells of domestic cat to be deployed for endangered felids species.

Testis tissues from adult domestic cat (*Felis catus*) (n =11), Asian golden cat (*Catopuma temminckii*) (n=1), and Cheetah (*Acinonyx jubatus*) (n=1) were dissociated in two step enzymatic protocol, dissociated testicular cells were directly cultured (37°C, 5% CO<sub>2</sub>) for three hours in order to isolate somatic cells, floating testicular cells were cryopreserved in DMEM supplemented with 30% fetal bovine serum and one of two DMSO concentrations (10 or 20%), a slow and a fast freezing method were applied. Cell viability was evaluated before and after cryopreservation by using two combinations of fluorescent dyes: SYBR14 with propidium iodide (S/PI) and calcein AM with propidium iodide (C/PI). Staining was observed by microscopy and flow cytometry.

A two factorial linear model revealed a significant influence of DMSO concentration and freezing method ( $P=0.001$  for S/P and C/PI) on survival of cat testicular cells with superiority in 10% DMSO associated with slow freezing:  $35.49 \pm 2.53\%$  by S/PI and  $43.59 \pm 2.63\%$  by C/PI respectively. Testicular cells of Asian golden cat and Cheetah followed similar pattern and the highest viable cells recorded microscopically for 10% DMSO portion associated with slow freezing ( $34.59 \pm 4.57$  and  $35.73 \pm 2.43$ ) by S/PI and C/PI for Asian golden cat and ( $40.42 \pm 3.59$  and  $42.522 \pm 7.62$ ) by S/PI and C/PI for Cheetah, respectively.

Flow cytometry revealed that cell dissociation was not complete before freezing, for example in Cheetah 62.5% of the recorded events by S/PI were classified as aggregates in scatter plots with high cell viability (98.8%), Aggregates were best preserved (12.8 % for S/PI) in 10% DMSO after slow freezing with the highest share of viable cells (97.2%) in aggregated pool.



## Embryo vitrification for the Felid-Gamete-Rescue-Project

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Within the Felid-Gamete-Rescue-Project we aim to preserve gametes and embryos of all felid species to safe the genetic diversity in captive populations. Although embryo freezing, due to the smaller blastomeres size, often has higher survival rates than oocyte freezing, in felids no standard protocols exist. Therefore, we aim to establish a suitable cryopreservation method for felid embryos.

Oocytes from domestic cat as our model species are subjected to *in vitro* maturation and were fertilized with either fresh or frozen testicular sperm. After 18 h of coincubation, presumptive zygotes were cultured for up to 5 days. Embryos in 8-16 cell or in morula stages were randomly vitrified with two different methods: 20 embryos with our IZW protocol (MIKOLAJEWSKA *et al.*, 2012) and 41 with the commercial Cryotech®. After warming procedure, embryos were cultured for further 24h and then stained with supravital stain Hoechst 33258 (10µg/ml) to evaluate the number of dead blastomeres. Embryos were fixed afterwards in 96% ethanol and finally stained with propidium iodide (10µg/ml) to evaluate the total number of nuclei.

All embryos showed live blastomeres after post-thawing culture. Within the IZW group 37.5% of the cells were dead in the 8-16 cell embryos (n=3) whereas in the morula group (n=17), we found 25.3% dead blastomeres ( $8.9 \pm 5.4$  of an average of 35.3 total cells). In the Cryotech® group the 8-16 cells embryos (n=19) showed 50.2% of dead blastomeres. The morulae (n=22) had 27.4% of dead cells ( $7.6 \pm 4.1$  of an average of 27.7 blastomeres). These results indicate that morulae have higher number of surviving blastomeres than 8-16 cell stage embryos (74.7% vs. 62.5% for our protocol, 72.6% vs. 49.8%, for Cryotech®), independent of the method being used. Currently, more experiments are being performed to increase the number of embryos and establish conclusive evidences.

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## **Serum-free vitrification of domestic cat oocytes compatible with Raman spectroscopy study**

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Low-temperature optical Raman spectroscopy studies are highly informative approaches providing new important data about the changes occurring in oocytes and preimplantation embryos during cooling (Okotrub et al., 2018). Fetal calf serum (FCS) is a traditional component of cryoprotective solutions used for vitrification of oocytes and embryos. However, FCS has intensive autofluorescence that limits its usage in low-temperature Raman studies. The aim of our study was to exclude FCS from vitrification solution for feline oocytes and to develop FCS-free vitrification solutions without compromising the efficacy of the procedure.

In vitro matured (IVM) oocytes from ten domestic cats were vitrified on Cryotech (Reprolife, Japan) storage devices in three solutions: (1) PBS + 20% EG + 20% DMSO + 0.5 M sucrose + 10% Ficoll PM-70 + 20% FCS (19 oocytes); (2) the same solution without FCS (18 oocytes) and (3) PBS + 20% EG + 20% DMSO + 0.5 M sucrose + 7.5% Ficoll PM-70 + 4.5% polyvinylpyrrolidone (PVP) (20 oocytes). Equilibration, vitrification, warming and dilution steps were standard for all the groups (Fernandez-Gonzalez, Jewgenow, 2017). After vitrification and the subsequent warming and incubation of oocytes in IVM medium for 2 hours membrane integrity was assessed in oocytes morphologically. The recovery rate did not differ between groups (63.1, 61.1 and 50% respectively). DAPI staining of fixed oocytes has demonstrated that nuclear structures of the survived oocytes were also morphologically intact. Raman spectroscopy studies demonstrated that the serum-free solutions (group 2, 3) have no large level of autofluorescence.

**Conclusion.** Our observations indicate that FCS is not an obligatory component for the successful vitrification of feline IVM oocytes. Serum-free solutions may be applied for the oocyte vitrification experiments and are compatible with Raman spectroscopy studies.

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- Fernandez-Gonzalez, L., & Jewgenow, K. (2017). Cryopreservation of feline oocytes by vitrification using commercial kits and slush nitrogen technique. *Reproduction in domestic animals*, 52, 230-234.

## Domestic cat (*Felis catus*) oocytes cryopreservation: Controlled-rate cooling versus vitrification

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Domestic cat (DC) oocytes are lipid-rich and thus are supposed to be sensitive to chilling/freezing procedures, but in fact, exhibit relatively high survival rate after controlled-rate (slow) freezing. Chilling is known as a crucial stage of slow freezing, and lipid phase transition (LPT) is believed to be one of the main sources of cell damage. The aim of this study was to compare the most effective protocols of slow freezing and vitrification for DC oocytes and to match these results with the recent Raman spectroscopy measurements for LPT temperatures.

Immature domestic cat oocytes of grade I and II were randomly divided to three groups. One group (n=54) was frozen/thawed according to Apparicio et al. (2012) protocol. Another group (n=48) was vitrified/warmed according to Fernandez-Gonzalez, Jewgenow (2017) protocol. The third group (n=69) was used as controls. All the oocytes were matured *in vitro* (IVM) in TCM-199 supplemented with 2 IU/ml eCG and 10 IU/ml hCG for 24 h and, thereafter, were stained with propidium iodide (PI) to assess their viability, then fixed and stained with DAPI to assess their maturation stage. The percentage of viable/matured oocytes was significantly higher after slow freezing (66.7) as compared to vitrification (20.8), and did not significantly differ from controls (82.6).

The lipid unsaturation degree (LUD) in cat oocytes as well as LPT was studied using Raman spectroscopy in parallel experiments (Okotrub et al., 2018). LUD was relatively high in DC oocytes (0.0925) and the LPT temperature was relatively low (-1.7°C) in cats.

Conclusion. Our study revealed that controlled-rate slow freezing is less damaging for DC oocytes than vitrification. High levels of LUD and low LPT may explain relatively high tolerance to chilling/freezing procedures for DC oocytes.

This study was supported by the Russian Foundation for Basic Research (Project No. 19-016-00025)

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## BEHAVIOUR, LIFE HISTORY AND PHENOTYPIC PLASTICITY

### Individual variation in hunting behaviour of cheetahs in an intensively managed space-limited reserve at the Sir Bani Yas Island (United Arab Emirates)

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The cheetah (*Acinonyx jubatus*) is a large carnivore with a unique social system in Felids. Females are mostly solitary and males may form stable coalitions of two or three individuals, with ultimate function to increase individual fitness benefits from cooperative hunting. Our aim was to investigate the individual variation of cheetahs hunting in an intensively managed island reserve. Particular objectives were to identify the proportion of prey species hunted in multispecies enclosures, the prey sex and the degree of prey consumption. Study was conducted at the Sir Bani Yas Island reserve (UAE). The reserve is space limited, animal populations largely exceed natural carrying capacity, therefore regular food for herbivores is provided. Four cheetahs were ranging area with high density populations of five herbivore species. Data including cheetah individual, prey species and degree of consumption were collected during routine daily monitoring by reserve rangers between 2014 and 2018.

Two cheetah females hunted solitary (370 and 268 records), while two cheetah males hunted mostly together; there were 460 records of cooperative hunt and four individual records for each individual. The most frequent prey for cheetahs was Sand gazelle (*Gazella leptoceros*) reaching up to 74% of hunted animals. Next species was Mountain gazelle (*Gazella gazella*, 13%), followed by Axis deer (*Axis axis*, 9%), Blackbuck (*Antilope cervicapra*, 3%) and Barbary sheep (*Ammotragus laervia*, < 1%). Proportion of prey species in individually hunting cheetahs was composed mostly by Sand gazelle and other prey species formed a minority. The cooperative hunting involved all five available prey species. All cheetahs hunted mostly males, despite females were more abundant in prey population. Degree of prey consumption was variable for cheetah individual, not related to collective hunting. We may preliminarily conclude that management decision on individual cheetah presence in multispecies enclosures have potential to affect prey species population.

## **Terns of the genus *Sterna* nesting on the islands of the Valaam archipelago**

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The Valaam archipelago is located in the northern part of Ladoga Lake. Each island is distinguished by its specific characteristics (both geographical and biological), and therefore here is a very diverse biotic complex.

The Valaam archipelago is a sympatry zone for two species of terns of the genus *Sterna* - polar tern (*S. paradisaea*) and common tern (*S. hirundo*). The common tern is the most abundant at the Valaam archipelago. This is a widespread representative of the suborder Laridae, which has a wide range of nesting habitats. At the same time, this species demonstrates noticeable variability in its biology (e.g., in nesting timing, in choosing specific places for nesting colonies). In this regard common terns can act as indicators of the stability of environmental conditions, especially in the presence of anthropogenic influence.

We have been studying the nesting of terns on the Valaam archipelago during June-July of 2003-2018.

We recorded all bird species on the terns' colony; the number of nests and the number of eggs in nests; the eggs' ovification stage; the number of chicks and their stage of development.

The number of nesting pairs of the common tern on the Valaam archipelago increased at the turn of the 20-21 centuries by no less than 4 times; in recent years, it remains at the level of 640-740 pairs. Common terns here use various types of islands for nesting: ludas and small islands, including those covered with forests. The largest colonies of terns are located on islands remote from the largest island. The terns often nest together with other species of gulls: common gull (*Larus canus*), little gull (*Hydrocoloeus minutus*) and black-headed gull (*Chroicocephalus ridibundus*). The location of the colonies on the islands is unstable, after a number of years the colony may disappear on one island and arise on another.

## **Evaluation of pumas (*Puma concolor* L.) body condition that visits water ponds in the Dos Lagunas Biotopo Protegido from 2014 to 2017**

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The species *Puma concolor* L. is a Conservation Element in the Master Plan of the Maya Biosphere Reserve (MBR) and the Dos Lagunas Biotopo Protegido (BPDL). Based on records obtained through camera-traps located in seasonal water ponds, locally known as *aguadas*, the body condition of pumas was visually estimated based on the feline body condition guidelines of the Association of Zoos and Aquariums of the United States (AZA). Therefore, we sought to relate changes in estimated body conditions, with the climatic conditions in the BPDL during dry seasons from 2014 to 2017, observing that there is a correlation between the body condition of pumas and the cumulative average rainfall during the months March to August. Greater amount of water accumulated in seasonal water ponds during the dry season, better body condition was observed in pumas. Remarkable findings are those corresponding to 2016, the driest year with the most recorded pumas events, where in the driest months (May and June) the individuals photographed are classified in categories 1 and 2 (very low and moderate low, respectively). More than precipitation itself, it is the accumulation of water in seasonal water ponds that indirectly limits the big carnivores to obtain prey, and therefore having the need to move across the Maya Forest. Due to the importance of seasonal water ponds for the survival of large carnivores, such as pumas, it is suggested to increase the studies on this resource and the dynamics that it presents in the wild.

## The genetic basis of morphological and behavioral island syndrome traits in deer mice

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Animal populations on islands often exhibit dramatic differences in morphology and behavior compared to mainland populations, a phenomenon known as the "island syndrome". These differences are likely adaptations to environmental conditions on islands, notably altered resource and population densities. However, the extent to which island traits have a genetic basis, indicative of past selection processes, or whether they instead represent plastic responses to environmental extremes has rarely been investigated. Here, we revisit a classic case of island syndrome in deer mice (*Peromyscus maniculatus*) in British Columbia. Previous studies suggested that Saturna Island mice exhibit several island traits, including larger body weight and reduced aggression relative to their mainland ancestors. First, using historical collections, we show that body weight in Saturna Island mice is representative of neighboring island populations, and ~5g (~35%) greater than mainland populations. We next collected deer mice on Saturna Island and the mainland to establish laboratory colonies, and found that Saturna Island mice are heavier both because they are longer and have disproportionately more lean mass. Importantly, these traits are maintained in captive-born mice raised under common conditions, implying a strong heritable component. In addition, F1 hybrids are heavier when born to island mothers than to mainland mothers, revealing a maternal effect on body weight. Second, using behavioral testing in the lab, we also find that wild-born island mice are less aggressive than mainland mice, consistent with previous studies. Remarkably, however, lab-raised male mice born to these founders do not differ in aggression, even when tested shortly after mating with a receptive female, suggesting this behavior difference is not genetic. Together, our results suggest that rodents respond variously to environmental conditions on islands by evolving heritable changes in offspring and maternal genotypes determining a morphological trait, while expressing non-heritable phenotypic responses in a behavioral trait.

## Lion-tailed macaques (*Macaca silenus*) in zoos. A case for “HIREC” studies?

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Lion-tailed macaques have been kept in zoological gardens for more than 100 years, with a historical global population of 2749 individuals. As in many other captive mammals and birds, breeding problems are reported. The long-term viability of the captive population seems doubtful. Problems may come from the human made altered living conditions. They might be regarded under the perspective of a “human induced rapid change of environmental conditions” (HIREC) as investigated in wild populations. Such changes according to the usage of this terminology, includes habitat loss, fragmentation, changes in habitat characteristics and altered species interactions. The aim of this contribution is to assess for the lion-tailed macaque whether its living conditions in zoos match or go beyond its ability to cope and hence its adaptive potential. We qualitatively describe aspects of its living conditions and discuss them with reference to conditions in the wild and aspects of the species biology, especially with reference to life history patterns. The historical captive population of lion-tailed macaques has been fragmented with isolated groups having sizes below mean numbers in the wild and deviant demographic composition and social structures. Their simply structured enclosures may range in size between some dozen and a few thousand square meters ground space, especially lacking vertical structures, as important for an arboreal species. Management-induced population dynamics do not mimic conditions in the wild. Mortality and births patterns were used in this study to assess the capacity to cope with these reduced living conditions. Reproductive output per female was low and infant mortality high, thus indicating that the zoo conditions went beyond coping capacity. The analysis of demographic structures revealed that they might not have matched with and supported the adaptive female-bonded social structures. The HIREC perspective thus seems useful to investigate this and similar populations.



## Parasite infections in a social carnivore: Evidence of their fitness consequences and factors modulating infection load

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There are substantial individual differences in parasite composition and infection load in wildlife populations. Few studies have investigated the factors shaping this heterogeneity in large wild mammals or the impact of parasite infections on Darwinian fitness, particularly in juveniles. A host's parasite composition and infection load can be shaped by factors that determine contact with infective parasite stages and those that determine the host's resistance to infection, such as abiotic and social environmental factors, and age. Host-parasite interactions and synergies between co-infecting parasites may also be important. We test predictions derived from these different processes to investigate factors shaping infection loads (faecal egg/oocyte load) of two energetically costly gastrointestinal parasites: the hookworm *Ancylostoma* and the intracellular *Cystoisospora*, in juvenile spotted hyenas (*Crocuta crocuta*) in the Serengeti National Park, in Tanzania. We also assess whether high infection loads curtail survival to adulthood and longevity. *Ancylostoma* infection load declined as the number of adult clan members increased, a result consistent with an encounter-reduction effect whereby adults reduced encounters between juveniles and infective larvae. Both *Ancylostoma* and *Cystoisospora* loads decreased with age, possibly because active immune responses to infection improved with age. An increase in *Cystoisospora* load with the number of juveniles most likely reflects increased environmental contamination at communal dens. Differences in parasite load between clans possibly indicate variation in abiotic environmental factors between clan den sites. The survival of juveniles (< 365 days old) to adulthood decreased with *Ancylostoma* load, increased with age and was modulated by maternal social status. The longevity of juveniles (< 180 days old) was greater in higher-ranking than low-ranking ones, and greater in those with low than high *Ancylostoma* load. This suggests that high infection loads with energetically costly parasites such as hookworms during early life can have negative fitness consequences.

## **Is hibernation good for your health? Leukocyte numbers in a small hibernator, the edible dormouse (*Glis glis*)**

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In vertebrates, immune defense is essential for survival and varies remarkably among individuals and in time. Extreme physiological changes occurring during hibernation are known to affect various components of the immune system. To determine the effects of hibernation on immune parameters and their relevance for fitness, we investigated leukocyte profiles during the active season of edible dormice (*Glis glis*) in the field. Edible dormice are small arboreal rodents characterized by an extraordinarily long hibernation period of at least 8 months. Previous studies on other hibernators showed a dramatic decrease (~90%) in circulating leukocytes during torpor, applying to all subtypes, that is reversed within a few hours after torpor is terminated. In contrast to these findings, our study revealed that in edible dormice hibernation results in depleted phagocyte (neutrophils and monocytes) stores upon emergence that recovered only slowly. As the phenomenon of low phagocyte counts was even more pronounced at the beginning of a low-food year and primarily immature neutrophils were present in the blood upon emergence, preparatory mechanisms seem to determine the regeneration of phagocytes before hibernation is terminated. Recovery of phagocytes thereafter took several weeks, presumably due to energetic restrictions. This impaired first line of defense coincides with lowest survival probabilities in the annual cycle of this species. Summarized, results of our study clearly reveal that the leukocyte picture of active edible dormice responds sensitively to physiological conditions associated with hibernation, and can further be linked to fitness parameters such as survival.

## Visitation of jaguars to seasonal ponds during dry season in a Tropical forest

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Jaguars are the largest cats in the Neotropic. For jaguars, water availability is determinant during dry periods along wetlands such as seasonal ponds, that could be a determining factor to delimit home ranges since they are influenced by the grouped distribution of prey around them. The aim of this study was to describe the visitation of jaguars to seasonal ponds in a Tropical forest during dry season and their activity patterns. Along dry seasons 2014-2017 camera-traps were installed in seven ponds in Dos Lagunas Biotopo to record jaguar presence and identify individuals. We described daily activity patterns and capture histories for individuals and ponds. We recorded 60 visit events. Jaguars are with greater daytime activity. Most events occurred during daytime and twilight. Both sexes differ in their activity after dawn in the measure in which males show greater activity, females decrease theirs, suggesting different habitat use. Females, in spite of being represented in smaller quantity in comparison with males, have more visit events in ponds. Home ranges of female jaguars overlap in one of all the ponds we sampled. During dry season, a pond can be visited more than once by the same jaguar in the same day, and at the same time be visited by at least two jaguars in a single day in the course of 1 hour. A pond is visited by a jaguar in an average of 14 days; and a jaguar visits the same pond in an average of 4 days, while can visit a different pond in an average of 22 days. Constant visitation of jaguars confirms seasonal ponds are important for their populations during dry season. We suggest to increase research in seasonal ponds in dry and rainy season to better understand the use of this resource by wildlife.

## Immediate post-translocation monitoring of re-introduced West African giraffe in Gadabedji Biosphere Reserve, Niger after 50 year absence

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Eight West African giraffe (*Giraffa camelopardalis peralta*) were re-introduced after 50 years from the last remaining wild population in Niger to Gadabedji Biosphere Reserve – a move of approximately 800km north-east. Two groups of four individual giraffe were transported by road, the second occurring three days after the first. To assess post-release space use, social behaviour and interactions with livestock, giraffe were opportunistically monitored for the first two weeks using scan sampling (every 20min) combined with focal sampling. Data about giraffe and livestock were collected using CyberTracker and analysed in Statistica and ArcGIS. During this initial study period only seven giraffe were observed as one moved immediately out of the reserve with the longest distance travelled in a day recorded immediately after the release (107 km). During the initial monitoring period 73 scan sampling events were undertaken over 9 days (2–14 per day). Two herds of three giraffe was recorded in 56 sightings (77%), consisting of individuals from the original translocated groups which were not mixed together. Two giraffe were recorded together 17 times (23%). In six observations (8%) giraffe were observed in close vicinity of livestock (cow n=2, camel n=3, goat=1). The mean distance between giraffe and livestock – 50.24m (range 10.35-160.97m) was greater than the distance among giraffe individuals (mean 15.55 ±18.29m, range 1.74-103.98m, N=118) ( $p=0.022$ ;  $U=157$ ). The initial activities recorded during total 24h of focal sampling consisted of 16h browsing (66%), 5h ruminating (21%), 2h walking (7%), 1h standing (4%), 4min vigilance (0.28%) and 3min grooming (0.21%). Activity budget did not statistically differ according to sex, time of day nor release group order and was consistent with observations in their original area. The results of post-translocation monitoring will provide the recommendations and valuable information for a future translocation.

## **A systematic review of mammalian activity patterns: Moonlight, predation risk, and human disturbance**

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Activity patterns are a fundamental aspect of an animal's biology. The temporal niche of a species represents a complex balancing effort between the endogenous biological rhythm and the need to acquire and secure food, water, rest, and mating opportunities while avoiding predation and competition. Many factors have been found to affect activity patterns, such as moonlight, predation risk, or human disturbance. I systematically reviewed the published literature on the activity patterns of nine mammalian families. The review provided insight into a substantial amount of research on the effect of human disturbances on activity patterns, but little on the effects of moonlight or predation risk. Human disturbances were found to affect activity patterns in most of the studies included in this review and that effect was consistently the same: increased nocturnality/decreased diurnality. Moonlight effects on activity patterns were inconsistent and site and species-specific. Activity patterns of prey living in predator-free areas and in areas with predators where present were species-specific. Methodological differences hampered a more thorough exploration of activity patterns and factors that affect the animals studied insofar. Recommendations are provided for future research on activity patterns, including the importance of providing definitions of each activity pattern, the necessity of incorporating precise sunset and sunrise times, and GPS and camera-trap specific recommendations.

## Seeking to conserve the Tasmanian devil (*Sarcophilus harrisii*) species through dental pulp stem cell (DPSC) studies and furthering current understanding of Devil Facial Tumour (DFT)

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Tasmanian devils are iconic Australian marsupials under threat of extinction by a transmissible cancer of Schwann cell origin: DFT. Transmission occurs during feeding and mating interactions where affected individuals inoculate DFT cells into unaffected individuals through biting. Human DPSC studies have reported an affinity for Schwann cell differentiation; applying these study methods to Tasmanian devil DPSC (tdDPSC) will enable future comparative studies between tdDPSC-derived Schwann cells and DFT cells, in turn furthering current understanding of DFT and how it initially arose. This is a study update for the stem cell characterisation and Schwann cell differentiation of tdDPSC.

Canine teeth were extracted from 5 devils following welfare-related euthanasia and tdDPSC were isolated (Gronthos *et al.* 2000). Cell growth was measured via the WST-1 proliferation assay, and multipotency was assessed by culturing tdDPSC in osteogenic and adipogenic-conditioned media for 4-6 weeks. Specific DPSC mRNA gene expression was analysed by quantitative polymerase chain reaction (qPCR) and Schwann cell differentiation was induced (Martens *et al.* 2014).

Following tdDPSC isolation, WST-1 results demonstrated stable cell proliferation rates with no significant differences amongst tdDPSC populations (n=5, p>0.05). tdDPSC also demonstrated capacity for multilineage differentiation; calcium matrices were verified via Alizarin Red-S calcium staining following tdDPSC culture under osteogenic conditions. Fat deposits were verified via Oil Red-O staining following tdDPSC culture under adipogenic conditions. qPCR analysis has thus far demonstrated positive CD166 mRNA gene expression of tdDPSC (n=2); further analysis of additional DPSC genes is underway. tdDPSC (n=3) cultured under Schwann cell conditions have thus far demonstrated a morphological transition with immunocytochemical characterisation in progress.

tdDPSC have effectively demonstrated 'stem-like' characteristics and displayed high potential for Schwann cell differentiation. Successful production of tdDPSC-derived Schwann cells will be of great influence to Tasmanian devil conservational efforts, enabling further investigation into DFT biology and potential development of subclinical diagnostics.

## Cardiac excitation-contraction coupling during torpor in the bat *Nyctalus noctula*

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In order to cope with adverse environmental conditions such as low temperatures and low food availability, most temperate bat species undergo torpor. Torpor is a physiological state characterized by the controlled reduction of several metabolic processes, including cardiac function. During torpor bats are able to reduce heart rate to extremely low levels without dysfunction, and still provide the body with the necessary metabolic supplies to survive. To further understand the intrinsic capacity of the heart to withstand cold temperatures during torpor, we quantified heart rate, subcutaneous temperature ( $T_{sub}$ ), and cardiac excitation-contraction coupling in the common Noctule bat (*Nyctalus noctula*;  $n=7$ ). To calculate heart rate (HR), electrocardiogram (ECG) recordings of torpid bats were measured at an ambient temperature of 8°C. A pulse transducer was set into the experimental chamber flush with the chest of the bat and was sensitive enough to record the rate of cardiac contraction. In order to measure the cardiac excitation-contraction coupling, the correspondence between ECG and cardiac contraction was evaluated, and the time difference between electrical excitation and cardiac contraction was calculated. At an ambient temperature of 8°C, *N. noctula* reduced  $T_{sub}$  to  $9.0 \pm 0.3^\circ\text{C}$  with a corresponding HR of  $8 \pm 2$  bpm. Excitation-contraction coupling was consistent between animals at  $0.175 \pm 0.055$  s. We present the first data examining cardiac excitation-contraction coupling in a torpid animal. These results shed new light on the mechanisms by which torpid animals are able to resist cardiac arrhythmia and dysfunction during the cold temperatures experienced during torpor.

## **Is not eland as an eland: How to distinguish common Common eland from the critically endangered Derby eland? Try the dung**

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Eland antelope is considered as the largest antelope in the world. Confusions, however, do arise in distinguishing two separate species of elands and are frequently interchanged. Besides taxonomic and clear morphological features, the ecological requirements and adaptations may serve as a guide to identify the species correctly. While elands are referred as intermediate feeding type by Hoffman's typology and it is largely applied to both species, the most recent findings on Common eland support them to tend more to browsing than to grazing and Derby elands have been observed as almost pure browsers. Our aim was to identify the diet quality using chemical analyses of faeces samples, hereby to indicate the natural feeding type, in two nature reserves in Senegal with contrasting (semi-arid and sub-humid) types of savannah. We found out that Common and Derby elands did not differ in concentrations of macro-elements, rather the macroelement concentrations were different by location, i.e. vegetation and consequently by food resources. Fiber fractions followed the same pattern which means not different between species, rather than location. The exception was the content of lignin which was higher in Derby eland, indicating thus that Derby eland browse more than Common eland, and this was more pronounced in the sub-humid vegetation in the Fathala reserve which is closer to Derby elands' native environment in the Niokolo Koba national park in south-eastern Senegal. We conclude that Common and Derby elands may have very similar quality of diet which is rather plastic according to the environment where they are placed, however our findings indicate that Derby elands maintain their ecological niche narrower.



## Similarly low-frequency stag rutting calls and hind contact calls develop from the high-frequency newborns calls in Pannonian red deer

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Studying the vocal ontogenetic pathways across subspecies and populations of red *Cervus elaphus* highlights evolution of vocal communication. Formerly, similarity of high-frequency stag and hind calls and their development from similarly high-frequency newborn calls was revealed in American *C.e. canadensis* and Siberian wapiti *C.e. sibiricus*. At the same time, similarity of low-frequency stag and hind calls and their development from high-frequency calf calls was revealed in Iberian red deer *C.e. hispanicus*. This study investigated stag, hind and newborn calls in the Central European Pannonian red deer *C.e. hippelaphus* of Southern Hungary. Audio recordings were collected by using automated recorders in the rutting seasons of 2015 and calving season of 2016. Keeping females with calves apart from males on the farm and distinctive acoustics of calves allowed us to identify and analyze their calls blindly from the automated recordings. Analysis of 71 stag rutting roars (the longest roars within bouts), 159 oral contact calls of hinds and 148 oral contact calls of calves revealed very close values of the maximum fundamental frequency between hinds and stags ( $160 \pm 28$  Hz and  $163 \pm 65$  Hz respectively,  $p=0.79$ ), whereas peak frequency differed between sexes ( $610 \pm 596$  Hz in stags and  $1034 \pm 877$  Hz in hinds,  $p < 0.001$ ). At the same time, both maximum fundamental frequency and peak frequency of calves contact calls was high ( $785 \pm 82$  Hz and  $1641 \pm 1008$  Hz). Stag calls ( $1.62 \pm 0.53$  s) were longer than either hind or calf calls ( $1.22 \pm 0.67$  s and  $0.29 \pm 0.12$  s respectively). We discuss that the descending ontogeny of fundamental frequency observed in Pannonian red deer, is typical for other studied European subspecies of Iberian and Corsican *C.e. corsicanus* red deer in opposite to the non-descending ontogeny of fundamental frequency in Siberian and American wapiti. Supported by RFBR grant 19-04-00133.

## Forest undergrowth phytocenosis as a factor impacting the bank vole's area usage

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The aim of the study was investigating the bank vole's (*Clethrionomys glareolus*) area usage within the context of the habitat's local heterogeneity, particularly considering the characteristics of the forest undergrowth phytocenosis. The research was carried out in 2017 on a 1-hectare research plot in the commercial forest stand of the Białowieża Forests. During field works, undergrowth features (dominant plant species, the average height of vegetation and the degree of plant coverage) of the area within the research plot were described. After that, telemetry studies of 9 individuals of the bank vole (4 males, 5 females) were performed. 339 bearings among all tracked animals were collected, mapped and linked with phytocenotic description of the research plot. It was found that bank voles were tracked the most frequent in places with more than 70% of plant coverage (95% of all bearings). That ratio was different from the research plot structure, where the availability of places with high coverage was significantly lower ( $p$ -value < 0.01). Animals clearly avoided places with low vegetation cover. Second factor impacting area usage was the average height of vegetation. Animals chose places covered by plants higher than 50 cm more frequently (23%) than their occurrence in research plot (11%) would suggest. We noticed that the research plot was covered mostly (82%) by *Stellaria holostea*, *S. nemorum* and *Oxalis acetosella*. Almost 88% of bearings were collected in places with these dominant plants. However, the research plot contained few places (7.5% of all area) with *Pteridium aquilinum* and *Athyrium filix-femina*, but these places were distinguished by a significantly large number of bearings (12%,  $p$ -value < 0.01). Animals were never tracked in places covered by *Impatiens parviflora*, despite the plant covering a relatively large proportion of the research plot, amounting to 7%.

## **Pest suppression by bats in a human-modified landscape**

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Human-modified landscapes are often composed of patches of small, isolated natural habitat fragments immersed in agricultural and urban matrices. Within them, ecosystem services provided by wildlife, such as pest suppression, may be lost; leading to a substantial increase in agricultural production costs. Pest suppression by bats has been identified as an essential ecosystem service but remains poorly investigated. For example, we still lack a basic understanding of the proportion of pest insects within bat diets. Here we explored the diets of 10 Brazilian bat species (78 individuals in total) in a human-modified landscape through the analysis of carbon (<sup>13</sup>C) and nitrogen (<sup>15</sup>N) stable isotopes in fur. Additionally, we investigated diet through time by comparing different tissues within the same individual.

Our results of nitrogen values indicated that bats of different guilds belong to similar trophic levels. Isotopic data from the other tissues showed a consistent diet within the individuals in this area all year round.

Bats can consume up to 34% of pest insects in a human-modified landscape. The trophic level of all bats showed a more generalist diet than previously assumed. The proportion of forest insects in the diet of open space insectivores may indicate the importance of small forest patches as food resources. Besides providing pest suppression throughout time, bats' contribution to this ecosystem service could improve the economic conservation value of Neotropical bats in human-modified areas.

## **The influence of parasitism, food availability and predation on the breeding success of the Little Vermilion Flycatcher**

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The aim of the project was to identify the factors that led to a rapid decline of the Little Vermilion Flycatcher *Pyrocephalus nanus*, an endemic land bird of the Galápagos Islands.

During the breeding season 2018, we compared breeding success, reasons for breeding failure, level of *Philornis downsi* parasitism (an introduced parasitic fly), predation and indicators for habitat quality between three study sites that differ in habitat and population density. We searched for individual birds, their nests and monitored nest activity. To test for the causal role of *Philornis* parasitism for brood loss we injected insecticide into 50 % of nests. We measured habitat quality indirectly via parental feeding and foraging observations of adult birds. Predation pressure was measured with the help of artificial nests, containing Plasticine eggs.

We found difference in breeding success, parasite intensity and habitat quality among the sites, whereas predation intensity resulted to be similarly low.

The results show that *Philornis* parasitism is a major threat for this species and can cause high brood loss in areas with high *Philornis* intensity. Indeed, in the study site where *Philornis* parasitism intensity was significantly higher, only nests that were experimentally freed from parasites were successful.

We found a difference in parental feeding rate, foraging rate and foraging behaviour among the sites, revealing a difference in food availability and habitat structure. Nevertheless, the direct influence of habitat quality on breeding success remains uncertain. Further studies are required, especially at the study site in Santa Cruz holding an extremely small population density in a highly transformed habitat.

## **Daubenton's bat (*Myotis daubentoni*) hibernation at the Leningrad region**

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Daubenton's bat is in the Leningrad region's Red List. The research of water bats' hibernation was conducted during autumn, winter and spring of 2017-2019. The number of hibernating animals was counted in artificial caves of the Leningrad region: Tanechkina, Rebrovsky (2 caves), Sablinsky (5 caves) and Borschovsky (2 caves). We registered the height from the floor and the exact location for each bat (it might have hanged open on the cave roof, or in the chink), the presence of condensation on the fur, the animal was in a group of species-mates or singly. We also measured temperature and humidity in each cave. The total number of hibernating Daubenton's bat was 269 in all examined caves.

The largest number of water bats overwintered in Tanechkina cave. This is the longest cave of the Leningrad region, it's length is 6,5 km. We found 235 individuals wintering, which is close to the number of animals that wintered in the cave in 2003–2004 (Chistyakov, 2005).

Most of the bats preferred to spend the winter open on the walls of the cave (up to 97% of individuals in some cases). The water bats were located singly the most times, there were also cases when the animals were arranged in groups of two, three and even six individuals. Such clusters were purely mono-specific in the Borshchovsky and Rebrovsky caves complex, whereas Daubenton's bats were noted together with Brandt bats and in pond bats' clusters in Tanechkina Cave.

The caves of the Leningrad region are often visited by people, who light fires, candles and smoke bombs inside the caves during the bats' hibernation. Taking this in account, constant monitoring of the number of hibernating animals and a more detailed study of the influence of anthropogenic factors on the number of bats is necessary.

## Size matters: Do leukocytes number and ratio depend on felids hunting strategy?

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The total number of leukocytes and their types is related to species immune systems. In mammals it may be related to the animals' mating strategy (in carnivores and primates), but body mass has more impact in other taxon (rodents). We analyzed the factors affecting leukocytes number in felids: a group of phylogenetically closely related species with promiscuity as their main mating system. We checked the data on 26 species in zoos (ZIMS Data Base) and considered them as small (less than 10 kg), medium (10-30 kg) and large (more than 30 kg). The total number of leukocytes varied significantly in felids of different sizes ( $\chi^2=9.4$ ;  $p=0.0091$ ) and correlated at species level with the body mass of animals ( $r=0.53$ ,  $p<0.05$ ). Higher numbers of leukocytes in big cats may be explained by greater risks of infections associated with larger body surface, lifespan and home range size. Large cats also have more neutrophils and monocytes but fewer lymphocytes than smaller cats ( $\chi^2=8.7-10.5$ ;  $p=0.0013-0.0094$ ). The ratio of neutrophils to lymphocytes is greater in large felids. This phenomenon may be related to diet: relative prey size (about 80% for big cats and about 10% for smaller ones) and kills' utilization time (few hours for small cats and up to one week for large ones). Longer intervals with the kill suggest regular contact of large cats with bacterial and protozoal pathogens in contrast to the small cats. The analysis of seroprevalence of Amur tiger and Bengal cat confirmed that tigers have contacted with non-viral pathogens more often than Bengal cats. There were no differences in seroprevalence to the nine tested viruses. These differences in leukocytes number and ratio should be taken into account in animals' health assessments in the wild and in captivity. This study was supported by Russian Science Foundation 18-14-00200.

## **Larks, owls, swifts and woodcocks among fruit flies: Maladaptive responses of the sleep-wake cycle to hot and long summer days are modified by heritable chronotype**

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*Drosophila melanogaster* and our own species have many things in common including history of rapid out-of-Africa dispersal. In Eurasia, we both faced the problem of adjustment of our circadian rhythms to seasonal variation in day length, and each of us usually responds to night sleep disturbances by prolongation of siesta. To further explore similarity between two species, a division of flies into chronotypes was examined. By testing the circadian rhythms of locomotor activity in constant darkness, 4 strains originating from three wild populations of Africa, Europe and the USA were selected as the representatives of 4 distinct chronotypes: “larks” (early morning and evening peaks), “owls” (late morning and evening peaks), “swifts” (early morning and late evening peaks) and “woodcocks” (late morning and early evening peaks). The locomotor rhythms and sleep-wake pattern of selected chronotypes were tested under either long day condition (L:D 20:4) at 20 °C or combination of high temperature (29°C) with L:D 20:4. The circadian rhythms of 4 chronotypes showed distinct patterns of maladaptive response to L:D 20:4. “Woodcocks” became fully arrhythmic. “Owls” exhibited as many as three prominent peaks of activity. In “larks” the reaction to the light off was blunted but their response to the light switch was very strong, while the opposite was true for “swifts”. We concluded that an experimental study of heritable chronotypes in *Drosophila melanogaster* can deepen our understanding the genetic underpinnings of individual variation in vulnerability to maladaptive sleep-wake behavior, circadian misalignment and sleep disorders.

## **To migrate or not to migrate... is it my personality?**

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Many studies have highlighted the importance of migratory species in connecting different habitats, but also stressed the vulnerability of these species to changing environmental conditions. Insights into the processes mitigating animal migration are thus crucial to understand and protect migratory species and the key ecological roles they play.

Migratory strategies do not only vary between species, but also within species. These 'partial' migratory species are ideal study models to better understand migration. Partial migration is also known to occur in certain bat species, yet studies have mostly focused on birds. Because bats differ from birds in a number of key life-history traits (e.g. hibernation, lactation), insights from partial migration in bats would give us a more comprehensive understanding of the processes mitigating animal migration and thereby the overall vulnerability of this vital ecological phenomenon.

A potentially important factor in partial migration is animal personality, i.e. individual differences in behaviour that are consistent over time and/or context. Nowadays, there is strong scientific evidence for animal personality in many species and for links between personality and important life-history traits. A link between specific personality traits and migration strategies would be especially relevant because the presence of personality differences usually implies that individuals are not completely flexible in their behavioral responses. Migrants might thus differ from their conspecifics in their ability to cope with novel (environmental) stressors and changes.

We therefore investigate the potential link between migratory strategy and exploration behavior, an established personality trait in a wide variety of species, in partially migratory noctule bats (*Nyctalus noctula*). Individual noctule bats were recently shown to consistently differ in their migratory strategies, using non-invasive isotopic geolocation. In our current study we will now combine isotopic geolocation data with bat personality assays in the field. Here, we will present our first findings.



## **Diet quality of zebra and buffalo in two nature reserves in Senegal**

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Resource partitioning describes the way how species whose main diet consist of grass can live in the same niche at the same time. The general prediction is that larger herbivore species utilize abundant low quality forage while smaller herbivore species use scarcer high quality forage. The aim of this study is to determine the concentrations of macro and micro elements in faeces as diet quality indicators of zebras and buffaloes in the semi-arid Sahelian savannah in the Bandia reserve and sub-humid savannah in the Fathala reserve in Senegal. These two species are grazers with occasional browsing and buffalo can reach twice the body size of zebra. Minerals concentrations were analysed by ICP-OES for 45 samples of faeces collected throughout the year. Data were statistically tested by factorial Anova for differences between locality and animal species. Locality had significant effect on 11 (Mn, Fe, Co, Se, Lignine, etc.) out of 18 indicators and animal species had significant effect on 8 (Cu, K, Mg, Zn, Lignine, etc.) out of 18 indicators. Lignine was found to be in much higher concentration in buffaloes in the Fathala reserve when compared to those in Bandia reserve. Concerning lignine polymer in zebras, our results show a low and stable concentration in both localities. The finding indicates that buffaloes in the Fathala reserve browse in larger extent. We detected big differences in concentration of Mg and Zn in faeces of buffaloes and zebras in the Bandia reserve, and buffaloes had higher levels of these minerals. Contradictory to resource partitioning general prediction, our sample reveal that buffaloes use higher quality forage than zebras and are more variable in diet selection and use its environment in broader extent than zebra.

## Contrasting strategies to cope with thermal variation in a wild fish community

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Understanding responses of wild marine animals to temperature variability is essential to predict impacts of future climate change and inform conservation actions. Most ectotherms are expected to adjust their behavior to avoid extreme temperatures and minimize acute changes in body temperature. However, measuring such behavioural plasticity in the wild is challenging. In Tvedestrand fjord, in southern Norway, surface water temperature ranges seasonally from 0 to 24 °C challenging the behaviour and distribution of the inhabiting fish community which includes cold- and warm-water affinity species. Here we hypothesized that 1) species with contrasting thermal tolerance will display different strategies (i.e. behaviour and distribution in the water column) to cope with the thermal variation in the fjord, 2) within a species, individual characteristics (e.g. body size) will influence their plasticity to temperature changes. To test these hypotheses we used aquatic acoustic telemetry to continuously record the movements and behaviour of a total of 360 individuals belonging to three fish species with different thermal preferences and life-history strategies: cod (*Gadus morhua*), pollach (*Pollachius pollachius*) and ballan wrasse (*Labrus bergylta*). In parallel we recorded water temperature at several depths. Using mixed-effects models, we show how thermal preference is a main driver of behaviour and distribution of the fish community in Tvedestrand. We discuss how this information can be considered into conservation actions such as the design and implementation of marine protected areas.

## **Individual identity of ultrasonic calls along ontogeny in the yellow steppe lemmings (*Eolagurus luteus*)**

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Individual vocal identity is important for supporting mother-offspring relationship and for individual vocal recognition in groups of mammals. Pup rodents primarily vocalize in the ultrasonic (USV) range, but ontogeny of individual vocal identity until maturation was not investigated in rodents. Our expectancies were that a degree of individual identity in the USV calls will increase with age, as it is more important for the mobile adolescents and adults with permanent social relationships than for mothers looking for their neonate pups falling out of the nest. We recorded USV calls of 120 yellow steppe lemmings *Eolagurus luteus* in the laboratory colony of Moscow Zoo (Russia) at February-June 2018. Subjects were recorded at one of 12 post-natal-day (PND) age-classes: PND 1-4, 5-8, 9-12, 13-16, 17-20, 21-24, 28-32, 33-36, 37-40 (pups), PND 41-60 (adolescents); PND 60 and older (breeding adults). We recorded 10 individuals per age-class, 120 in total, each isolated for 2 min at 22<sup>o</sup>C on an unfamiliar territory, using Pettersson D1000X (384 kHz, 16 bit). In total 1176 USV calls (up to 10 per individual) were analysed spectrographically. We measured 6 acoustic variables in each call and estimated the vocal individuality for each age-class with discriminant function analysis. In newborns (PND 1-4 days) 57% of USV calls were correctly assigned to individuals. In the older pups (PND 5-40 days), percent of correctly assigned to individuals USV calls ranged from 43 to 62%. In adolescents, percent of correctly assigned to individuals USV calls was 52%; whereas in adults it was 40%. ANOVA did not reveal significant differences in the individual vocal identity between the age-classes ( $F_{11,105}=0.74$ ,  $p=0.70$ ). We discuss that, against expectations, vocal individuality of USV calls in yellow steppe lemmings did not increase with age, remaining at the same level in pups and adults. Supported by RSF grant 19-14-00037.

## SOCIAL BEHAVIOUR AND MATING SYSTEMS

### The estimated size of a population of Jaguar and its behavior in the Pantanal region, Brazil

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The Jaguar (*Panthera onca*) due to its feeding characteristics lives in constant conflict with man. Knowing the size of the population of this species, its social and food behavior is fundamental for effective conservation and management. The objectives were to know the displacement, feeding behavior and degree of gregariousness of the animals. Trail cameras (installed near carcasses) were used. The study was conducted between December 2015 and September 2018. 200 points were georeferenced in three ranches (TP(21), CF(62) and PC(117)) and jaguar images were captured at 67 points. Adult animals (n=70) were identified by comparing patterns (the main signs, icons, designs and spot of each animal were observed) according to the position of the animal (back(n=17); front(n=21); left side (n=36); right side(n=46), date and time of the picture). The offspring (n=18) were counted separately. Many animals observed near a carcass were photographed alone, however, it was found that others remained in groups [group size, g=1:49; g=2:9; g=3:2; g=4:3; g=5,6,8,17:1, (total=67)]. As juveniles begin to mature they begin to accompany their mothers (9 females with cubs) and begin to feed on meat. The juveniles learn to hunt through accompanying their mother. Predated cattle had an estimated mean weight of 251 ± 88 kg, with a minimum of 35 and a maximum of 380 kg. A high disappearance of calves, born in the first weeks of life, was observed in the maternity pastures. It is likely the calves have been preyed upon by Jaguar, without the cows witnessing it. The population of Jaguar is likely to be growing due to the abundant food source and lack of predators of the species. Mothers teach cubs to prey on domestic animals and the jaguar's were observed to coexist in groups, often close to the residences of the cowboys.

## The importance of vultures in the elimination and location of carcasses in the field

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The objective of this project was to study the activities of vultures in the field as scavengers and as carcass indicators. Vultures are the species most commonly encountered at cattle carcasses depredated by jaguar. They are birds belonging to the order Cathartiforme, with seven species found in Brazil: the greater yellow-headed vulture (*Cathartes melambrotus*), turkey vulture (*Cathartes aura*), lesser yellow-headed vulture (*Cathartes burrovianus*), king vulture (*Sarcoramphus papa*), and the black vulture (*Coragyps atratus*). The latter two feed on carcasses. *Cathartiformes* digest large amounts of rotting flesh. Of the more than 200 carcasses found, the presence of these birds was detected at all of them. When a carcass is freshly felled by a jaguar, the constant presence of vultures facilitates locating the carcass. However, if the carcass is in an open field, flocks of vultures can devour an entire carcass in 24 to 48 hours. These scavengers are of paramount importance for the disposal of carcasses and decaying organic matter, avoiding the spread of diseases, and eliminating bacteria that could cause problems to other living organisms and the environment. The research presented supports conclusions concerning the importance of these birds for maintaining and balancing the ecosystem.

## **Females rule, males serve: The recipe for social monogamy in a Neotropical monkey?**

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Social monogamy is rare in mammals, and the mechanisms of maintenance and evolution of pair living and pair bonding remain a puzzle. Among mammals, the highest proportion of pair-living species is found in primates. Titi monkeys, a “textbook example” for a “monogamous” primate, have long-term pair bonds and unusually high levels of paternal care, with males being the principal infant carriers. To investigate mechanisms of pair-bond maintenance and contribute to our understanding of its evolution, we studied 7 wild groups of red titi monkeys (*Plecturocebus cupreus*) in Peruvian Amazonia over a period of 14 months. We analysed pair bonds by measuring proximity, grooming, and approaches/leaves within pairs and collected data on intergroup and predator encounters, activity budgets, and diet in males and females. Females invested in the pair bond more than males, especially during infant dependency, when most of the grooming within pairs was done by females. Females expressed more proactive behaviours within pairs, initiating most changes in proximity (approaches/leaves) with males. Males, on the other hand, invested more in territorial and anti-predator defences. They participated in all intergroup encounters, while females participated in 73% of them. In 46% of intergroup encounters and 40% of encounters with predators, males initiated the calling and females only joined later or did not join at all. Females never initiated the calling. Infant care strongly affected pair bonds and animals’ activities and diet. After infant birth, males and females spent significantly less time in close proximity (<1 m) than before, and females rested less and consumed more protein-rich foods, while males rested more and consumed less protein-rich foods. Our results support the hypothesis of male services as a selective pressure for the pair-bond evolution, where females invest in pair bonds in exchange for male services: infant care and territorial and anti-predator defence.

## **Social behaviour variation in wild adult female vervet monkeys under food provisioning experiment**

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Time is a crucial aspect in animal's lives. In group-living species, the different individuals' time management has to deal with the coverage of different requirements such as feeding, resting, socialising and moving. Many studies have tackled the issue of time in different primate species, so we know that not only feeding but also resting and socialising can have important effects for individuals' fitness. During this study, we will provide eight adult female individuals (4 top-ranked dominants, 4 bottom-ranked subordinates in 4 different groups) additional food to examine the potential shift in their time management. We will analyse changes in their resting, feeding and social activity patterns (grooming given and received) in different study phases. More specifically, we will look at the possible changes in grooming behaviours that the experiment individuals may undergo while being fed: the grooming effort, grooming partners and the dynamics of change of grooming interactions with their partners. This framework may offer us insights into how individuals may organize and strategize over their grooming behaviour distribution, possibly with implications of changes in their social standing within the group.

## **Blood in space: The elements of sociality in Eurasian lynx local population formation**

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Eurasian lynx are felines that regardless of living solitary lives, show elements of sociality that are important in the processes of forming local populations. Female Eurasian lynx may stay close to their female relatives, forming genetically distinguishable maternal clusters. Males are randomly spaced considering relatedness. Home range overlap is density-dependent and affects the social relations in the population. Natal dispersal is male-biased as many females stay philopatric, but both sexes are known of dispersing both short and long distances.



## **What can relatedness analysis teach us about Eurasian lynx sociality?**

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Studying aspects of sociality of a crepuscular and solitary species is challenging, and even further complicated by the facts that most European lynx populations are either small or fragmented. Combining genetics and ecological information on specific individuals can give us novel insight into the social life of this solitary felid. Finnish population of Eurasian lynx is rather large, currently approximately 2000 adult individuals, and more or less continuously spread over southern and central Finland. Relatively recent studies have shown that Finnish population is genetically still connected to Russian lynx population even though exact details on the rate of immigration and emigration are not known. We have studied different aspects of genetics of Finnish lynx in a study area in southeastern and southern Finland focusing especially on relatedness analysis of the recognized individuals and other ecological data linked to these individuals. Study material is from both hunted and otherwise dead lynx, but also from marked individuals and non-invasive sampling. Results are presented and the implications of results on the conservation and management of the species discussed.

## Friends over muscle: Social support explains why females dominate males in spotted hyaenas

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Identifying how dominance within and between the sexes is established is pivotal to understanding sexual selection and sexual conflict. In many species, members of one sex dominate those of the other in one-on-one interactions. Whether this results from a disparity in intrinsic attributes, such as strength and aggressiveness, or in extrinsic factors, such as social support, is currently unknown. We assessed the effects of both mechanisms on dominance in the spotted hyaena (*Crocuta crocuta*), a species where sexual size dimorphism is low and females often dominate males. We found that individuals with greater potential social support dominated one-on-one interactions in all social contexts, irrespective of their body mass and sex. Female dominance emerged from a disparity in social support in favour of females. This disparity was a direct consequence of male-biased dispersal and the disruptive effect of dispersal on social bonds. Accordingly, the degree of female dominance varied with the demographic and kin structure of the social groups, ranging from male and female co-dominance to complete female dominance. Our study shows that social support can drive sex-biased dominance and provides empirical evidence that a sex-role defining trait can emerge without the direct effect of sex.

## Mate choice in white rhinoceros (*Ceratotherium simum*, Burchell, 1817), new insights for conservation management

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Mate choice is prominent in species with high parental investment (Trivers 1972). It is a key element in the reproductive behaviour of a species and can directly influence the genetic variability of populations and their risk of extinction (Anthony & Blumstein 2000). Preferences for mating partners can cause a bias in the breeding sex ratio and lead to a reduction in the effective population size while mate choice against related individuals contributes to maintaining a genetically diverse population, and can decrease the probability of extinction (Quader 2005).

The white rhino (*Ceratotherium simum simum*) is characterized by a low genetic variability at neutral or nearly neutral markers (Guerier et al. 2012). Currently, the species is threatened by extinction and all remaining individuals live in isolated populations that are susceptible to a loss of variation through genetic drift or inbreeding. The high maternal investment of female white rhinoceros in their offspring suggests that female mate choice could be pronounced in this species.

We combined 11 years of field data with paternity assignments of 69 individuals. We show that while the overall mating system was promiscuous, a third of all females with multiple offspring were monogamous. Moreover, relatedness did not influence mate choice; indeed, the male with the highest reproductive success was most closely related to all females and one daughter produced a progeny with her father. The lack of inbreeding avoidance, in combination with the skewed reproductive success of males, the partial monogamy in females and the territorial based mating system, jeopardizes the already low genetic variation in white rhinoceros. Considering that the majority of populations are restricted to fenced reserves and private farms we recommend the regular exchange of unrelated males to avoid further declines in this species.

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## Noisy neighbours: Patterns of signal partitioning in mixed-species aviaries

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Many species communicate using acoustic signals, which are important for survival and reproduction. It is therefore beneficial for species to be heard within the acoustic landscape. Noise is a prominent feature of all environments, and can differ widely between habitats. Whilst habitats themselves have typical noise patterns, biotic sources of noise can be harder to avoid. Signal partitioning, both temporal and spectral, is frequently reported in wild bird assemblages. However, this phenomenon has not been studied in zoological collections. Mixed-species enclosures are a prominent feature in zoos with a number of benefits for animals, zoo staff and visitors. Such enclosures often hold a range of species that would not overlap in the wild, creating an unnatural acoustic landscape. It is not clear whether birds can alter their vocalization behaviours to adapt to these new assemblages.

We examined signal partitioning in a number of mixed-species aviaries at Chester Zoo, UK. Automated recording units, set to record continuously, were deployed in these enclosures to obtain recordings across the diel period. Species vocalizations were classified by comparison to aviary list and example recordings from available online datasets. We report on both coarse- and fine-scale temporal partitioning in birds housed in mixed-species aviaries, comparing the extent of partitioning for a number of categories, such as geographic location in the wild and phylogenetic relatedness. Differences in spectral characters of song were also considered in cases of overlap.

The results of this study are important to zoo planning and management, particularly on composition of mixed-species enclosures. Although any changes in vocal behaviour at this scale are likely to be plastic, zoos often want to preserve wild-type characteristics for education and conservation purposes.

## **Does being cheated on speed up biological ageing in zebra finches (*Taeniopygia guttata*)?**

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A growing body of literature shows that having strong, stable pair bonds improves health, longevity and success in raising offspring across taxa. But what are the physiological mechanisms underlying the link between pair bond strength and fitness?

Various environmental factors (such as poor early-life nutrition) have been linked to increased rates of biological ageing through accelerated shortening of telomeres (the DNA caps at the ends of chromosomes). It is possible that social situations, such as extra-pair paternity where monogamous pair bonds are compromised, may induce stress at a rate that accelerates telomere loss. We predicted that strong pair bonds reduce physiological stress, resulting in a slower rate of biological ageing. We tested this by experimentally manipulating pair bond strength in the zebra finch, a highly social bird species that forms lifelong pair bonds where parents raise young together. We exposed females in aviaries to males from two different breeding lines, which were selected to show either high or low courtship rates, generating different rates of extra-pair paternity.

We predicted that females paired with cheating males would suffer increased physiological costs of reproduction, and age faster compared to females mated to faithful males. We inferred rates of biological ageing by measuring telomere shortening across the breeding season while controlling for the number of eggs laid. We found no effect of social mates' unfaithfulness on rates of ageing, suggesting that there might not be a trade-off between parental investment and infidelity.

## Does sexually attractive facial colouration in male rhesus macaques reflect their ability to cope with oxidative stress?

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Elevated oxidative stress (OS) can affect health, longevity and fitness. Studies of sexual selection have hypothesised that signals used in mate choice may indicate an individual's ability to cope with OS and therefore communicate information about their health. Yet primate research on this topic is entirely lacking. Female rhesus macaques prefer mating with darker, redder faced males and such males sire more offspring. However why females prefer this phenotype is unknown. Here we test whether male facial colouration in rhesus macaques is associated with a putative measure of health and condition (oxidative stress). We predicted that males with redder and/or darker faces exhibit lower oxidative damage and higher antioxidant protection. To quantify face colour we measured redness and luminance in digital photographs from free-ranging adult males (N=19) on Cayo Santiago, Puerto Rico. To measure OS, we assayed non-invasively urine samples for 8-OHdG (a marker of DNA oxidative damage) and Total Antioxidant Capacity (TAC). Social rank was calculated from pairwise agonistic interactions. Linear mixed models were conducted on weekly average values for facial luminance and redness and both OS markers. The association between age and social rank was tested using a Spearman's rank correlation. Across the mating season, there was no relationship between facial luminance and oxidative damage and TAC ( $p = 0.58$  and  $p = 0.10$  respectively) nor between facial redness and oxidative damage and TAC ( $p = 0.69$  and  $p = 0.88$  respectively). Higher ranking males were generally older ( $r_s = -0.74$ ,  $p = 0.0007$ ) and higher ranking/older males tended to have redder faces, although this was not statistically significant ( $p = 0.08$ ). We conclude that in our study facial colouration in male rhesus macaques did not reflect underlying OS but we speculate that during the mating season facial redness may be weakly related to social rank in males.

## **Rainfall decrease and Iberian red deer rutting behaviour: Less roaring but higher opportunity for sexual selection**

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In the last decades, climate change has caused a reduction in average rainfall in southern Europe, which is expected to reduce resource availability for herbivores. Resource availability can influence animals' physical condition and population growth. However much less is known on its effects on sexual selection. In this study, we assessed the impact of drought events on several red deer (*Cervus elaphus*) rutting features. We measured the intensity of male sexual behaviour, mean female crowding, percentage of territorial males, and the opportunity for sexual selection in Doñana Biological Reserve (Southwest Spain), from data of daily observations collected during the rut over a period of 22 years. For this study period, we found an increasing trend for less raining and hence poorer environmental conditions, which associated with decreased rutting intensity (less roaring) and less territory-defense mating strategies, along with higher female crowding. This favoured higher degree of polygyny and opportunity for sexual selection, although all these relationships were modulated by population density and sex ratio. This study highlights how climate change (rainfall reduction) can alter the conditions for mating and the opportunity for sexual selection in a large terrestrial mammal.

## Changing quality of pair bond over reproductive season in grey wolves?

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Data from other monogamous bird and mammal species as well as ethological theory suggest changes in male versus female behaviour during stages of canid reproductive cycles. This assumption is preliminarily supported by Data from other canid species like maned wolves or corsac foxes e.g. by changes in approach/leave coefficient, behavioural synchrony and behavioural sequences.

Males tend to be more interested in contacts to females during pro-oestrus and oestrus whereas females tend to follow males more than vice versa during the metoestrus phases (combined pseudogravity/pseudolactation). No significant differences could be found in anoestrus.

Pair-formation and male-female behaviour have been observed (focal sampling, scan sampling, behavioural sampling) for a total of 845 hours in grey wolves in two zoos (Osnabrück and Vienna). There were two different group structures. One pack and one pair have been observed during 20 and 9 months respectively, during all phases of the female reproductive cycles.

The results of the pack confirm a process of pair-formation in one pair by increasing asymmetry of contact seeking as well as increasing seasonal changes in social behaviour over the whole observation periods. The data from the pair show a trend as well. Following behaviour and a calculated approach/leave coefficient suggest pair-formation in a pair of grey wolves just living alone for one year.

This study is in line with observations from zoo and field studies of other pair bonded or monogamous species (e.g. siamang, allied rock-wallaby). Also behavioural ecology-based hypotheses on relative value of male versus female partners for reproduction correspond to the results. These hypotheses say that, especially after copulation, the female's interest in the male as a potential helper should increase in species with a significant contribution to paternal care.



## **The social organisation African mole-rats**

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Naked and Damaraland mole-rats (*Heterocephalus glaber* and *Fukomys damarensis*) are often described as eusocial vertebrates that resemble some eusocial insects to a greater extent than other vertebrates. But does the social structure of African mole-rat societies differ from that of all other social vertebrates – and, if so, in what ways? I discuss the similarity of social mole-rats with obligatorily eusocial insects and other specialised cooperatively breeding vertebrates and explore the implications for our interpretation of the social organisation of African mole-rats.

## DEFAUNATION: SPECIES FUNCTIONAL EXTINCTIONS AND THEIR SOCIO-ECOLOGICAL CONSEQUENCES

### Maxent modeling for predicting suitable habitats in the Central Caucasus (North and South Ossetia) for Persian leopard (*P.p.ciscaucasica*) based on GPS data from collared and released animals

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One of most popular modeling algorithms for spatial distribution of species forecast nowadays is maximum entropy algorithm – MaxEnt. Such a model is based on the presence-only data for species which habitat is needed to be estimated. Inaccessibility for direct evaluation considerably limits studying the animal ecology in mountainous regions. To overcome this constraint remote sensing methods were applied, and the results obtained for a limited area covered by field routes were interpolated for the whole study area.

As basic information for modeling we used gps telemetry results from six tagged and released Caucasian leopards (2016, 2018 – 2♀4♂). The modelling area covers the Caucasus mountain country. Digital elevation model (DEM, 250 m resolution) including morphometric characteristics of the relief provided the basis for interpolation. 19 climatic variables from global climatic database were added. To assess the spatial distribution of animals across the Caucasus the potential habitats were analyzed for the species in general, as well as for males, for females, and for each individual separately. To obtain a reliable final model 15 repeated models were run in 10 000 iterations in each pixel of the study area, 25% of discrete points in each analysis were randomly selected to test the resulting model. To estimate standard error the Area Under the Curve was calculated (mean AUC value for the 15 repeated models equaled 0.935, and SD was 0.003).

Among 111 factors of the interpolation model 13 contributed more than 1% to modelling the potentially suitable habitats. The major factors determining the areas potentially suitable for the leopard included precipitation of the warmest quarter; altitude above sea level; slope steepness; NDVI (vegetation index) and two indices reflecting the depth of the snow. Notably, the total percent contribution of the abovementioned factors equaled 44,3%, being relatively low for each of them.

The interpretation demonstrates that the most suitable habitats are confined to rather steep slopes with herbaceous vegetation at the altitudes of 1200 m and higher independent of the aspect with average values of snow cover indices.

## **Inventory of Siberian tiger (*Panthera tigris altaica*) habitats in lesser Khingan mountains (Heilongjiang Province, PRC)**

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Siberian tiger population dramatically decreased under poaching pressure during first part of XX<sup>th</sup> century. Currently, the population is small, its range is limited, and this species is listed the IUCN Red List with status Endangered. Strategies, action plans and conservation programs for this species include acts focused on both restoring population size and habitat range. At 2013-2014 six tigers with GPS collars (3 males, 3 females) were reintroduced at the historical habitat area in the Russian Far East. During monitoring we received data on tigers crossing Russian-China border several times near Lesser Khingan Mountains forest area (Heilongjiang province). Chinese government expressed commitment to organize network of protected areas focused on tiger conservation with the scientific base.

Program of Tiger habitats inventory includes three main stages: field studies, habitats classification and habitat suitability modeling. The modelling area covers the Lesser Khingan mountain country and adjacent agricultural areas. Generic desktop modeling of tiger spatial distribution was conducted in MaxEnt based both on pure GPS tracks accumulated from collars of released tigers and remote sensing data. Model results were used for field survey planning. Field data (2017-2019) contain information on forest conditions and wild ungulates density. For modeling we used MODIS dataset and Landsat 8 images (two seasonal periods – June, September). Images were complemented with spectral vegetation, soil and moisture indices, as well as digital elevation model and morphometric parameters (30m resolution). About 400 field descriptions of forest composition were classified by K-means procedure to obtain 15 main habitat types. That was used as learning sample for maximum likelihood classification of habitats for the whole territory of Lesser Khingan. On the further step we used remote sensing dataset together with habitat types' map for extrapolation of tiger's prey distribution – wild boar, roe deer, red deer. We've implemented for this two modeling approaches – MaxEnt and Discriminant analysis.

Both models show similar results. Ungulates density positively correlates with elevated (up to 450-500 m a.s.l.) steep and convex slopes; also with distribution of small-leaved and broadleaved forests with sufficient soil drainage. Coniferous forests (often at highest elevation above 500-500m a.s.l.) impact models negatively. Wild boar model tends to be correlated with open (non-forested) areas. Three integrated "ungulates" models were used for suitable tiger habitats modeling. This map aimed for planning of Lesser Khingan ecological network.

## HUMAN-WILDLIFE INTERACTIONS: COMING FROM BOTH SIDES

### **Wildbird sellers' - wildbird interaction on biosecurity in live wildbird markets in Kaduna State, Nigeria**

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First avian influenza(AI) outbreak in Africa occurred in Kaduna State, with possible introduction through wildbirds. Few studies have been undertaken on role of human-wildbird interaction in live wildbird markets(LWBMs) in diseases introduction. This study assessed sellers'-wildbird interaction in LWBMs and wildbird trade in Kaduna State. Sellers'-wildbird interaction was assessed using structured questionnaire. All sellers were male and main income was from wildbird trade. Some sellers(22.7%) report sick birds only when attempted treatment fails; and kept poultry at home(78.9%) with 100% allowing poultry-wildbirds contact. Sellers(31.6%) do not wash hands with soap after handling wildbirds. No sellers believe wildbird diseases affects humans. Sellers report disease outbreak to reduce losses(38.9%). Wildbirds were allowed to move in LWBMs(25%). Wildbirds were kept on wood/metal cages and fenced pens constructed from wood/wire mesh with un-cemented floor. Other livestock were sold in LWBMs(75%). Free flying birds(75%) and free range poultry(25%) interact with wildbirds in LWBMs. No seller wore protective clothing. All LWBMs dispose dead birds by burning or burying though 25% dispose wildbird manure improperly. LWBMs features(75.9%) encouraged risky sellers-wildbird interactions with biosecurity practices and poor LWBMs infrastructures contributing 76.2% and 80%(17/21) risky interactions respectively. Wildbirds uses includes food(31.8%), traditional medicine(45.5%) and pets(77.3%). Birds of prey demand was high during election years. Threatened and rear wildbird species were traded in the LWBMs. Over 45% of wildbirds were sourced from 9 foreign countries with majority coming from Chad. Sellers'-wild bird interaction was high and sellers' risk perception was low. Wildbird trade in Kaduna State is linked to the global trade and could be a source for disease introduction into Nigeria. There is need for sellers to be trained on role of high human-wild bird interaction in the introduction of emerging infectious diseases. Routine surveillance of emerging infectious diseases in LWBMs is recommended.

## Does the anthropogenic noise affect foraging in small mammals?

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Noise generated by human activities has increased over the last decades as a result of human population growth, global transport and urbanization. Expertise from the diverse spectrum of disciplines is mandatory to improve understanding of the impacts associated with noise. The aim of our study was to test the foraging of yellow-necked mouse in relation to anthropogenic noise. Our study was conducted in Poznań, Poland, in years 2017 and 2019. We used “giving-up densities” to examine the foraging of yellow-necked mouse (*Apodemus flavicollis*) and conducted road noise surveys to verify whether it influences the foraging. We also recorded abiotic variables such as temperature, wind strength, cloudiness, humidity, and moonlight. In 2017 (pilot data), there was no relationship between the noise level and foraging of small mammals. Here, we will present the comparison of results from two field seasons – from 2017 and 2019.

## Management of human-wild pig conflicts in densely urbanised area – the case of Hong Kong

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While wild pig (*Sus scrofa*) was once considered near to extirpation in Hong Kong in the 1950s, the species has now recolonized almost all countryside areas throughout the territory. In recent years, wild pig has adapted to thriving near human settlements. Some of them become habituated to straying into urban fringe for anthropogenic food, often resulting in conflicts with local communities. The situation is reflected from the handling of over 3,000 public reports related to wild pig sighting or nuisance by Agriculture, Fisheries and Conservation Department (AFCD) of the Hong Kong Special Administrative Region Government between 2011 and 2018. In 2018, the public reports have reached a new record high over 900 cases.

In the past, hunting operations had been adopted as the last resort to deal with persistent wild pig nuisance in rural areas of Hong Kong. However, hunting operation is considered not feasible due to the public safety concern of using firearms near residential areas. Recently, there have been strong opposition against hunting operations from animal right and welfare perspectives. In view of that, there is a pressing need for new control measures to alleviate the human-wild pig conflict situation. Contraceptive control for the habituated wild pig offers an alternative to lethal control.

AFCD has launched a pilot scheme of “Capture, Contraceptive and Rehome/ Release Programme” (“CCRP”) since 2017 as one of the multi-pronged approaches to deal with the increasing human-wild pig conflicts. In addition, the scheme is to examine the effectiveness of GonaCon<sup>TM</sup>, an immuno-contraceptive vaccine, on controlling the reproduction of wild pigs. CCRP creates opportunities for AFCD to test different mitigation methods and conduct scientific studies with a view to better managing the conflict caused by wild pigs. AFCD will monitor the wild pig populations covered by the pilot scheme to evaluate the effectiveness of the scheme by the end of 2019. In parallel, AFCD is developing field surgical routines, including endoscopic neutering and castration, for long-term controls of the habituated wild pigs.

## Human-elephant interaction in north-west India – drivers, patterns and conservation implications of crop-raiding behaviour in a human-dominated landscape

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The largest fraction of the global Asian elephant (*Elephas maximus*) population inhabits India utilising habitat patches which are often suboptimal - degraded, fragmented as well as surrounded by indiscriminate sprawl of rural, semi-urban as well as urban human settlements. Forced co-existence of human and elephants at the interface of elephant habitat and human-dominated fertile tracts of north-west India, the focal area for this study, give rise to frequent negative interactions. Therefore, conservation strategies must attempt to alleviate human-elephant conflict by elucidating the patterns and biological drivers of elephants straying from forests and raiding crops.

To address this issue, we estimated habitat use by the elephant in Rajaji Tiger Reserve (RTR), India by systematically employing occupancy framework with suitable site and survey co-variates (n=12) while recording spatiotemporal patterns of crop-raiding through 28-point semi-structured questionnaire surveys (n=90) along RTR periphery. We used multi-locus microsatellite genotyping (n=5) for molecular tracking of individuals using DNA extracted from elephant faeces opportunistically collected from raided crop fields (n=117) across 45 months.

Elephants naturally frequented the RTR fringes interspersed with crop-fields and settlements, being driven by forage availability, forest cover, terrain and weed abundance ( $\Delta AIC < 2$ ). Raids were frequent in the winters (65.5%) and during 2100-0000 hours (64.4%). We identified 69 unique genotypes ( $P_{ID} = 3.6 \times 10^{-4}$ ) from the faecal DNA. We found that 15 elephant individuals carried out 54.7% of the total raids, while six animals had  $\geq 5$  genetic recaptures. Mean time between recaptures of individuals was 80 days whereas the mean minimum convex (MCP) polygon area of the recaptures was 24.5 km<sup>2</sup> which indicated that habitual crop raiding individuals operated in specific areas. Though the insight gained from the multidisciplinary study is useful for adaptive management of human-elephant conflict, long-term data on the spatial and nutritional ecology of elephants and landscape-specific socio-economy would provide lasting solutions.

## Should I stay or should I go – variability in migration behaviour in red deer

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Migratory shifts between summer and winter ranges are frequently observed in ungulates. Despite the costs of seasonal migration such as high energy investments in locomotion, migratory individuals are hypothesized to benefit from higher forage quality. Thus, the main factor leading to initiation of migration in spring is assumed to be green-up of vegetation. In contrast, return movements in autumn are assumed to be mainly related to the onset of winter. However, in addition to such natural factors, humans likely alter the cost-benefit balance of seasonal migration and thus, might affect migration behaviour. For example, substitutes from agriculture or supplementary feeding in winter may impact migration propensity and timing. Furthermore, hunting is the biggest source of ungulate mortality in Europe and has been shown to alter the spatial distribution of ungulates. Thus, preventing mortality risk might affect the initiation of migration in autumn.

Here, we tested for effects of environmental and anthropogenic factors like agriculture or hunting on the migration behaviour of red deer (*Cervus elaphus*) in terms of timing, distance, and duration. We used telemetry data from more than 350 individuals covering the European latitudinal gradient. Migration behaviour varied across study areas and overall males were approximately twice as migratory as females. We found significant differences in the timing and distance of migration. Migration probability was a function of limiting winter conditions at northern latitudes and higher elevations. Predictability of seasonality affected the probability of migration as well as the migration distance. However, unexplained variability was yet observed, which is likely related to ancillary factors, such as predation risk due to hunting or agricultural subsidies. Overall, environmental alterations, including changing plant phenology under climate change, will alter the benefits of seasonal migration for partially migratory ungulate populations, which must be considered for the management of such populations.



## **The corridor of the last chance: A study of the impacts of livestock on the biodiversity of the Kalahari Desert fauna, Botswana**

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In African savannas, where forage quantity and quality are highly variable both spatially and temporally, numerous wildlife species need to migrate to meet their resource requirements throughout the seasons. However, fewer conservation areas encompass all seasonal resources, due to anthropogenic development encroaching on the remaining wildlife habitats, creating human-wildlife conflicts. After a few years spent in the Botswana savannas as a conservationist, I started a PhD project aiming at studying the impacts of pastoralism on wildlife biodiversity within the largest sub-Saharan free-ranging conservation area, the Kalahari Desert. There, a succession of Wildlife Management Areas form an ecological corridor in between two protected areas. My goals are to: (1) identify the wildlife core habitats and their connectivity within the corridor, for 7 large herbivores and 5 large predators, (2) assess the impact of surrounding pastoral lands and selected livestock water points (LWPs) on wildlife, and (3) identify the most appropriate LWPs for developing alternative livelihoods for local populations. Beside scientific advances, this project will suggest tangible ground-actions to preserve this priceless area, its wildlife and its people.

Large-scale spoor surveys, run with the help of local Basarwa trackers during transitional months when animals shift seasonal ranges, will highlight abundance and movements of wildlife in the conservation corridor, as well as the effect of surrounding pastoral areas and specific LWPs. Involving Basarwa trackers is key as they are highly skilled for identifying animal tracks, but are also then involved in the conservation of their own lands and cultural heritage.

During my talk, I will present the results of the first 2019 spoor survey, used to identify current migration routes, and quantify gradual changes in wildlife presence and abundance according to the distance to the edge of the conservation corridor and to LWPs.

## **Forestry and browsing by deer in central Europe: Paths towards integrative management**

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Goals of forestry are endangered by a number of influences. For example, biotic factors such as bugs, diseases, and browsing, play a major role. On a longer perspective, climatic change may increase these threats and even alter habitat suitability for specific tree species.

In respect to climate change, oak (*Quercus*) and fir (*Abies*) are of particular interest in Baden Württemberg, Germany, because they are assumed to remain important forestry species in a predicted world of changed climate. It is therefore of great interest to reduce the impact of any factor damaging growing trees substantially during any part of their lifecycle. Specifically, it is of great interest to reduce browsing by roe deer (*Capreolus capreolus*).

While roe deer and its browsing on sapling and young trees is part of the natural ecosystem, it may prevent natural rejuvenation. Lethal control of roe deer is often regarded as the only way to reduce browsing damage and hence to successfully maintain natural rejuvenation. Yet, damage of oak and fir by browsing has partly been severe for decades in large areas despite of hunting. Our research results show a complex system of causes and effects, including the responsibility taken by different stakeholders.

We therefore propose a more holistic approach by including selected silvicultural management efforts: 1.) We define integrated management strategies, in each case aligned with the characteristics of a region, 2.) apply them to selected districts, 3.) establish control areas in these districts and 4.) analyze the effect of the proposed management versus no management. The results allow to evaluate the hypothesis that the proposed knowledge-based integrative approach provides a powerful, effective management tool.

## **Movement patterns of endemic swamp deer across fragmented, human-dominated landscape of the northern Indian subcontinent**

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The Northern swamp deer *Rucervus duvaucelii duvaucelii* (IUCN-Vulnerable) is the largest grassland-dwelling endemic cervid of human-dominated Gangetic plains. With a global population of around 3000 individuals, they are distributed across fragmented grassland patches in north India and southern Nepal. Information about its distribution in the upper Gangetic plains was restricted to protected areas of Jhilmil Jheel Conservation Reserve (JJCR) and Bijnor Barrage area of Hastinapur Wildlife Sanctuary (HWLS) only. We surveyed the entire stretch of Ganges river between JJCR and HWLS to assess fine-scale swamp deer distribution. We looked for swamp deer signs, collected biological samples and identified suitable habitats and threats across the entire human-dominated landscape. Further, using radio-telemetry, camera trapping and genetic analyses we investigated movement pattern in these urban grassland patches.

We found much fine-scale swamp deer distribution than earlier known and identified a new population. Our assessments indicate habitat encroachment, infrastructural developments, hunting and habitat conversions as major threats for swamp deer. We genetically identified 192 unique individuals from two genetic lineages between JJCR and HWLS. Subsequent analyses indicated an intermixing population with low inbreeding coefficient ( $F_{is}=0.039$ ). Information from two females radio-collared in JJCR suggested movement towards HWLS and extensive use of fragmented, non-protected grasslands between JJCR and HWLS. Camera-trapping revealed temporal segregation between human-swamp deer (16% overlap) and indicated that these grasslands are critical fawning and breeding grounds. Amidst burgeoning human interventions, the remnant grasslands between the two protected areas continue to play a pivotal role in maintaining viable swamp deer population in this landscape. Without these grasslands, the genetic connectivity between JJCR and HWLS will break down which might result in inbreeding and isolation in the future. Our results have led to boundary realignment of HWLS and community-driven programs for focused conservation of urban grasslands and associated species in the entire landscape.

## Going to the dogs? Human-induced evolution in the grey wolf

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Domestication is one of the most striking outcomes of human-wildlife interactions, and the grey wolf was the first animal that was affected by this process. Domestic dogs thrive in human-dominated habitats, and the continuous expansion of such habitats have resulted in demographic expansion of the global dog population, currently estimated at 1 billion, which in turn has increased the spatial overlap between free-ranging dogs and wild wolves. More frequent wolf-dog encounters are likely to increase the frequency of hybridisation, especially in regions of low wolf density or in the presence of strong hunting pressure. Hybrids living in natural wolf habitats may have lower fitness than non-admixed wolves, but in habitats being rapidly transformed by humans, hybrids can show higher fitness. Dog-derived gene variants may facilitate adaptation of their wild owners to human-dominated habitats, leading to human-induced evolution. We studied genome-wide introgression patterns in wolves from across Eurasia, and identified 15 chromosomal blocks having a significant over-representation of dog-derived alleles, suggestive of positive selection. Among 105 functional genes located within these chromosomal blocks, we found an over-representation of functions associated with nervous system regulation, reproduction, development and metabolism. This result suggests that hybridisation can be an important source of adaptive variation for wolves, and may facilitate their adaptation to living in human-dominated habitats by modifying variation in genes affecting morphological, physiological and behavioural traits. Adaptation of wolves to human-dominated habitats may result in a shift of their trophic niche from apex predators to scavengers of anthropogenic food, leading to ecosystem-level effects.

## **Using a behavioural game to understand pastoralist decision-making in response to carnivore conflict**

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As conservation conflicts become increasingly complex and widespread, explorations of the acceptability and effectiveness of different management options are critically needed. Experimental games are a potentially powerful way to disentangle this complexity and offer insights into the decision-making processes of local stakeholders.

In the Ruaha landscape of Tanzania conflict between pastoralists and large carnivores is widespread and severe. Previous studies in this area have reported high levels of hostility towards wildlife and frequent incidences of illegal killing of carnivores. This study aims to use a novel behavioural game to explore the effect of different interventions and incentives, as well as issues such as trust and equity, on local pastoralists' behaviour; namely their decisions to use lethal control or to support conservation interests.

The tablet-based game was designed using NetLogo, based on and in collaboration with the author of NonCropShare: an insect-based ecosystem services game. This is the first trial using this model for human-carnivore conflict. Players are given various choices relating to incentives such as support for non-lethal deterrents or subsidies for wildlife habitat provision. Following the game, participants take part in a questionnaire survey to compare game decisions to factors relating to socio-economic status, attitudes and levels of conflict.

While games are necessarily simplified, they are framed to represent the reality of the local situation. They may therefore act as a lens into real world choices and also create a friendly environment to discuss sensitive issues such as illegal killing of wildlife. It is hoped that the outcomes of this work will offer insight into the motivations and thought processes of local stakeholders and provide suggestions of where to focus future mitigation efforts.

## **The effects of tourism on the behaviour of the endangered Zanzibar red colobus monkey**

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Primate tourism provides an important income source for governments and communities in habitat range countries, but it can also have detrimental effects on the species visited. Habituating primates to human observers itself has been shown to increase physiological stress levels, but even well habituated groups can show higher stress levels when exposed to human observers. Self-directed behaviour is a simple behavioural indicator of stress, commonly used in the welfare assessment of primates. We studied the behavioural effects of tourist presence on groups of the endangered Zanzibar red colobus in Jozani Chwaka Bay National Park on Zanzibar (Tanzania). We hypothesised that tourist presence will be associated with higher rates of self-directed behaviour (self-scratching). We followed two colobus-groups with contrasting exposure to tourists for a total of 30 days over 3 months during peak tourist season at Jozani. Ca. 72 hours of focal observations were collected from 41 individuals (33 females, 8 males). The 'tourist group' experienced daily visitations of up to 452 tourists (mean = 188.7). By contrast, the 'non-tourist group' only occasionally and briefly encountered small numbers of villagers. While the monkeys appeared extremely tolerant of close proximity of tourists and never fled, self-directed behaviour rates were significantly higher (mean = 8.73 +/- 0.71 acts/h; Mann-Whitney U test,  $p=0.0044$ ) in the tourist group compared to the non-tourist group (mean = 4.57 +/- 0.56 acts/h). Our preliminary observations suggest that despite years of habituation and tourist presence, the colobus at Jozani may still experience adverse effects of close human observation. Whether this behavioural indicator of stress is also underlined by physiological factors and their associated implications for reproductive performance and health remains an important direction for future work and would be key to informing management decisions in ecotourism in protected areas such as Jozani.

## **Grey seals in the German Baltic Sea: Conservation, research and monitoring of Germany's largest marine predator**

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The return of grey seals was a success of international long-term nature conservation efforts. For more than 80 years grey seals were presumably extinct in the Southern Baltic Sea as the result of massive hunting programmes. Since, the grey seal is now a protected species, monitoring to evaluate the condition and development of the local colonies and haul-out sites is crucial. The monitoring of strandings and sightings in the German Baltic Sea is conducted by the German Oceanographic Museum. During dissections of strandings and by-caught animals data on health status, demography and prey consumption of grey seals is collected. Due to this long-term monitoring, unusual events are easily recognized. For example, a grey seal mass stranding event in 2017 was detected due to fresh carcasses found in an unusual time of the year. This event was most likely caused by a large fish trap causing drowning of 23 seals in few weeks. A legal charge lead to the definition of requirement for seal safe fish traps, that now will be implemented as an additional clause for each permit of a fish trap in Greifswald lagoon. Frequent counts at the common haul-out sites document local occurrence rates since the seals' return 2005 accurately. Observation with wild life and web cams as well as photo-id to analyse temporal and spatial habitat supplement these standard methods. Site fidelity was documented for several individuals showing that, even though haul out site usage varies over the year, seals return after absence for moult and reproduction. The photo-ID catalogue now holds more than 200 animals and 30 matched individuals. This data is necessary to define important areas for grey seals and to take effective management measurements. Temporal closures of potential breeding sites are necessary to complete the recolonization of grey seals on the German Baltic Coast.

## **Temporal changes in reproductive rates of coyotes (*Canis latrans*) in Nova Scotia during an incentive program**

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Common management strategies for introduced wildlife are often directed toward targeted removal, but attempts at eradication or reduction frequently fail. One reason may be that reproductive rate increases with removal pressure. We quantified reproductive rate in coyotes (*Canis latrans*) using placental scar counts to determine if an incentive program from 2010 to 2015 and post-incentive from 2016 to 2018 affected fecundity. We also examined associations between placental scars, age, and mass. Finally, we examined whether age structure changed over time. Reproductive tracts were collected from 1647 females from 2010 to 2018. Lower canines were extracted to age animals. Unexpectedly, placental scar counts decreased over time, contrary to prevailing assumptions. This may suggest that population density did not decrease from the incentive program. Consistent with previous research, older and heavier females had more placental scars; we found no evidence of senescence, possibly because tooth pulp ratios do not precisely reflect actual ages. Age structure was inconsistent among years for females, but consistent for males. A higher percentage (54.1 %) of juvenile males may be due to higher dispersal rates that make males more susceptible to capture, or could represent actual age ratios in Nova Scotia populations but we have no clear explanation for differences between females and males in age structure; this requires further investigation.



## SMART TAGS FOR SMART ANIMALS; BUT ARE WE BEING SMART ABOUT WHAT WE ARE DOING WITH THEM?

### An improved method for the attachment and reattachment of bio-logging devices to hedgehogs (*Erinaceus europaeus*)

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Bio-logging is an essential tool for the investigation of behaviour, ecology and physiology of wildlife. Device attachment usually requires species-specific solutions to ensure that data loggers exert minimal influence on the animal's behaviour and physiology to ensure high reliability of recorded data.

Here we present a modified method of device attachment to hedgehogs that do not hinder the animal's movements and can be easily removed and replaced, thereby solving the trade-off between small device size and the collection of long-term high-resolution data.

In a field study, we collected location and acceleration data from 27 wild hedgehogs using different devices (VHF, GPS and accelerometers) for up to 42 days. We only used hedgehogs with the required body mass of 600g; maximum total mass of the attachment was 30g. Hedgehogs were tracked and checked every day to detect whether they behave normally or had problems. Additionally, once a week all hedgehogs were weighed and inspected.

Our results showed that hedgehogs behaved naturally; as individuals curled, moved through dense vegetation, slipped under fences and built regular day nests without any indication of impediment.

Our novel method overcomes the issue of short battery lifetime common to many lightweight loggers; it enables attachment of high-precision devices for substantially longer than with previous efforts as well as a quick response to unforeseen events by removing or exchange devices.

Overall, our results demonstrate that the back plate system had little influence on the study animals' behaviour. However, we still suggest regular re-capture of individuals to mitigate any potential negative consequences to welfare.

## Large-scale automated monitoring of a long-lived seabird

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We study life-history biology in a mono-specific colony of common terns (*Sterna hirundo*) located on the German North Sea coast. In 1992, 101 adult birds were caught and marked with transponders, and since 1992 all locally hatched birds have similarly been marked with a transponder shortly prior to fledging. The colony walls hold 44 resting platforms equipped with antennae and scales, detecting marked individuals and registering their body mass. Three-times-weekly checks of the colony allow accurate assessment of laying date, clutch size and egg size. During incubation, which is shared between partners, mobile antennae are placed around clutches to identify breeders, as well as used in combination with blood-sucking bugs placed in fake eggs to non-invasively collect blood samples, which are used to assess several physiological and genetic parameters. Chicks are ringed 2-3 days after hatching and monitored until fledging. Finally, we use light-level geolocators and pinpoint GPSs to assess individual migration routes and foraging tracks, respectively. Once birds have established themselves as Banter See breeders, their re-sighting probability is almost 100% and their local survival probability is 80-90%, such that we can collect data over long individual life cycles. Thanks to our unique system, we can therefore investigate life-history variability both within and between individuals and assess its causes as well as consequences.

## **Movement and behaviour of canids through biologging**

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The energetics underlying specific behaviours can yield information on decisions made by animals regarding how they move in space and time. Modern biologgers featuring tri-axial accelerometers and magnetometers offer powerful insights into the fine-scale movement and behaviour of species. However, accurately identifying behaviour from high-frequency, multi-channelled datasets remains a challenge, particularly on free-roaming animals which are frequently out of sight. Deploying biologgers on captive animals can aid interpretation of data from wild individuals. Here we present classification rules for identification of movement and feeding behaviours from accelerometer and magnetometer data for African wild dogs (*Lycaon pictus*). Data were collected over 4 weeks on captive individuals using “Daily Diary” biologgers. Behaviours were classified according to distinct signatures derived from first principles using DDMT Behaviour Builder software. Direct behavioural observations and CCTV footage were used to validate behavioural classification software outputs, achieving 67-96% and 91-100% classification accuracies for feeding and movement behaviours respectively. Movement classification rules were then applied to data collected on 15 domestic dogs of 11 different breeds (*Canis lupus familiaris*). Contrary to expectations, slope estimates were close to zero in all cases, over a 5.5 – 38 kg range in body mass. Next these rules were applied to a wild crab-eating fox (*Cerdocyon thous*), to test the ability of behavioural classification rules derived from captive and domesticated animals in unravelling unobserved wild behaviour through biologging. This work provides the basis for future studies of free-roaming canids, allowing fine-scale movement and behaviour patterns to be determined from field data, where direct observation is often impossible.

## **Smile for the camera: How detection probabilities of camera traps are shaped by animal behaviour and the environment**

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Camera trapping has become an increasingly important tool for wildlife monitoring. However, despite its popularity many factors that may influence the detection probability of animals still lack thorough investigation. For example, the sensitivity of the pyroelectric sensor changes with animal characteristics and environmental variables. In this study, detection distance and angle were measured for photo sets available from the Bohemian Forest Ecosystem to investigate different influences on the estimation of the effective detection zone. Another factor is that animals apparently react to properties of camera traps, such as the flash, which may also change trapping rates over time. We analysed the behavioural response of red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) to 900 camera trap deployments with white, infrared and black flashes in the Bavarian Forest National Park and the Northern Black Forest, both located in Southern Germany. Red deer reacted more frequently to camera traps than roe deer, and a stronger behavioural response was observed with infrared flash when compared to the other flash types. Other important factors for an animal's response were its distance to the camera, its approach direction and whether it was located inside a winter enclosure. A significant decline of observations over time was not detectable for any of the flash types. Overall, while black flash can be generally recommended for behavioural studies, the choice of camera trap flash type does not seem to introduce bias to studying population parameters of native deer species in Europe.

## **Box traps 2.0: Smart, efficient and selective to capture wildlife**

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Wildlife research as well as wildlife management often requires live trapping of animals. For ethical and welfare reasons, the capture should be selective, efficient and minimize the possibility of injuries and stress levels. Here, we present an automatic solar powered box-trap controlled by a microcomputer that uses a GSM/GPRS modem to communicate with the user by providing status reports and live images of the trap. An array of sensors monitors the trap and its surroundings comprising of infrared light beams and pattern recognition from live imagery. This reduced the bycatch and increased the capture success of the target species. To further increase capture success, we connected a sound system to the microcomputer playing audio baits to attract the target species to the trap which proved to be particularly useful in the case of large carnivores occurring at low density. Our box trap 2.0 proved to be reliable and safe to capture big cats, thus reducing animal welfare concerns by reducing the response time of the capture team. Our trap has a higher efficiency and selectivity in balance with economic and welfare considerations than other conventional trapping methods.

## Test what you use: An empirical assessment of proximity loggers functionality

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Thanks to the recent advancements in biologging technology, new tools are available for animal ecology investigation, among which proximity loggers. By exchanging radio beacons one with the other via UHF radio wave transmission, these devices allow the detection of contacts, potentially opening exciting research scenarios for investigating inter-individual relationships and/or use of focal resources. Still, a calibration of these tools is recommended prior to their application in the field. We present a calibration exercise to test the functionality of proximity loggers on animals prior to the application of the loggers in final deployments. We performed a controlled experiment with free-ranging horses and roe deer in semi-controlled settings, to model the relationship between contact detection occurrence and inter-individual distance, while quantifying the associated errors in contact detection. We found that contact detection measured by proximity loggers is not deterministic, i.e. the probability to detect a contact decreases not linearly with the distance between a dyad of loggers. We also found that false positive (unexpected occurred contacts) and false negative events (expected missed contacts) occur at any distance and power setting, and as such must be taken in account to measure the precision and sensitivity of the system, to ultimately avoid biases in the biological inference on proximity patterns. We conclude that proximity loggers represent a remarkable advancement for the investigation of animal ecology and behavior, but we recommend not to blindly applying them in the field without a prior assessment of their performance, which is indeed context-dependent.

## RECENT ADVANCES IN CAPTURE-RECAPTURE STUDIES WITH APPLICATIONS IN WILDLIFE RESEARCH AND CONSERVATION

### Does site occupancy predict local abundance? A comparison of different methods

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Management and conservation of wildlife is ideally guided by information on local abundances and temporal changes in space-use of the species under consideration. However, spatial and temporal accuracy of applied methods can vary substantially. Thus, evaluation of different approaches is needed to optimize data quality and guide practitioners with their decision among available methods.

A multitude of methods has been developed using different sources of information such as camera traps or genetic samples from feces. Information on the number of genotyped individuals can be used for estimating density based on spatial explicit capture recapture models (SCR). Camera traps provide data applicable for estimation of occupancy and relative abundances at a given site. This approach commonly provides a lower spatial resolution, but a higher temporal resolution due to year-round sampling.

Here, we compare these two different approaches using an extensive dataset focusing on roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*) and chamois (*Rupicapra rupicapra*) in the Bavarian Alps. Fecal samples of all three ungulate species were collected in two different study areas in autumn 2018. Upon genotyping of samples, population densities for all three species were estimated using spatial capture recapture analyzes. Simultaneously, 73 camera traps were deployed in both study areas in order to test for temporal changes in habitat use of the three ungulate species. The information retrieved from the pictures was used to fit occupancy models and estimate local (relative) abundance. Finally, we compared the spatial predictions of both approaches and tested for correlation between estimates of local density based on the SCR model and the local abundance/occupancy estimates based on the camera trap data.

Our results showed that the local density estimates of SCR models and the local abundance estimates of camera traps compared well, but accuracies varied and each method held different advantages and disadvantages. For example, fecal sampling showed least accuracy for roe deer due to low detectability of feces

To conclude, our results indicate that camera trap data provides a valuable solution for tracking changes in local abundance and space-use of a given species. However, in order to provide accurate information on population densities SCR models should be taken into consideration.

## **Small mammals as model species to evaluate environmental and climatic effects of climate change across European habitat heterogeneity**

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Background – European biomes and specifically boreal-alpine regions are particularly sensitive to climate change impacts because of their distinctive environmental and climatic context. Environmental bioindicators, such as small mammals, are extremely relevant to determine impacts resulting from anthropic and fast occurring global changes. The presence of these indicator species to track habitat shifts and the recording of strong modification at individual, population or community level can provide important insights on climate-induced effects on ecosystems.

In this context, a large-scale spatio-temporal assessment across Europe will permit to evaluate the climatic and anthropogenic factors which modulate community and population dynamics of small mammals. Moreover, a local scale assessment between boreal and alpine areas will aim to investigate the impacts of climate change and different natural conditions on small mammal movement and disease transmission.

Proposed methods – We will perform (i) a large-scale meta-analysis spanning from Southern Italy to Northern Fennoscandia to disentangle changes in small mammal community and population dynamics through time. We will then perform (ii) a capture-mark-recapture local-scale study in Eastern Italian Alps and in Central Norway to evaluate space-use pattern and parasite load within small mammal communities along an altitudinal gradient. The data obtained from the large and local-scale assessments will be inserted in a relational database and modelled with multivariate statistical approaches.

Expected results and conclusions – Climate parameters variations driven by climate change may induce modifications on small mammal behaviour and habitat selection with consequent changes on species distribution patterns. Indeed, it is possible that these shifts may alter community composition and population dynamics, leading to new inter-specific interactions, with potential insurgence of competition phenomena. Furthermore, predictions derived from output models and based on climate change scenarios will be relevant to evaluate population and community states whose alteration will provoke relevant consequences on disease transmission and lastly on ecosystems stability



## **Predator-prey relations and density estimations based on camera trap data in Bükk National Park, Hungary**

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Population increase of large carnivores in Hungary is a recent phenomenon that causes many tension among different stakeholder groups affected by these animals. Human-wildlife conflicts are intertwined with strong bias and misbeliefs thus the solution of these conflicts must be based on objective data and sound science. Bükk National Park Directorate in Hungary was our study area for testing the effects of the naturally returning wolf (*Canis lupus*) on the local prey and mesocarnivore population. Being an apex predator, the wolf has the potential to regulate the lower trophic levels by direct consumption or by indirect behavioural changes (ecology of fear). To be able to determine the magnitude and the intensity of wolf presence on its common prey species, such as red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*), reliable population density estimations are needed both for predator and prey. The current estimations however, are based on hunting bag data and expert's assessment, which methods are questioned by many experts. Random Encounter Model (REM) can provide reliable alternative for density estimations, by using the information of camera traps without the need of individual recognition of the animal. By comparing the results of REM it is possible to see if this non-invasive, cost-efficient and objective method could offer an alternative of the previous approaches used by wildlife management.

## Pilot estimation of leopard density in the Nama-Karoo habitat in Southern Namibia

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Leopards (*Panthera pardus*) face major threat of habitat degradation and loss, therefore all new data are of tremendous value. Main aim is to acquire population parameters, such as density, abundance and sex ratio on newly established private conservancy area. Capture-recapture camera trapping method was implemented as leopard coat pattern is unique for every individual. 40 cameras were used with two cameras at each station to capture both flanks. Stations were placed at strategic bottlenecks to maximise detection rates. Study area of 460 km<sup>2</sup> was divided into 2 sectors and sampled individually for 60 days. Programme CAPTURE was used to determine population closure and estimate. Both sectors were treated as separate areas to maintain an assumption of population closure. To estimate population density, mean maximum distance moved was calculated and its half was added as a buffer to the area covered by camera traps. 41 leopard captures were recorded in the first sector with 8 animals identified. Population estimate in first sector was  $11 \pm 2.87$  in area of 426 km<sup>2</sup>, which represents density of 2.58/100 km<sup>2</sup>. Second sector had 52 leopard events with 7 identified leopards, but with 2 males already recognized in the first part of study area. Population estimate of the second sector was  $6 \pm 1.57$  in area of 413 km<sup>2</sup> which gives density of 1.45/100km<sup>2</sup>.

Differences among sectors could be caused by shape of study area as the latter was composed by long stretch of a land where 3 individuals were recorded only on one station with high possibility of them staying on neighbouring land. Densities are lower than elsewhere in Namibia, which could be caused by habitat differences as Karoo biome is considered as a dry area often characterised as semi-desert. This causes scarcity of prey species connected with necessity of bigger leopard home ranges.

## Estimating density for the endangered Himalayan brown bear by integrating non-invasive DNA-sampling and camera traps

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Rare species, by definition, persist at low densities. They are also often elusive and inhabit areas that are difficult to survey. The resulting data sparsity hampers our ability to obtain reliable information on demographic parameters for species that are in the greatest need for informed management and conservation. Hierarchical models that incorporate multiple survey methods and cope with incomplete data help conservationists make the most of the available information, given the limited resources available for monitoring. To illustrate the usefulness of this approach in estimating density, we studied an endangered population of brown bears (*Ursus arctos*) in northern Pakistan. Despite deploying multiple survey methods – non-invasive genetic sampling and camera trapping- the data remained sparse and incomplete, as not all observations were attributable to individuals. We developed an integrated spatial capture-recapture model that incorporates multiple data sources and imperfect individual identification. In addition, we used simulations to compare the models in terms of precision and accuracy, and investigated the conditions under which the greatest gains in performance can be expected. Data integration yielded a greater precision and reduced bias in parameter estimates. We estimated bear density at 22/1000 km<sup>2</sup> and average home range size at 193 km<sup>2</sup>. Our model shows great promise for monitoring of rare or elusive wildlife where sparse and imperfect sampling is common.

## HORMONES, INDIVIDUAL PLASTICITY AND FITNESS

### **Faecal evaluation of PDG in a female okapi (*Okapia johnstoni*) to define oestrus cycle and fertile window for reproduction program of conservation**

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The okapi (*Okapia Johnstoni*) number is declining rapidly in their native habitat and the species is listed as endangered in the IUCN red list. To increase conservation efforts and to improve the welfare of okapis under human care, the evaluation of endocrine profile is an essential part of the scientific research. The need to use a non-invasive matrix for the endocrine analysis in wild life species is linked to the difficulty in obtaining blood samples and to the necessity to not stress the animals with restraining and medical procedure. This study aims to evaluate the concentration of pregnanediol-3-glucuronide (PDG) in faeces of a young female hosted in Falconara Marittima zoo, Italy. Faeces have been collected twice a week, immediately after the emission, by zoo staff from March to May 2019. Samples have been labelled and stored at – 20 °C till analysis. For hormones extraction 200 µg of faeces have been weighted and added with 2 ml of ethanol, vortexed at 100 rpm for 60 minutes, centrifuged at 2500 rpm for 20 minutes and dried. For PDG detection an ELISA kit has been used, following test procedure. As far as we know, few information is available regarding oestrous cycle and reproduction of the okapi, so a comparison of our results with bibliographic data was difficult. Despite this, we analysed our results in order to define the different phases of the oestrous cycle and to estimate their length with the goal to identify the fertile window of the subject. The results will allow scientists to have a further knowledge of the physiology of this species and will represent an essential step to define best strategies for the management of the subjects under human care and to establish programmes to strengthen the effort in assisted reproduction.

## Validation of an enzymatic immunoassay for the quantification of serum progesterone levels in a viviparous matrotrophic lizard *Mabuya* sp

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The endocrinological study by immunological methods allow to elucidate the mechanisms of response to environmental challenges and reproductive regulatory mechanisms in animals. However, it is often overlooked that immunological assays for the detection and quantification of steroid hormones require prior validation tests. The aim of this study was the physiological and chemical validation of an Enzyme-Linked Immuno Sorbent Assay (ELISA) for the detection of serum progesterone levels (P) in *Mabuya* sp, a Neotropical highly placentotrophic viviparous lizard. The immunological similarity between the standard antigens of the P and the antigens of the females' plasma samples showed parallelism in the assay, validating the analyses. Thus, the value of the curve slope for the Log of concentration by percentage of union for the pool of females (slope = -32.35) was essentially equal to that of the curve of the standard progesterone (slope = -38.79,  $P < 0.05$ ). The accuracy assay for the test showed values of 91.5 ( $\pm 11$ ) for P as a mean recovery of added hormones after spiking. The precision of the assay estimated by the intra and inter- assay coefficients of variation was 5% and 10% respectively. High-performance liquid chromatography identified and confirmed the presence of P in these plasma samples of *Mabuya*. Lizard females produce microlecithal eggs, have a prolonged gestation, and transfer most nutrients to the embryo through placenta. We tested for significant differences among means of P concentrations in females at different reproductive stages (non-reproductive, vitellogenic, recent ovulation, early gestation, mid gestation, and preparturition). Significant differences were found; non-pregnant females had the lowest values. Females at early stages of pregnancy (embryos at neurula/pharyngula stages) had three times higher values than females with recent ovulation and two times than females at later stages of pregnancy. Consequently, pregnancy in these lizards seems to be supported by progesterone.

## Hormonal control of sexual dimorphism in chameleons

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Squamate reptiles are highly diversified vertebrate group with large variability in sexual differences in body size, social behaviour and other traits. However, proximate control of sexual differences is still debated even in such highly studied group as are reptiles. The expression of many male-typical traits such as aggression, colouration and sexual behaviour in squamates is controlled by male gonadal androgens, but the proximate control of sexual dimorphism in skeletal structures is less clear. We test the role of testosterone in the expression of male-typical traits in the veiled chameleon (*Chamaeleo calyptrotus*) using the manipulative experiment involving castration and application of exogenous androgens. As expected, the hormonal manipulations strongly affected the male-typical social behaviour and colouration. Castrated males did not court females and attack males and were not able to exhibit variegated male-typical colouration; they kept plain juvenile colouration. The application of exogenous testosterone led to male-typical behaviour and colouration in both castrated males and females. These traits are thus masculinized by gonadal androgens. On the other hand, castrated males attained male-typical body size and head casque size, which demonstrates that male-biased sexual size dimorphism in body size and such an extravagant morphological trait as head casque is not under the control of male gonadal androgens in chameleons. Exogenous testosterone led in females to slightly male-like casque development, which might reflect interference of testosterone with the feminizing effects of female gonadal hormones. The study supports the view that both testicular and ovarian hormones play a crucial role in the ontogeny of sexual dimorphism in squamates.

## Two novel matrices for non-invasive monitoring of glucocorticoids in loggerhead sea turtles (*Caretta caretta*)

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Over the past two decades non-invasive methods for glucocorticoid (GC) measurement have provided detailed knowledge of wildlife physiology. However, these methods in sea turtles are comparatively poorly developed. To fill this gap of knowledge we studied whether the cloacal excretion and the salt gland secretion of sea turtles contain corticosterone, the main GC in reptiles. Additionally, we assessed the potential of these matrices to reflect the adrenocortical activity by comparing corticosterone levels in the new media to those in matched blood samples. The study was carried out in wild loggerhead sea turtles (*Caretta caretta*) kept in a rescue and rehabilitation centre of marine animals (CRAM, Barcelona). Blood (n = 26), cloacal excretion (n = 12) and salt gland secretion (n = 22) were consecutively sampled from every sea turtle (n = 26). Corticosterone levels were successfully determined by enzyme immunoassay, demonstrating for the first time that cloacal excretions (mean  $\pm$  SD =  $16.73 \cdot 10^5 \pm 17.48 \cdot 10^5$  pg/mg) and salt gland secretions (mean  $\pm$  SD =  $57.54 \pm 76.35$  pg/mg) of sea turtles contain GC. A significant correlation was detected between plasma and cloacal excretion ( $p$ -value = 0.037;  $r = 0.61$ ), and a tendency towards correlation was observed between plasma and salt gland secretion ( $p$ -value = 0.069;  $r = 0.39$ ). These results reveal that corticosterone may be excreted into the faeces in proportion to the amount of circulating hormone, revealing that this tool could be applied to assess the adrenal activity in sea turtles. Likewise, results suggest that probably, corticosterone could also diffuse into the salt gland secretion proportionally to blood hormone levels, although further research is needed in order to completely state this relationship. Overall, the current study presents two simple, fast to perform and relatively non-invasive techniques that could have a wide applicability in free-ranging sea turtles, whether they are applied for animal welfare purposes, for conservation issues or for routine health monitoring in rescue centres.

## **Contraceptive efficacy and dose response effects of the GnRH agonist deslorelin in Tasmanian devils (*Sarcophilus harrisii*)**

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The selective use of contraception for endangered species breeding programs is a relatively new approach to wildlife management, but has many potential applications. Following the establishment of a Tasmanian devil insurance metapopulation, there was a desire for greater control over breeding within group housing situations. Therefore, preliminary studies were conducted to ascertain the efficacy, duration of effect, optimal dosage, and any potential side effects of the Suprelorin contraceptive implant (containing the gonadotrophin-releasing hormone (GnRH) agonist, deslorelin; Virbac (Australia) Pty Ltd) in Tasmanian devils (*Sarcophilus harrisii*). In our pilot study, Suprelorin was found to effectively suppress oestrous cycles in female devils, yet caused a paradoxical increase in testosterone in males. Therefore, we focused on females in further trials. Females received one (n = 5), two (n = 5) or no (n = 5) 4.7 mg Suprelorin implants, with quarterly GnRH challenges used to test pituitary responsiveness over two breeding seasons. Reproductive status and general health parameters were also recorded. Both Suprelorin dosages suppressed pituitary responsiveness for at least one breeding season, with a reduced effect in the second ( $p < 0.001$ ). There was a dose-response effect on duration rather than magnitude of effect, with high-dose devils remaining suppressed for longer than low-dose animals. There were no apparent negative effects on general health, yet captivity and contraception together may cause weight gain. Suprelorin contraceptive implants are now routinely used in the Save the Tasmanian Devil Program insurance metapopulation to meet the aims of maintaining genetic and behavioural integrity by controlling individual reproductive contribution in group housing situations.



## **Stress kills sex: Physiological stress mediates male performance and reproductive skew in a social mammal**

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In most societies, socially dominant males sire more offspring and/or offspring of higher quality than subordinate males. The proximate mechanisms by which social rank influences reproductive success are poorly understood. Here, we investigated the influence of rank-related dominance potential and socially-induced physiological stress on male sociality and courtship behaviour in free-ranging spotted hyenas (*Crocuta crocuta*). We found that physiological stress was similar in all males when they courted females and competitors were absent or when they were resting alone. In contrast, when males engaged in social activities or courted females when competitors were present, low-ranking males, who have a low dominance potential, had higher physiological stress than high-ranking males. Low-ranking males adjusted their behaviour to their stronger physiological constraints by minimising intrasexual competition; they spent more time alone, less time engaging in social and sexual activities, and they invested less in the most attractive and most contested females than did high-ranking males. These behavioural adjustments allowed low-ranking males to downregulate their physiological stress but also reduced their chances to be chosen as sire, explaining why their reproductive success is both quantitatively and qualitatively lower than that of high-ranking males. Our results demonstrate that male dominance potential mediates the physiological costs of intrasexual competition and shapes behavioural trade-offs between the allocation of time and physiological resources to social integration, reproduction, and self-maintenance. Our study shows that physiological constraints play a pivotal role in the emergence of rank-related male reproductive investment and reproductive skew in group-living species.

## Superovulation and embryo collection in European Roe deer (*Capreolus capreolus*)

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The European Roe deer is the only artiodactyl displaying embryonic diapause. After mating in July/August, a blastocyst develops and hatches from its zona pellucida. The blastocyst exhibits extremely decelerated growth before elongating and resuming a normal pace of development in the typical ruminant fashion in November/December. Attributed to the hunting ban during the rutting period and the unknown day of mating, there are only very few and historic descriptions of very early embryonic stages, presumably prior diapause. The time frame for blastocyst development and entry into diapause is therefore not known up to date. To describe timed early embryonic stages in a great number of embryos, we performed cycle synchronization and superovulation in captive roe deer. The basic principle hereby based on ovulation inhibition during the natural breeding season via progesterone analogues, follicular growth stimulation by equine chorionic gonadotrophin at day -8, induction of ovulation at day -2 by human chorionic gonadotrophin and artificial insemination (AI) and natural breeding (NB), respectively, at day 0. The response of the superovulation treatment (n=33) was evaluated by plasma progesterone (P4) analysis (average  $6.4 \pm 4.0$  ng/ml; (mean  $\pm$  SD)) and the number of corpora lutea (CII) as determined by ultrasound (n=6.6  $\pm$  2.2 (mean  $\pm$  SD)) at the day of embryo flushing (EF). Non-stimulated does usually exhibit one to three CII only. At days 6 and 7, embryos (n=37 from eight females) from the 2-cell to the morula stage were collected via embryo flushing (EF). On days 12 and 13, mainly blastocyst stages (n=20 from seven females) still enclosed in the zona pellucida were collected, proving their developmental capacity after superstimulation. To confirm that these findings correspond to physiological development, EF without treatment after observed NB needs to be performed.

## Does rural tourism cause stress to a wild population of Iberian red deer?

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We have studied the effects of the rural tourism on a wild population of Iberian red deer during two years and a half. We chose two zones in the Boumort National Hunting Reserve in the eastern Pyrenees, one with easy access to people and with a mountain refuge, which increases tourism; the other far from regular hiking paths and difficult to arrive, and therefore seldom visited. Having into account that the adrenal gland produces cortisol in response to stress, we collected faecal samples in four significant moments along the annual cycle of this mammal to analyse the levels of cortisol metabolites (FCM). The first was during summer, a potentially stressful time for red deer do to the high temperatures and the difficulties to find food. The second was during the rut, a significant moment in the annual cycle of the deer because of the copula. The third was in winter, when snow cover makes it hard to find food. Finally, the fourth was in spring, when females are in the final stage of pregnancy and food is abundant. Faecal pellets where collected from both males and females, as identified by size. A total of 104 samples were collected and analysed. Our results showed significant differences among seasons, with the highest levels of FCM in winter. The reason of the stress in winter could be the difficulty to find food because of the snow cover and the extreme low temperatures. The high availability of food during spring could be in relation with the lowest FCM levels. We did not detect significant effects over FCM levels due to the presence of tourists nor among sexes. The final conclusion is that scarce food availability seems to be the most important factor stressing the wild population of Iberian red deer, more than other factors such as reproduction or high presence of tourists.

## Effects of chronic stress on sexual maturation rate in different seasonal generations of dwarf hamsters *Phodopus sungorus*

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We investigated the effect of chronic stress on the sexual maturation rates of animals in different seasonal generations and examined males ( $n=48$ ; 44 days old) of dwarf hamsters of fall (born in September) and spring (born in February) generations. For standard activation of hypothalamic–pituitary–adrenal (HPA) axis, we applied the injection of adrenocorticotrophic hormone (ACTH, *Synacthen depot*) in the dose that exceeded the physiologically relevant levels of the hormone. Animals were injected (*ip*) for 2 or 4 weeks with ACTH or saline solution.

The results indicated that animals of the fall generation at ACTH-injected groups had lower body weight and testosterone level than the animals of the control group, whereas spring ones had no significant difference between groups, which allows concluding about less suppression HPA activity on the sexual maturation of this generation. Moreover, the cortisol level after the final injections was higher for the animals of fall generation ( $Z=2.3$ ;  $p<0.05$ ; Mann-Whitney *U*-test) especially in the two-week ACTH-injected group, while for spring generation the difference was non-significant. Nevertheless, animals of this generation had a higher level of peroxidase activity in the blood ( $t=2.6$ ;  $df=32$ ;  $p=0.01$ ), than in the fall ones. Estimation of the metabolic rates showed higher basal and maximal oxygen consumption in the animals of fall generation ( $t=2.7$  and  $t=8.4$ ,  $df=43$ ,  $p<0.001$ , respectively) and higher ability to maintain temperature homeostasis ( $t=2.7$ ;  $df=43$ ;  $p=0.01$ ) in comparison with the spring-born animals.

To conclude, the obtained data indicates higher sensitivity to stress stimulus in fall born animals in comparison with those, born in spring. The higher reaction to ACTH injection in the animals of late generation could be the adaptation to severe winter conditions. It might be characteristic for species with winter above-snow activity.

## Recreational activities and hunting create a landscape of fear for deer in the Bohemian Forest Ecosystem

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Diversification of human outdoor activities has become a major concern in protecting biodiversity as it exerts pressure on wildlife habitats, of which many are already affected by fragmentation and degradation due to intensive land use, increasing urbanization and road construction. Depending on the species and type of human activity, wildlife has various ways to respond to human presence. Most of these wildlife responses are energy demanding, can affect immune response, and reduces fitness. To implement a management concept, which is able to regulate and protect a species at the same time, precise knowledge on the influence of human outdoor activities on free-living animal populations is necessary. Measuring stress through the analysis of glucocorticoid levels in fresh faeces is a noninvasive monitoring method which allows the determination of disturbance caused on the population as well as on the individual level. In order to investigate the influence of tourism, logging and hunting on free-living red deer (*Cervus elaphus*) in the Bavarian Forest, a total of 284 pellet groups were collected from 13 GPS-collared individuals between June-November 2018. Besides seasonal changes and individual heterogeneity in stress levels, we expected different responses to the different activities as well as different responses to the intensity of the activities. As the stress level is also related to habitat and food quality, these factors were considered in our analysis. Our analysis yielded new information on the drivers of stress responses in red deer and allowed us to make suggestions to improve wildlife management.

## Changes in call structure, body mass and testosterone level during voice-breaking in adolescent Siberian Cranes (*Grus leucogeranus*)

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The vocal development of cranes has a special stage, voice breaking, when chicks produce calls with two fundamental frequencies; the first one corresponds to those in adult low-frequency and the second one - in juvenile high-frequency vocalizations. The factors that affect voice breaking are mainly unknown. Here we study the relation between call structure, body mass and testosterone level during voice-breaking in adolescent Siberian Cranes (*Grus leucogeranus*). We analyze 5846 calls, 39 body mass measurements and 60 blood samples from 11 Siberian Crane chicks in 8 ages from 2.5 to 18 months of life together with 90 body mass measurements and 61 blood samples from 24 Siberian Crane adults. We found that the ages of onset, culmination and completion of voice breaking were  $7.7 \pm 1.8$ ,  $9.2 \pm 1.7$  and  $12 \pm 2$  months correspondingly. The plasma testosterone level was stable at 2.5-9.5 months (e.g.  $0.24 \pm 0.17$  and  $0.22 \pm 0.14$  ng/ml at 2.5 and 9.5 months correspondingly), but increased dramatically to 10.5 months ( $0.47 \pm 0.23$  ng/ml), decreased to 18 months ( $0.22 \pm 0.12$  ng/ml) and then increased to adulthood. The body mass was  $0.13 \pm 0.01$  kg at hatching, increased to 7.5 months ( $7.31 \pm 0.38$  kg), after that fronted plateau. The individual dates of voice breaking onset, culmination and completion depend neither on body mass nor on testosterone level at various ages. However, we observed some coincidence in time between the onset of voice breaking and termination of body mass gain; between the completion of voice breaking and start of a new breeding season; and between the culmination of voice breaking and jump of testosterone level. So, we suppose that voice breaking in cranes may be triggered by the end of chicks' body growth, stimulated by the increase of testosterone levels and ends soon after the breakups of families in nature.

## Female attractiveness pheromone is not needed for sex recognition in geckos

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The nature and hormonal control of cues used for recognition of sex and reproductive status of conspecifics remain largely unstudied in reptiles. It has been proposed that production of a female attractiveness pheromone controlled by female ovarian hormones (and which is suppressed by male gonadal androgens) is necessary to elicit courtship in males. Alternatively, it was suggested that demasculinization of the cues used for sex recognition by ovarian hormones is necessary for expression of female cues. We tested these hypotheses by manipulative experiments in two distantly related geckos: Madagascar ground gecko (*Paroedura picta*: Gekkonidae) and leopard gecko (*Eublepharis macularius*: Eublepharidae). Males of the leopard gecko attacked the individuals with high androgen levels (i.e., control males and females treated with exogenous testosterone and dihydrotestosterone), while they courted control females, castrated males, and prepubertal individuals. Similarly, females of *Paroedura picta* with elevated androgens were recognized and attacked as males, while ovariectomized females were as sexually attractive as control females. Our results indicate that hormonally controlled pheromones advertising female attractiveness are not required and that sex discrimination is based on the presence or absence of cues dependent on masculinization by male gonadal steroids in geckos. Based on the critical evaluation of literature, we suggest that the same simple mechanism can be widely distributed in sauropsids.

## **Acyclicity to cyclicity: Breeding the elusive okapi (*Okapia johnstoni*)**

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Okapi, *Okapia johnstoni*, are an endangered species of the Giraffidae family, with a decreasing in-situ population. Within ex-situ collections, the European Endangered Species Programme (EEP) and Species Survival Plan (SSP) cooperatively manage the ex-situ population. In-situ, okapi are primarily solitary; therefore, within ex-situ collections, pairs are often only when mixed for breeding purposes.

The aim of the current study describes how two acyclic females became reproductively active following management changes.

Faecal samples (n=2074) from female okapi (n=2) were collected over one to seven year period and analysed using a progesterone enzyme immunoassay to monitor oestrous cyclicity. Additionally, keeper observations were used to map oestrous behaviours, including pacing, vocalisation/chuffing and grooming.

One female was paired with three different males over a seven year period. Only on the third pairing were clear and regular oestrous cycles observed. This was followed by a successful pregnancy.

The second female only began to show regular oestrous cycles and regular expression of oestrus when the time mixed with the male increased from 30 mins per day to full day access. This too was followed by a successful pregnancy.

The results illustrate that females become reproductively active following the introduction of a particular male or increased access to the male. In this data set, additional factors such as maturity of individuals and enclosure changes may have affected cyclicity.

In both cases, faecal progesterone analysis pinpoints when clear cycles commenced, and therefore determine which management changes likely induce cyclicity. Therefore, this use of non-invasive techniques to monitor reproductive status of individuals could support the Okapi ex-situ breeding programmes.



## **Sensitive window for sex determination in a lizard with environmental sex determination**

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Sex of an individual is a key characteristic affecting numerous traits of an organism. The mechanism of sex determination can influence adult sex ratios and other demographic parameters of a population and thus population dynamics. Majority of vertebrates have genotypic sex determination, when there is a consistent genetic difference between sexes. However, up-to-date all examined crocodylians, many turtles and some squamate reptiles possess environmental sex determination (ESD), where sex of a progeny depends on environmental factors. The adaptive significance of ESD is questionable and at the same time a dependency of sex ratio on an environmental factor, e.g. incubation temperature, might lead to vulnerability of a population to the contemporary climate change. The sensitive period of sex determination is an important trait, which was determined only in a small number of species. We introduce the project on determination of the sensitive period in the leopard gecko (*Eublepharis macularius*), a model ESD reptile. The determination of the sensitive period will allow to further explore the proximate mechanisms of environmental sex determination in this squamate.

## Practical implications of using different oestrogen-metabolite assays in giant panda reproductive monitoring

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A female giant panda (GP) has one breeding opportunity annually. The follicular phase is announced by subtle behavioural changes, confirmed by increasing oestrogens surpassing progesterone levels at the cross-over point. This cross-over aligns with the start of an, on average, one- to two-week period towards peak oestrogen and subsequent decline (ovulation), which is used to coordinate (inter)national teams for natural mating or artificial insemination (AI). As the ovulated oocyte has limited fertility (24-72h) pinpointing the timing for mating/AI is crucial in GPs, highlighting the importance of endocrine monitoring.

This study aimed to compare two approaches for non-invasive oestrogen monitoring in urine.

Oestrogens were detected by the Arbor Assays DetectX<sup>®</sup> estrone kit with estrone-3-sulfate (E1S) standard and the estrone-3-glucuronide (E1G) kit. Seven cycles (4 GPs) were included with a total of 85 samples, equally distributed across cycles.

Urinary E1S and E1G concentrations were strongly correlated (Pearson's correlation,  $r=0.966$ ,  $p < 0.01$ ) highlighting that both can be used to monitor urinary oestrogens. Nevertheless, significant differences in the concentrations were recorded (paired sample t-test,  $p < 0.001$ ), with an average E1S/E1G ratio of  $3.55 \pm 0.82$ , tending to increase slightly towards peak. The standard concentration range of E1S was 40.96-4000 pg/ml while E1G was 15.625-1000 pg/ml. Both involved antibodies show similar cross-reactivities against estrone, oestradiol and their metabolites. Consequently, the same total oestrogens are measured in both assays per sample with results plotted against a different scale explaining the ratio of 3.55. However, due to the wide standard range for E1S, small increases in oestrogens are measured earlier, resulting in an earlier cross-over of at least one, but up to 5 days.

In conclusion, both approaches serve their purpose, however, the artificially increased sensitivity of the E1S method may lead to logistic advantages in panda breeding with an enhanced timeframe to co-ordinate mating/AI.

## CONSERVATION GENETICS

### Noninvasive molecular genetic method for individual identification of Persian leopard (*Panthera pardus saxicolor*) in Parvar Protected Area, Semnan, Iran

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The Endangered Persian leopard (*Panther pardus saxicolor*) is widely distributed in Iran. Rough estimates show 550-850 leopard individuals in Iran which comprise more than half of its global population. Considering population monitoring of this flagship large carnivore is one of the main objectives both for designing conservation strategies and evaluating current plans, we need to diversify our methods to have more reliable, cost effecting and pragmatic measures. Hence we conducted a pilot study for individual identification of Persian leopard in Parvar Protected Area located in north Iran through noninvasive molecular genetic methods to test the feasibility of this approach. We monitored trails often used by the leopard for collecting scat samples during 2013-2015. Mt-DNA control region of extracted DNA from scat samples were amplified to distinguish sympatric species based on size variation of PCR products. For individual identification we selected 12 reported polymorphic microsatellite loci. PCR products were electrophoresed in 8% acrylamide gel and visualized by silver staining. Out of 90 scat samples collected from the field, 32 confirmed as leopard and had readable results, meanwhile from 12 microsatellite loci only 5 microsatellites successfully amplified. Further, the number of unique genotypes and  $PID(sib)$  were also analyzed by the software *GIMLET 1.3.3*. Finally, seven genotypes were grouped by data analysis but inability to distinguish cubs is likely to cause overestimation in population. However, as missing data could affect genotype assignment in *GIMLET*, we excluded the samples with deficient data (even for one loci) so as to achieve more accurate results. Calculated  $PID(sib)$  was 0.05 which shows the probability of identification even for closely related individuals with 99.9% certainty. Through this study we conclude that DNA extracted from scats can be used as a reliable source of DNA and this approach is feasible for population monitoring in larger scale.

## **Genetic diversity and degree of differentiation of wild reindeer populations (*Rangifer tarandus* L., 1758) in the European part of Russia and Siberia based on the analysis of polymorphism of microsatellite loci**

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Reindeer (*Rangifer tarandus*) is an important resource species with biosphere and socio-economic importance. The study of the genetic structure of reindeer is important for understanding the processes of formation of the genetic diversity and microevolution of a species, as well as for developing a management and conservation strategy for the resources of this species.

Genotypes were obtained for 16 microsatellite loci for samples of wild reindeer in the eastern part of the Kola Peninsula, the Republic of Karelia, the Arkhangelsk Region, the Komi Republic, central and western Taimyr, and samples from Yakutia collected in the Aldan, Anabar, Olenok and Kolyma rivers.

For a total sample of samples (n = 185) of reindeer, indicators of genetic diversity were obtained: the average number of alleles per locus was 10.42, the average number of effective alleles per locus was 6.3, the expected heterozygosity was 0.820, the observed heterozygosity - 0.710.

Analysis of the results revealed a different level of genetic diversity for the reindeer of individual groups studied. The values of the observed and expected heterozygosity and the average number of alleles per locus were the highest for the reindeer of Taimyr and Yakutia. Also in the samples from these groupings, the largest number of unique alleles was found. For reindeers of the European part of Russia, not high indices of genetic diversity were revealed. Some deficiency of heterozygotes is observed in all studied groups.

Cluster analysis revealed a fairly clear differentiation of reindeer groups. Among the northern deer of the European north of Russia there are three main groups: Karelia, the Kola Peninsula and the European North-East of Russia. Reindeer of Karelia are the most genetically isolated from the other studied groups. Samples from the Arkhangelsk Region and Komi are represented by mixed genotypes, some of which are closer to the reindeer of the European northwest, and others to the northern deer of Siberia. Taimyr reindeer have a homogeneous genetic structure, but genotypes have alleles in them that are common to all other studied groups. Reindeer of Yakutia have a complex genetic structure.

Thus, the wild reindeer of Taimyr and Yakutia has an average level of heterozygosity and a wealth of allelic composition. A relatively low level of genetic diversity was revealed for reindeer in the European part of Russia, which may be due to a decrease in the number and, probably, isolation of these groups.

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## **On thin ice: The cold hard facts about the future of conservation**

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For an increasing number of species, drastic reductions in population sizes can lead to rapid loss of genetic diversity and threat of extinction. To achieve maximum genetic diversity, ex situ programmes rely on intensive demographic and genetic management of animal populations for their success.

In recent years, technological advances, along with decreased costs, have made molecular tools more readily available to zoo and conservation communities, creating additional research opportunities, if samples are available.

A biobank, as a well-organized system of managing large quantities of biological samples, can serve as a genetic resource for supporting population management and conservation. Some zoos have existing archives of samples which vary in size, and quality. The EAZA Biobank is a new initiative focused on pooling these resources to serve as a standardized, accessible, optimally maintained system for comprehensive, long-term storage of biological material from hundreds of species. This repository can greatly benefit conservation efforts and strengthen the quality of the research produced, for population management as well as more fundamental research questions.

Beyond biobanking, cryopreservation of reproductive material like germplasm or gonadal tissue has enormous potential to not only preserve, but also restore lost genetic diversity, thus requiring fewer individuals to maintain healthier populations for more species, making it much more sustainable over time and potentially saving more species from extinction.

However, zoos are challenged by lack of infrastructure and knowledge for cryopreservation and molecular practices. Here, researchers and their institutions, with established state-of-the-art facilities, storage and maintenance protocols, and sophisticated knowledge of the capabilities of innovative molecular techniques, can support the scientific initiatives of the zoo community and help preserve these invaluable resources to safeguard biodiversity for the future.

## Low immune-gene diversity and disease susceptibility: Implications for the survival of the endangered black-footed ferret (*Mustela nigripes*)

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The black-footed ferret (BFF), one of North America's most endangered mammal species, once numbered in the tens of thousands, was thought to be extinct until a small population was discovered in Wyoming in 1981. BFF populations had declined to the brink of extinction by the 1960s, as a result of habitat loss due to conversion of prairies to farmland, widespread poisoning of the main prey (prairie dogs) and infectious diseases. Over the last 30 years, the capture of the last surviving BFF individuals and successful breeding programs have facilitated assisted reproduction and led to reintroduction of more than 9000 ferrets throughout their historic habitat.

Nonetheless, diseases such as canine distemper and sylvatic plague pose a major threat to both captive and reintroduced populations due to the low diversity of immune genes in ferret populations. This is suggested to be related to inbreeding depression and overall decreased heterozygosity among individuals. Runs of homozygosity (ROH) and structural variants (SVs) have been linked to inherited monogenic and complex diseases in mammal species and have been increasingly used as valuable metrics in conservation studies.

To understand the effect of inbreeding on immune gene diversity among BFFs, we investigated SVs in immune-related genomic regions and genome-wide patterns of homozygosity in 3 BFF and 2 domestic ferret individuals. For this purpose, a highly contiguous *de novo* genome assembly (contig N50 size = 275 Kb; scaffold N50 size = 145.4 Mb) of a male BFF has been generated using 10X Genomics linked-read technology, Bionano optical mapping and Hi-C scaffolding. The chromosome-level assembly serves as the first reference genome for this species and provides us with the opportunity to study the impact of the loss of genetic diversity. This is, therefore, a valuable example of applying genomic tools for the conservation of endangered mammal species.

## **Mitochondrial variation and provenance of the population of Eastern black rhino in European Zoos**

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Captive populations are a valuable resource of individuals and genetic variation for dwindling wild populations. Such is the case for the critically endangered Eastern black rhino (*Diceros bicornis michaeli*) where the animals present in European Zoos represent a large proportion of the remaining extant population. As a species, the total population of Black rhino (*Diceros bicornis*) now numbers at around 5,050 individuals and the huge losses it has undergone are reflected by a massive loss of genetic diversity. Many of the founders of the current population of ~95 *D. b. michaeli*, held by the zoos of the European Association of Zoos and Aquaria (EAZA), have an unknown origin specified only as from “East Africa”. As the establishment of the European population pre-dates the catastrophic decline of *in situ* populations, these animals could therefore represent valuable genetic diversity that has been lost from the wild. Our ongoing project makes use of a set of mitochondrial and nuclear markers to quantify the diversity of this important population and make a direct comparison with wild populations. By incorporating our data into haplotype networks with data from past and present wild populations, we aim to identify the provenance of the founders of the European population. The results of this project will be used to inform management strategies for both *in situ* and *ex situ* conservation efforts and their integration in the form of a One-Plan approach.

## **Near threatened: Geographic distribution and genetic variability of the garden dormouse (*Eliomys quercinus*) in South-West Germany**

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The garden dormouse (*Eliomys quercinus*) is a small hibernating rodent belonging to the family Gliridae. It is endemic to Europe and was formerly widespread from Portugal to the Ural Mountains (Russia). Over the last 20 to 30 years the eastern garden dormouse populations have declined drastically and therefore this species may have disappeared from 50% of its former range. The reasons for this decline are still unknown. The Black Forest in South-West Germany is assumed to be one of the last main distribution areas of the garden dormouse in the country. However, actual information about its current distribution and genetic status is lacking. The aim of this study was therefore to investigate the geographic distribution of the garden dormouse in the Black Forest National Park (NLP) and to characterize its genetic variability. Since 2016, we carried out capture-mark-recapture studies in six different study sites, where we collected tissue samples of all individuals captured and subsequently genotyped 41 dormouse individuals with six microsatellite markers. Since 2018, we additionally monitored 80 locations distributed all over the NLP with footprint tunnels, with which the presence of the garden dormouse can be unequivocally proven by its species specific footprints. Results of our study reveal, that garden dormice are still widely distributed within the Black Forest NLP, where they occur mainly in spruce dominated forests. Genetic diversity within the study area was relatively high (mean number of alleles  $NA=6.6$ ) and thus similar to previously studied populations. Genetic structure within the study area was low, indicating substantial gene flow among the different sites. However, a relatively high inbreeding coefficient indicates potential effects of inbreeding, which may reduce the survival probability of garden dormice in a changing environment induced for example by climate change.



## **Research challenges and opportunities for EAZA Ex situ Programmes (EEPs)**

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### **EAZA**

Members of the European Association of Zoos and Aquaria (EAZA) work together to run EAZA Ex situ Programmes (EEPs) for populations of over 400 species. Historically, the roles of some EEPs were planned in isolation within EAZA. Now, EAZA has adopted the “One Plan” approach for its EEPs, so that any conservation roles of EEPs are planned as an integrated part of a species’ conservation strategy. An EEP’s conservation activities are then ideally executed in cooperation with all appropriate partners.

In this new population management structure, more specific and concrete conservation roles are being identified, allowing each EEP to develop goal-oriented management strategies and objectives. As a result, there is a growing list of research priorities in EAZA focused on husbandry, behaviour, physiology, etc. These studies will require long-term commitments of researchers from outside EAZA.

Conservation genetics is of particular importance in this respect. Many EEP populations function as insurance populations in the event of extinction in the wild and therefore receive careful demographic and genetic management to maximise long-term viability. However, because EEP populations are small, genetic diversity is still lost rapidly and this compromises reintroduction success. To improve this, it is essential that novel techniques and management structures are developed. For example, methods that would facilitate geneflow with wild populations or techniques that allow efficient cryopreservation of reproductive materials would revolutionise genetic management of EEPs.

Currently, collaborations between research institutions and EAZA members is too often opportunistic from both sides. A more structural way of cooperation that optimises the use of resources could benefit all parties and lead to much more high-quality research that can also be applied. Here, there is a great opportunity for research institutions and EAZA to effectively maximise their mutual contributions to research and conservation.

## Epigenetic variation in territorial and non-territorial cheetah males in Namibia

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Epigenetic modifications such as DNA methylation pattern can change flexibly, regulate gene expression and as such increase adaptability of (wild) mammalian species. Epigenetic adaptability might be especially important in populations with low genetic variability. Cheetahs (*Acinonyx jubatus*) have a low genetic variability, are a vulnerable species (IUCN Red List) and have low reproduction success in captivity. In male cheetahs reproduction is secured via two behavioural tactics: being either territorial or non-territorial. Territorial males occupy and defend small areas, while non-territorial males (floaters) roam over larger areas. During their lives, cheetah males aim to switch from being floaters to becoming territory holders. The latter have a better body condition (higher body mass index) and are less anxious when captured and approached by humans. This implies a change in physiology and behaviour once the spatial tactic has changed. In our project we aim to identify whether the change in spatial tactics is reflected by changes in DNA methylation patterns and whether these changes occur at specific genes and physiological pathways. We expect to find high epigenetic differences between floaters and territory holders at loci that regulate genes relevant for energy allocation and stress response. We will also focus on genes regulating the immune system and reproduction to identify additional epigenetic changes associated with males switching spatial tactics.

## DNA methylation patterns associated with cheetahs' health status in captivity versus free-ranging

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Our research seeks to detect DNA methylation differences between free-ranging and captive cheetahs (*Acinonyx jubatus*) that might contribute to the increased-disease susceptibility phenotype seen in populations held under captive conditions. In the light of the conservation challenges faced by free-ranging cheetahs, *ex situ* reproduction programs are essential to preserve the species and its genetic lineages. Despite their known poor genomic makeup, free-ranging cheetahs exhibit good health and are reproductively self-sustaining. On the other hand, even under improved management conditions some diseases of captive cheetahs prevail and its etiologies remain poorly understood. Therefore, we hypothesise that epigenetic regulation could hold a tangible mechanism by which the different environments experienced under free-ranging *versus* captive conditions are exerting relevant effects on cheetahs' homeostasis. Epigenetic modifications can react to environmental factors by regulating gene expression without altering the DNA sequence. DNA methylation is an epigenetic mechanism known to be stable and transmittable to subsequent generations. To test our hypothesis we will (1) identify differentially methylated genes between captive and free-ranging populations using a Methyl-CpG binding domain-based capture and sequencing method; (2) perform a bioinformatic gene set enrichment analysis to assign biological significance to differentially methylated genes and pathways; (3) select candidate genes and pathways associated with disease susceptibility (immunocompetence, stress, metabolic) and; (4) compare the immunocompetence among cheetah groups and to their DNA methylation profiles testing specific immunity parameters. This study will set basis towards identifying the epigenetic and associated molecular mechanisms underlying the differences in health status observed between free-ranging and captive cheetahs. This knowledge can be used to develop prophylactic, management, and therapeutic targeted practices to improve the health and breeding of cheetahs in captivity and, shed light for other species affected by similar conditions under captivity.

## **Genetic inference of population stability and dynamics in wild western lowland gorillas**

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Repeated and precise assessment of the number of individuals occupying an area can reveal population growth or decline. Most mammals however have complex social dynamics and form groups, whose composition and spatial distribution may change over time and represent additional information that is important for the assessment of population stability. The acquisition of precise population size estimates and monitoring of multiple groups over extended periods of time is however a challenge, especially for elusive and endangered species such as western lowland gorillas. In this study we use non-invasive collected genetic samples from two periods (2005-2009 and 2014-2017) over a ~100 km<sup>2</sup> area of Loango National Park, Gabon, to estimate the number of gorillas and genetically track individuals and groups over more than a decade. Based on the number of gorilla genotypes identified we inferred a minimum number of 83 gorillas in the first and 81 gorillas in the second period, with similar capture-recapture estimates across periods. A comparison of sampling designs suggests that strictly systematic sampling is inefficient compared to a more flexible design for group-living species with low abundance, evidenced by a low number of collected samples and a reduced precision and accuracy of the estimates with the former method. Based on sampling date and location we reconstructed the composition of 18 mixed sex groups and inferred six group formations, five dissolution and 40 dispersal events within 12 years. We observed a more dynamic period in 2005-2009 compared to 2014-2017. Overlap of minimum group home ranges was extensive between groups and we found area fidelity of four groups that were sampled over 8-12 years. In summary our study reveals a socially dynamic system co-occurring with stable population size and space use.

## Hybridisation and introgression in the Scottish wildcat

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The Scottish wildcat (*Felis silvestris*) is one of the UK's most endangered mammal species, with as few as 200 individuals left in the wild. Hybridisation with domestic cats is the most serious threat to wildcats in the UK, counteracting all efforts to prevent decline due to habitat loss and persecution. We aim to determine the timescale and mode of introgression in Scottish wildcats and evaluate the effectiveness of current hybrid tests. Using this information, we aim to better inform management of the captive population and generate a robust model for future wildcat conservation; we will generate whole-genome haplotypic data to address gaps in current understanding and inform ongoing conservation work.

Presented here are results from preliminary analysis of wildcat population structure using PCA and fineRADstructure. ddRAD data was generated from 108 individuals (4 domestic cats, 104 putative wildcats). We show that a population of wildcats genetically distant from domestic cats is still present in Scotland, though these individuals are found almost exclusively within the captive breeding program; most wild-living cats sampled were introgressed to some extent. We used ddRAD data to evaluate the accuracy of the existing hybrid tests, both genetic and morphology-based, and found the pelage-scoring test to be a somewhat unreliable predictor of wildcat ancestry. We also present some preliminary investigation into loci potentially under selection in wildcats, using pcadapt.

## **The genetic diversity of saiga (*Saiga tatarica tatarica*) population from the North-West Pre-Caspian region: mtDNA control region and microsatellite analyses**

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Saiga (*Saiga tatarica*) was a widespread species in the past. However, nowadays it is included in the list of protected IUCN species due to a depression of population. The saiga population (*S. t. tatarica*) of the North-West Pre-Caspian region is the only population in Europe. Over the last 20 years its number has decreased more than 40 times. Depression of population may negatively influence genetic diversity. Concerning, it became necessary to investigate the genetic diversity of this population. The aim of our research was to assess the level of genetic diversity in the North-West Pre-Caspian saiga population. We analyzed the polymorphism of the control region of mitochondrial DNA (mtDNA) and microsatellite nuclear DNA loci of 95 saiga's tissue samples. Samples were collected in «Chernye Zemli» and «Stepnoy» natural reserves at the initial stage of the last depression of population in 1999-2000 (the first group) and at present (the second group). The length of the mtDNA control region sequences was 920 bp. We described 32 haplotypes for the first group, and 30 haplotypes for the second group. The haplotype (H) and nucleotide ( $\pi$ ) diversity (about 98% and 3%, respectively) were high enough for wild ungulates in both groups. For nuclear DNA analysis we used 8 microsatellite loci (STa14, STa20, STa26, STa30, STa39, STa41, STa43 and STa47) (Nowak et al., 2013). Genetic differences between these two groups were insignificant. For both groups, heterozygosity values ( $H_e$ ) (0.515 and 0.504 for the first and the second groups respectively) were quite low for wild ungulates, and inbreeding ratios ( $F_{is}$ ) (0.172 and 0.185) was relatively high. The value of  $H_e$  obtained for the saiga population is comparable to those described mainly for the small populations of mammals included in the various categories of the IUCN Red List.

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## Highlighting the evolutionary history of the Iberian red deer (*Cervus elaphus hispanicus*)

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The red deer (*Cervus elaphus*), the most widespread species of wild ungulate in the Palearctic, has been used as a model to address questions related to cryptic refuges in Europa, the population structure shaped by anthropogenic effect and its influence on the post-glacial colonization. Given its important economic value, its wide distribution and taxonomic diversity, as well as the absence of ecological threats, the importance of local endemism has been overlooked.

Here, we focus on the Iberian red deer subspecies (*C. e. hispanicus*) to re-analyse the published separately outcomes from the mitochondrial molecular marker D-loop at the intra-subspecies level. We have collected data from the two most recent and comprehensive works (i.e., Carranza et al. 2016 and Queirós et al. 2019) to perform both genealogical and phylogenetic analyses. Our results indicate and reinforce the idea for the existence of at least one maternal lineage of Iberian red deer, at the Southwest of the Iberian Peninsula, highly differentiated from the rest of Iberian lineages. Our results also suggest that the Southwest's lineage did not re-colonized areas of Northern Europe from the Pleistocene Iberian refuge. The main aim of this study is to highlight the evolutionary history of the Iberian red deer in order to call attention on its state of conservation. Future threats such as loss of genetic diversity, hybridization or transmission of infectious diseases from red deer farms could deplete the existence of cryptic lineages and affect the main role played by this subspecies in the ecosystem services (i.e., recreation and hunting) in Spain.

## **Conservation management strategies in the face of genetic impoverishment: Case studies in small Central European populations of felids**

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Felid species such as Eurasian lynx are of high conservation concern in Central Europe, where small isolated populations are genetically impoverished and at risk of extinction due to demographic stochasticity. Managers require information to help make informed decisions regarding conservation actions which strive for the genetic recovery of these populations, a subject currently of high interest and the subject of various EU financed projects. We apply a recently developed spatially explicit individual-based population model which includes neutral genetic markers for the Eurasian lynx, to help understand the genetic processes in small populations of this felid under various management scenarios. We simulate management scenarios including population reintroductions, population reinforcements, translocations, and non-interference under a variety of conditions (such as genetic diversity of released individuals) parametrised for various small populations of Eurasian lynx found in Central Europe. By inverse fitting we can infer likely reintroduction conditions, and using contemporary conditions we forward simulate to deliver prognoses under the management scenarios in question. Preliminary results from inverse fitting indicate low effective genetic diversity of founder populations as a primary oversight, especially for populations facing high mortality rates due to illegal hunting. Here we present the first results applying this modelling tool to realistic management scenarios in order to find the best potential action plans for genetic maintenance of small felid populations and stress the importance of including genetics when considering long-term population viability of other endangered felids.



## Genetic management in conservation breeding programmes: The case of the Houbara bustard in Morocco

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Conservation breeding programmes are considered as key measures for the restoration of populations in the wild. These programmes must be managed to minimize genetic changes (e.g. inbreeding) that can alter populations' gene pool and evolutionary resilience once released in the wild. Here, we assessed the efficiency of a 20-year genetic management of a conservation breeding programme of a North African threatened bird, the Houbara bustard (*Chlamydotis undulata undulata*, Jacquin 1784). The genetic management, implemented at the Emirates Center for Wildlife Propagation (ECWP), includes equalization of family size, inbreeding avoidance and maintenance of a gene flow between wild and captive populations through supplementation releases and regular addition of founders from the wild. Secondly, we compared pedigree analysis, the common way of assessing and managing genetic variation in conservation breeding programmes, to molecular estimates of genetic variation based on 7 microsatellites loci. Results highlighted the maintenance of the initial genetic diversity (decrease of mean kinship, increase of allelic richness and of unbiased expected heterozygosity), reaching 99% on average in 2017, low inbreeding coefficients (maximum average inbreeding of 0.073) and a temporal decrease of the proportion of highly inbred birds ( $F > 0.1$ ). Pedigree-based inbreeding coefficient and molecular-based multilocus heterozygosity exhibited a weak correlation (between -0.081 and -0.050), suggesting that both approaches should be considered as complementary sources of information rather than alternatives. Our findings support the need for early implementations of conservation breeding programs, relative to populations drop, to allow for many founders to be collected and maximize the amount of genetic diversity sampled from the wild and ensure long term genetic diversity in captivity. Furthermore, this study suggests that a genetic management including both pedigree and molecular analyses represents an efficient strategy in minimizing genetic alteration that can occur in captivity and preserving genetic diversity and evolutionary resilience within a conservation breeding programme.

## **A genetic look at scent marking behaviour in wolves *Canis lupus***

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In grey wolves *Canis lupus* scent marking is mainly related to the defence of territories against members of neighbouring family groups. Earlier studies suggested that wolf territories are marked mainly by parental pair, with breeding male being the most active. To check this hypothesis we collected 130 fresh marking with scats and urine deposited by wolves along roads in managed forests of the north-eastern Poland. We applied microsatellite genotyping using 13 microsatellite DNA loci and two sex markers to identify individual wolves and their gender. Our results shows that scent marks were deposited by various members of family groups. We also found no evidences for the sex bias in scent-marking. Our studies highlighted an importance of all members of the wolf family group in the maintenance of the territory.

## **Estimating population size and connectivity of a fragmented capercaillie (*Tetrao urogallus*) population in the Black Forest**

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As a result of habitat deterioration and fragmentation, the endangered capercaillie (*Tetrao urogallus*) has experienced a severe population decline in the Black Forest over the past decades. The current population is threatened with extinction and highly fragmented. Thus, the connectivity between the spatially disjoint patches is of crucial importance for the long term survival of the local capercaillie population. To estimate and monitor population size and to study the connectivity between population patches as well as the functionality of the corridors connecting patches genetic analyses are conducted. Therefore, we use non-invasive genetic sampling and subsequent genotyping using 12 microsatellites to identify individuals in 3 consecutive years. We attempt to verify the functionality of corridors applying a parentage analysis and inferring movements of related individuals. Our results show that the spatially separated sub-populations in the Black Forest exhibit minor but significant genetic differentiation, as well as spatial patterning, suggesting possible barriers to gene flow due to fragmentation. Our results indicate the importance to keep corridors free of factors which might negatively affect connectivity between sub populations.

## Genetic structure of the expanding wolf population in Poland

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The gray wolf (*Canis lupus*) was extirpated from most of Europe, but recently recolonized big part of its historical range. Especially dynamic wolf population expansion is observed in central and western Poland. However, genetic consequences of this process have not yet been fully understood. We aimed to assess genetic diversity of this recently established wolf population, determine its origin and provide novel data regarding population genetic structure of the grey wolf in Poland. We utilized both spatially explicit and non-explicit Bayesian clustering approach, as well as model-independent, multivariate method DAPC, to infer about genetic structure in large dataset of wolf microsatellite genotypes. To put the studied population in broader biogeographic context we also analyzed mtDNA control region fragment widely used in previous studies. In comparison to source population in the newly recolonized areas we found slightly reduced allelic richness and heterozygosity. We discovered relatively strong west-east structuring in lowland wolves, probably reflecting founder-flush events during range expansion. Interestingly, also wolves from recently recolonized mountainous areas (Sudetes Mts, SW Poland) clustered together with lowland, not Carpathian wolf populations. We also identified an area in Central Poland that seems to be a melting pot of western, lowland eastern and Carpathian wolves. We conclude that the process of dynamic recolonization of Central European lowlands lead to formation of a new, genetically distinct wolf population. Together with settling and establishment of packs in mountains by lowland wolves and vice versa, it suggests that human-driven population dynamics and anthropogenic barriers rather than natural factors (e.g. natal habitat-biased dispersal patterns) shape current wolf genetic structure in Poland.

## Novel Y chromosome markers reveal low differentiation among brown bear populations in northern and central Europe

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Y-chromosome markers are particularly useful to study population genetic structuring in species with male-biased dispersal, such as the brown bear (*Ursus arctos*). Only one study has used Y-chromosome markers to study the Y chromosomal structuring among central and northern European brown bear populations (Bidon *et al.* 2014). That study surveyed seven Y-chromosome microsatellites and found significant differentiation between northern and central European populations. Screening haploid genetic systems such as the Y chromosome with only few markers will lead to underestimation of the number of genotypes and reduced power to resolve genetic processes.

To expand upon previous work, we here investigated differentiation between north and central European brown bear populations using six novel Y chromosome microsatellite markers, along with the previously published markers. Using this new toolbox of 13 Y-linked microsatellites, we genotyped 32 male brown bear tissue samples from three populations in northern Europe (n=26) and one in central European (n=6).

We identified 25 haplotypes across the four populations. Maximum parsimony network analyses based on the original 7 loci revealed haplotype sharing among populations, including between northern and central Europe. When adding our new loci to the analyses, we obtained a separate clade for central European haplotypes, and a predominantly northern European group that also included one interspersed haplotype from central Europe. Similarly,  $R_{ST}$  values indicated low differentiation between the central European population and the geographically closest northern European population. Our novel and higher resolution marker set thus revealed low differentiation between male brown bears in central and northern Europe, indicating relatively recent gene flow between these populations. Our results also highlight that using a greater number of markers can reveal previously unappreciated aspects of population genetic structuring.

## Population markers of the German origin red deer (*Cervus elaphus hippelaphus*) in Southern Russia: Cytochrome *b*, microsatellites and the acoustics of rutting calls

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Wild-living representative of *Cervus elaphus* in Russia belong to four subspecies: three native: *C.e. sibiricus*, *C.e. xanthopygus*, *C.e. maral* and *C.e. hippelaphus* population of "Voronezh" red deer originated in XIX century from about 10 individuals introduced from Germany to the European part of Russia. Studying population status of the Voronezh red deer is important because this population serves for re-storing red deer on the European plain part of Russia, where the native red deer are extinct. This study investigates the Voronezh red deer stag cytochrome *b* gene, microsatellites, and the acoustics of stag 467 bouts including in total 1335 rutting roars. These data were compared with the Central European Pannonian red deer *C.e. hippelaphus* from the Southern Hungary (mtDNA C haplogroup) and the West European Iberian red deer *C.e. hispanicus* from Spain (mtDNA A haplogroup). Number of roars per bout ( $2.85 \pm 1.79$ ) was intermediate in the Voronezh stags between the Pannonian ( $3.18 \pm 2.17$ ) and Iberian ( $2.11 \pm 1.71$ ) stags. Roar duration was the longest in the Voronezh stags ( $2.46 \pm 1.14$  s) compared to Pannonian ( $1.13 \pm 0.50$  s) or Iberian ( $1.90 \pm 0.50$  s) stags, whereas the maximum fundamental frequency of the roars did not differ between Voronezh ( $175 \pm 60$  Hz) and Pannonian stags ( $168 \pm 61$  Hz), being significantly lower than in Iberian stags ( $223 \pm 35$  Hz). Phylogenetic analysis of 74 mtDNA cytochrome *b* sequences 355 b.p. and 58 sequences 1031 b.p. from Voronezh, Pannonian and Iberian red deer revealed a high uniformity of the Voronezh red deer and their affiliation with European red deer mtDNA C haplogroup. However, the average genetic distance comprised 1.1% from either Pannonian or Iberian red deer. The preliminary fragment analysis of 48 samples from Voronezh and Iberian red deer by 4 microsatellite loci support the genetic uniformity of the Voronezh red deer and their distinctiveness from Iberian red deer. Supported by RFBR grant 19-04-00133.

## Optimizing the genetic management of reintroduction projects: Genetic population structure of the captive Northern Bald Ibis population

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Many threatened species are bred in captivity for conservation purposes and some of these programmes aim at future reintroduction. The Northern Bald Ibis, *Geronticus eremita*, is a Critically Endangered bird species, with recently only one population remaining in the wild (Morocco, Souss Massa region). During the last two decades, two breeding programs for reintroduction have been started (in Austria and Spain). As the genetic constitution of the founding population can have strong effects on reintroduction success, we studied the genetic diversity of the two source populations for reintroduction ('Waldrappteam' and 'Proyecto eremita') as well as the European zoo population (all individuals held *ex situ*) by genotyping 642 individuals at 15 microsatellite loci. To test the hypothesis that the wild population in Morocco and the extinct wild population in the Middle East belong to different evolutionary significant units, we sequenced two mitochondrial DNA fragments. Our results show that the European zoo population is genetically highly structured, reflecting separate breeding lines. Genetic diversity was highest in the historic samples from the wild eastern population. DNA sequencing revealed only a single substitution distinguishing the wild eastern and wild western population. Contrary to that, the microsatellite analysis showed a clear differentiation between them. This suggests that genetic differentiation between the two populations is recent and does not confirm the existence of two evolutionary significant units. The European zoo population appears to be vital and suitable for reintroduction, but the management of the European zoo population and the two source populations for reintroductions can be optimized to reach a higher level of admixture.

## **Population genomics of a reintroduced hybrid population – the Asiatic wild ass *Equus hemionus* in Israel**

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Species reintroductions are a powerful conservation tool, yet they are often characterised by low success rates and a population's long-term persistence strongly depends on its genetic makeup. Few founding individuals and population bottlenecks during reintroduction can cause low genetic diversity and high levels of inbreeding in the established population, ultimately increasing its risk of extinction. This can be counteracted by maximising the genetic diversity in the founder individuals.

In Israel, hybrid individuals of two different subspecies of Asiatic wild ass *Equus hemionus* ssp. were reintroduced in the 1980s and 1990s, after the endemic subspecies had become extinct.

The population has since expanded its range and currently counts approximately 300 individuals.

We used ddRADseq to analyse DNA samples from Israeli individuals and the original subspecies. We analysed admixture levels of the hybrids and investigated the population genomics of the reintroduction by comparing the Israeli population prior and post release with samples of the two subspecies from zoo populations.

The Israeli population showed high levels of subspecies admixture (Mean hybrid index =0.48, SD=0.05). Despite the severe bottleneck (11 individuals) we find low inbreeding levels and only a small decrease in heterozygosity in the reintroduced population. Overall more heterozygosity was retained in the Israeli population than in the managed captive populations.

Deliberate admixture of distinct populations or subspecies is a highly controversial topic in conservation biology. Yet, our study suggests that the reintroduced population may have benefitted genetically from prior admixture. These results add to a growing debate on the value of hybrids for species conservation programmes.



**OPEN SESSION**

**Carnet de conservation: Travel diaries focusing on wildlife research and conservation**

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Carnet de Conservation – *Meeting the Namib cheetahs* is a travel diary that offers insight into the daily life of wildlife research in Namibia. We follow Rubén Portas into the desert to study and capture cheetahs with the Cheetah Research Project, a project of the Leibniz Institute for Zoo and Wildlife Research.

At the crossroads of scientific research, conservation, and travel, this book is a tribute to the people who dedicate their lives to wildlife research. An adventure in watercolour paintings to describe the daily life in the field, the passion of wildlife and the desert beauty.

This book project is designed to make wildlife research and conservation subjects accessible and attractive to people of various ages and from different backgrounds. By combining science, creativity and education, it aims to raise public awareness about endangered species need for conservation.

## **On the pseudoscorpions from Serbia and their conservation**

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This study aims to summarize present knowledge on diversity of Serbian pseudoscorpions and their protection in the country. Serbia is home to 76 species grouped into 12 genera (*Roncus*, *Neobisium*, *Chthonius*, *Ephippiochthonius*, *Globochthonius*, *Acanthocreagris*, *Allochernes*, *Chelifer*, *Chernes*, *Dactylochelifer*, *Neobalkanella*, *Rhacochelifer*) and four families (Neobisiidae, Chthoniidae, Cheliferidae, Chernetidae). Out of the total number recorded in Serbia, 56 species are endemic to the country, three to the Balkan Peninsula and one to the Carpathian Mountains. According to the Rulebook on the declaration and protection of strictly protected and protected species of wild plants, animals and fungi of the Republic of Serbia, 46 pseudoscorpion species were included in the List of strictly protected species in 2011. Protection measures and activities were given together with the list of legally protected species. Major challenges in the field of conservation and main threats to pseudoscorpions and their habitats were discussed. Conservation of pseudoscorpion fauna requires more effective implementation of regulations, advanced research and increased public awareness.

## Automated detection of large ungulates from UAV acquired imagery

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The use of Unmanned Aerial Vehicles (UAVs) in a range of conservation-based monitoring applications have increased in popularity. The study investigates the automated detection of large ungulates in the Middle East and Africa from photogrammetry stitched and geo-rectified images. The data extraction methods used, were traditional GIS-based supervised classification of objects using Object-Based Image Analysis (OBIA) software by developing a rules-set for object classification. The second method used was deep learning in the form of computer learned object detection models. The models are trained by 'training images' with labelled objects and 'test images' with labeled objects, using TensorFlow and Python software applications.

The development of the rulesets and deep learning models used baseline imagery from captive animals. The baseline information was extended to the use of morphometric information acquired from captive animals, this scaled top view imagery from captive Arabian oryx provided the baseline morphometric data for the use in extracting supplementary information from UAV acquired imagery of re-introduced Arabian oryx. This additional information includes age-groups and the investigation of possible sex identification.

The research span over four countries: Senegal, Niger, Namibia and the United Arab Emirates in different biomes in these regions. Large ungulates include Western Lord Dery eland (*Taurotragus derbianus derbianus*) Zebra (*Equus quagga burchellii*), Addax (*Addax nasomaculatus*), Dama gazelle (*Nanger dama*) and the Arabian oryx (*Oryx leucoryx*).

## Feeding behavior of jaguar (*Panthera onca*) on bovine carcass in the Pantanal

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Jaguar, a top-level predator, are responsible for population control of several species. The objective of this work was to evaluate the feeding behavior of the species at the Pantanal Farm, Brazil. 41 images from camera traps of Jaguar feeding on bovine carcasses were evaluated. It was verified that for the majority of time a Jaguar remains close to the carcass for up to 5 days or while there is food. In more than 98% of the observations, the bovine has a broken neck and lacerations on the head. The feeding, occurring after slaughter, was generally observed to start from the scapular region (confirmed from 25 (60.98%) of the images). The scapular region is abundant in cartilage and brown fat and consists of short muscles which are overlaid in layers, and this facilitates access and rapid feeding; alternatively in 16 (39.02%) of the images the feeding began in the xiphoid region, going up to the inguinal region (rich in nutrients and fat). It is important to note that there was struggle during the slaughter of the prey and often the carcass is dragged for more than 200 m before being eaten. If the prey is less than 90 days old, it can be consumed almost entirely. The jaguar is an opportunistic animal and in situations of easy access chooses to prey on domestic animals instead of their natural prey.

## **Parasitological monitoring of coastal and synanthropic South American sea lion (*Otaria flavescens*) populations and first ultrastructural analysis on *Ogmogaster heptalineatus*-eggs**

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Since late 1970s, the city of Valdivia, Chile, harbours a unique bachelor group of South American sea lions (*Otaria flavescens*). Originally descending from colonies at the Pacific coast, these sea lions now adapted to an anthropogenic ecosystem and live in close proximity to both, a broad spectrum of domestic/wild animal species and humans. In the context of a parasitological monitoring program on protozoan and metazoan taxa, 115 individual faecal samples from synanthropic sea lions were collected and examined coproscopically by applying standard sodium acetate acetic formalin methanol (SAF) technique, carbolfuchsin-staining of faecal smears, *Cryptosporidium*/*Giardia* coproantigen ELISAs and Baermann-Wetzel funnel technique. Coproscopic analyses revealed infections with six different parasite species in these animals: Anisakidae gen. sp., Diphyllbothriidae gen. sp., *Ogmogaster heptalineatus*, Trematoda indet., *Giardia* sp. and *Cryptosporidium* sp., thereby including four parasite species with zoonotic potential. To further characterize *O. heptalineatus* specimen, we performed first ultrastructural studies on egg morphology and showed highly specific filamentous structures at egg poles reflecting maturation-dependent shape and length.

To additionally compare urban with coastal *O. flavescens* populations, 79 individual scat samples from two free-ranging *O. flavescens* colonies at the Pacific coast were collected and analyzed. Here, the presence of zoonotic *Giardia* and *Cryptosporidium* infections could also be stated. Overall, compared to Valdivian sea lions, a higher prevalence of Anisakidae gen. sp. and Diphyllbothriidae gen. sp. was detected.

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Hermosilla C, Silva LM, Navarro M, Taubert A (2016) Anthroozoonotic endoparasites in free-ranging “urban” South American sea lions (*Otaria flavescens*). Journal of veterinary medicine, 2016: 7507145

## Case report: Severe otostrongylosis in a juvenile female harbour seal (*Phoca vitulina*) from Northfrisian Island of Föhr, Germany, and detection of further endoparasite species

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*Otostrongylus circumlitus* (Metastrongyloidea: Crenosomatidae) is reported to parasitize pinnipeds of the order Phocidae, the earless seals, such as harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*). In December 2018, a juvenile female harbour seal was found dead at the beach of Northfrisian Island of Föhr, Germany. During necropsy, a severe infection with more than 30 adult individuals of *O. circumlitus* was detected in the trachea, at the *bifurcatio tracheae* and within bronchi, causing multiple granulomas as well as severe bronchopneumonia, affecting more than 50 % of lung parenchyma. The remaining lung parenchyma was markedly emphysematous. Histopathological examination unveiled severe catarrhal and suppurative bronchopneumonia with bronchiectasia, haemorrhages, hyperplasia of bronchial glands, multiple granulomas and myriads of nematode stages within these lesions. Antigen of phocine distemper virus was not detectable immunohistochemically in seal samples. Besides *O. circumlitus*, the following endoparasite infections were additionally diagnosed in this particular animal: *Parafilaroides* sp. in the respiratory tract, Anisakidae gen. sp. in gastric mucosa and acanthocephalans in small intestine mucosa. For further analyses, one *O. circumlitus* specimen was subjected to microbiological investigation. Cultivation of parasite homogenates on different media yielded growth of beta-hemolytic Streptococci which were specified as *Sc. phocae* by MALDI-TOF mass spectrometry analysis. These findings highlight the possible role of concomitant bacterial infections through *O. circumlitus* thereby complicating outcome of clinical manifested otostrongylosis.

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## Shifts in diversity of the gastrointestinal-parasites community in young forest musk deer (*Moschus berezovskii*)

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### Background and aim

*Moschus berezovskii* (Forest musk deer, FMD) is an endangered species according to IUCN Red List of Threatened Species. However, parasitic diseases (e.g. coccidiosis, nematodiasis, taeniasis) constitute a bottleneck problem in the process of FMD population expansion. Remarkably, coccidiosis is always found in the intestinal tracts of young individuals, who would suffer diarrhea, and causes high mortality. While presently, there is a paucity of data on young FMDs. Understanding parasite interactions and their roles to produce a stable gastrointestinal parasites (GIPs) community is particularly important in disease ecology and wild animal management. The aims of the study are to investigate the shifts in prevalence, diversity and interaction between species of GIPs community in young FMDs.

### Materials and methods

Here, the morphological database by micro-characters and molecular database by DNA barcoding of GIPs in young FMDs were established. The parasite eggs or oocysts in fecal samples were counted using saturated sodium nitrate solution flotation method. Specifically, a monoclonal antibody enzyme-linked immunosorbent assay (ELISA) was developed to detect the oocysts of *Eimeria* spp.

### Results and conclusions

In young FMDs, at least 20 species of GIPs are detected, including 12 *Eimeria* spp., 6 *Trichurid* spp. and 2 *Strongyloides* spp., with infections of *Eimeria* spp. and *Trichurid* spp. most severe. In the shifts of the gastrointestinal-parasites community, oocysts of *Eimeria* spp. are firstly detected from birth through 90 days age, while *Strongyloides* spp. and *Trichurid* spp. are gradually established after that. There is a key stage, which is the most serious infection in young FMD individuals, from 50 days through 70 days age. It is also the stage that young FMDs transfer foods from mother's milk to fresh leaves with low immunity but strong activity, which may be the main reason for parasites infection.

## Mountain gorillas in the Virunga: population growth or artifact?

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As over half of the world's primates are on the brink of extinction, regular monitoring and assessment of their abundance have become increasingly important to guide and evaluate conservation actions. Since 1996, mountain gorillas (*Gorilla beringei beringei*), a subspecies of the Eastern gorillas, were listed on the IUCN Red List as Critically Endangered and as of 2018 are considered Endangered. After a historical low of under 370 individuals in the 1970s due to poaching and habitat loss, they have steadily recovered in association with strong conservation efforts in the only two remaining populations. However, successive improvements in sampling methodologies have made estimation of growth rates difficult; specifically challenging is disentangling whether more animals are detected because of sampling effort or because of intrinsic growth. Here, we estimate the mountain gorilla abundance in the Virunga Massif population that spans the borders of the Democratic Republic of Congo, Rwanda and Uganda in the 2015-2016 survey, which doubled the sampling effort of the 2010 survey. We show that the population as a whole grew to over 600 individuals and that mark-recapture methodology suggests this growth is mostly driven by the groups habituated and monitored for tourism and research. On the other hand, the unmonitored gorillas do not benefit from daily human protection and their net increase in number appears to be primarily due to net immigration from the monitored groups and to improved detection methods, whereas their intrinsic growth exhibited large confidence intervals encompassing zero. Therefore, although the mountain gorillas are the only great apes with stable or increasing abundance, we advocate for continued conservation efforts and urge more regular and more intensive monitoring of the unhabituated gorillas without exposing them to human habituation, which comes with its own set of risks, including potentially fatal diseases from humans.



## The participation of young zoologists in field researches of the Leningradsky Zoo

ELIZAVETA LAEVSKAIA, MARIIA MATLOVA, ELENA AGAFONOVA

### Leningradsky Zoo

Science department of the Leningradsky Zoo has been conducting field researches for several years. Since 1929 in the Leningradsky Zoo there has been Young Zoologists' Club, which can attend kids from 12 to 17. Young zoologists of Young Zoologists' Club help in collecting data on some themes. Teenagers take part in researches during summer field expeditions which usually take place in specially protected natural area, for example, the Valaam Archipelago Natural Park, the Sebezhsy National Park. Also, in autumn and winter students participate in the project of studying bats hibernation in artificial caves on the territory of Leningrad region. This allows to increase the efficiency of collecting data and to provide projects which need fast and well-coordinated work of several people. It is obligatory for students to get some special skills about the methods of field researches and work with different equipment, knowledge about biodiversity of expedition region. At the beginning of the expedition young zoologists are supervised by adults (science department staff or the staff of national parks). Young zoologists take part in the following projects:

- Monitoring gulls' and terns' nesting colonies on the Valaam Archipelago
- Ornithological tracking on the different parts of the Valaam Archipelago
- Studying great cormorant (*Phalacrocorax carbo*) nesting colonies in the Sebezhsy National Park
- collection of data on animals hit by vehicles on the highway within the Sebezhsy National Park
- Studying the musk rat (*Ondatra zibethicus*) feeding in different lakes on Valaam Island
- Studying bats hibernation in artificial caves on the territory of Leningrad region

The collected data are given to the scientific departments of the Specially Protected Natural Areas, on which territories the expeditions are held, and enrich the database of the Leningradsky Zoo' scientific department. Children use collected data for making reports at different conferences.

## Baseline survey of Horseshoe Crabs in Singapore

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Horseshoe crabs are vital in the marine ecosystem food web but their populations are decreasing in the face of growing threats. There are 4 extant species of horseshoe crabs worldwide, but only *Carcinoscorpius rotundicauda* and *Tachypleus gigas* are found in Singapore. This research aims to discover the spatial and temporal distribution of horseshoe crab populations, as well as study their migratory patterns. A total of 46 surveys were done across seven locations around Singapore. There was a higher abundance of *C. rotundicauda* than *T. gigas* in the North-western Singapore as compared to North-eastern Singapore. *T. gigas* preferred sand-mud beaches whereas *C. rotundicauda* preferred mudflats. Live *T. gigas* were found at Coney Island, Punggol Settlement and Changi beach, with live individuals of both species found at Coney Island, indicating an overlap of habitats. A large proportion of specimens found at North-eastern Singapore were dead, possibly due to anthropogenic reasons. Our results would help provide additional baseline data to aid horseshoe crab conservation efforts in Singapore, which is important since they are listed in the Data Deficient category in the IUCN Red List, and *T. gigas* and *C. rotundicauda* are respectively classified as ‘Endangered’ and ‘Vulnerable’ in the Singapore Red Data Book. (200 words)

## **Evolutionary development of the carnassial tooth in extant canids using geometric morphometrics**

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In this study we analyzed the form of the lower carnassial tooth of 33 extant species of the subfamily Caninae (Canidae, Carnivora). For this purpose we explored the relationship between the carnassial shape and different dietary habits and taxonomic genera. We analyzed the complete carnassial outline using semilandmarks to describe the profile of different parts of the tooth. Our modularity hypothesis is that the carnassial tooth in Caninae is composed of two modules: the trigonid and the talonid these areas are related to grinding and slicing. The modularity test supports that the anterior part of the trigonid is a module relatively independent of the rest of the carnassial. Using the combination of PCA (Principal Component Analysis), modularity test, and multivariate regression, we could correlate the shape of the carnassial tooth, the different dietary groups and taxonomic genera. The first four PCs explain 80% of the variation and shows that individuals appeared grouped by genera as well as guilds. In the morphospace, the carnivorans are located between omnivores and hypercarnivorans in the center of the positive side of the PC1 and PC2. We could also observe a high proximity in shape space among South American genera and Vulpes. At the same time we could observe that insectivory in Caninae is represented by different carnassial shapes that could have evolved independently. We conclude that alimentary habits had strong correlation with the form of the carnassial tooth.

## **Burrow structure of the Bornean Porcupine, *Hystrix crassispinis***

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The Bornean porcupine (*Hystrix crassispinis*) is an endemic species to Borneo. It is protected under the Wild Life Protection Ordinance 1998 of Sarawak and the Wildlife Conservation Enactment 1997 of Sabah, Malaysia. The cryptic species lives in burrows that store food, house nests and serve as a shelter that preserves body moisture. The burrows are known to consist of several chambers connected with each other through via passages or tunnels. However, not much is known of the structure of the underground system. An abandoned burrow was excavated carefully to determine in detail its internal structure. Based on the excavation observations, a burrow system model was constructed and the characteristics of access holes, tunnels, junctions and chambers were measured. The burrow system was found to comprise of 11 access holes, 11 chambers (single or double storied) and 15 junctions covering an area of 210 m<sup>2</sup>. This study is useful in delineating the occupancy area of the porcupine for conservation purposes.

## Host-parasite associations in eastern coyotes (*Canis latrans*) in Nova Scotia, Canada

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Condition can be defined as fat reserves relative to body size, and it can profoundly influence fitness. Among many factors, parasites can influence condition. Coyotes (*Canis latrans*) are carnivores that are widely distributed across North America; they are vulnerable to various endoparasites, but whether this translates into measurable reductions in condition is unknown. We quantified parasite intensity (number of parasites/host) by collecting endoparasites from the lungs, tracheae, and small intestines of 70 coyotes from Nova Scotia, Canada. Species-specific parasite intensity was not significantly associated with host condition. Intensity of *Oslerus osleri* infections was greater in males, and consistent with previous studies on a variety of parasites. Tapeworm (*Taenia* spp.) intensity was greater in hosts infected with both *Taenia* spp. and *Crenosoma vulpis* than in individuals infected with *Taenia* alone. This could be due to weakening of hosts by initial infections. Finally, hosts infected with *O. osleri* were more likely to be infected with *C. vulpis*. These results will interest wildlife biologists and veterinarians, because coyotes and domestic dogs are hosts for the same parasite species. This study resulted in the first report of both *Angiostrongylus vasorum* and *Echinococcus granulosus/canadensis* to Nova Scotia; and therefore veterinarians can recommend de-worming medication for dogs. Furthermore, health officials should be made aware of zoonoses and appropriate preventative steps to take.

## **Characterization of early embryonic cellular defects after somatic cell nuclear transfer in goldfish**

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Cryopreservation of genetic resources is of major interest for the security of the biodiversity and sustainability of agronomic industry. In some case, especially in fish, regeneration of functional breeders requires the mastering of somatic cell nuclear transfer. It consists in injecting a somatic nucleus carrying valuable genetic information into a recipient oocyte to sire a diploid offspring who bears the genome of interest. It requires that the oocyte (maternal) DNA is removed. In fish cloning, because enucleation is difficult to achieve, non-enucleated oocytes are often used and still allow the production of clones bearing only the donor genome. This ability can help us to understand the role of the maternal DNA on the somatic cell fate during the early embryonic development. Somatic and maternal DNA fate during meiosis resumption and early mitosis was characterized by immunofluorescence approach in goldfish clones. Maternal DNA was always found intact within non-activated clones, while surprisingly, a high variability in somatic DNA condensation was observed. After activation, maternal polar body extrusion was minimally affected. During the first mitosis, only 40 % of the clones displayed symmetric cleavage, and these symmetric clones contributed to 80 % of those surviving at hatching. Maternal DNA was often fragmented under the cleavage furrow, while the somatic DNA was organized either into a normal or abnormal mitotic spindle. Finally, we concluded that clone cellular defects are probably due to the somatic DNA condensation observed before activation. The fish oocyte volume did not allow the meiosis resumption of the condensed DNA, and may induce an abnormal anaphase and developmental failures.

## **The Leibniz IZW Academy: A knowledge transfer tool to train professionals working with wildlife**

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Sound research findings provide the basis for new concepts and methods in conservation. Knowledge transfer can build a bridge between the scientific community and society by implementing activities designed to disseminate knowledge, but also technologies, skills, resources and an understanding of scientific methods. This dialogic process is essential since it enables society to understand and apply research-based knowledge. Any successful transfer involves appropriate presentation of research findings to the target audience.

The Leibniz IZW Academy is a structural part of the Leibniz Institute for Zoo and Wildlife Research, Berlin. Purpose of the Leibniz IZW Academy is to facilitate the dialogue between wildlife research and other professionals working with wildlife and wildlife-related topics. Hence, the Leibniz IZW offers further trainings on various topics on a regular basis for professionals working with wildlife.

By bringing together (1) the Leibniz IZW expertise resulting from research activities as well as (2) the experiences from external experts in the respective fields, we aim to improve wildlife conservation and animal welfare in practice. Our cooperation partners are, among others, the „Bundesverband für Fledermauskunde e.V.“ (Federal association for bat science e.V.) and the „Landesamt für Gesundheit und Soziales“, Berlin (State office for health and social affairs) in Berlin. Participants are usually professionals working with wildlife like freelance consultants, veterinarians, public authorities and (doctoral) students. Recent examples of workshop topics are: acoustical monitoring of bats, stable isotopes in animal ecology, bat conservation and artificial light and non-invasive monitoring of hormones. For further information, please visit our webpage: <http://www.izw-berlin.de/leibniz-izw-academy.html>.

## **New findings and distribution of the introduced moth *Acontia candefacta* (Lepidoptera: Noctuidae) in Serbia (Southeast Europe)**

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The Nearctic moth *Acontia candefacta* is considered a successful agent for biological control of *Ambrosia artemisiifolia* (Asterales: Asteraceae). It is the first insect species that was intentionally introduced into Europe for biological control of an invasive weed species. Several new findings of the moth have been recorded at five new locations in Serbia (Southeast Europe) using light trapping. In this study, we present and discuss the current distribution in Europe and the expansion of the range based on geographic information system (GIS) data. Using GIS techniques, we mapped the distribution and quantified values of environmental variables within the range of the analyzed moth species. We assume that further spreading of *A. candefacta* in Europe is probably closely linked with ongoing climate changes and future expansion of the host plant. New findings of the moth in Europe will help us to predict future paths of expansion. Future studies should be devoted to gaining an understanding of the precise role of the moth as an agent for biological control of *A. artemisiifolia*.



## FURTHER EVENTS

### Conference:

#### **6<sup>th</sup> International Berlin Bat Meeting: The human perspective on bats**

23<sup>rd</sup> – 25<sup>th</sup> March 2020

Venue: Langenbeck-Virchow-Haus, Luisenstraße 58/59, 10117 Berlin

Web: <http://www.izw-berlin.de/berlin-bat-meeting.html>

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### Workshops:

#### **Acoustical monitoring of bats**

24<sup>th</sup> – 25<sup>th</sup> October 2019

Speakers: Volker Runkel (ecoObs GmbH), Ulrich Marckmann (NycNoc GmbH)

#### **Bat conservation and artificial light**

8<sup>th</sup> November 2019

Speakers: Christian Voigt (Leibniz-IZW), Franz Hölker (Leibniz-IGB)

#### **Dissections and taking samples of wildlife**

23<sup>rd</sup> November 2019

Speakers: Claudia A. Szentiks (Leibniz-IZW), Gudrun Wibbelt (Leibniz-IZW)

#### **Bat conservation and construction of wind turbines**

2<sup>nd</sup> – 3<sup>rd</sup> December 2019

Speakers: Markus Melber (BVF e.V.), Lothar Bach (Büro Bach Freilandforschung), Guido Gerding (Echolot), Leo Grosche (Stiftung FLEDERMAUS), Andreas Lukas (Baumann Rechtsanwälte PartG mbB), Mona Strack (Institut für Tierökologie und Naturbildung)

#### **ProBat: Use and recent news**

27<sup>th</sup> – 28<sup>th</sup> February 2020

Speakers: Oliver Behr (Oekofofor GbR), Hendrik Reers (Oekofofor GbR), Sören Greule (Oekofofor GbR)

#### **Bats in the veterinary practice**

21<sup>st</sup> – 22<sup>nd</sup> March 2020

Speakers: Gudrun Wibbelt (Leibniz-IZW), Jean Meyer (Tierarztpraxis Völkendorf), Patrizia Wunderlin (Stiftung Fledermausschutz)

All workshops are in German language and take place at the Leibniz Institute for Zoo and Wildlife research, Alfred-Kowalke-Straße 17, 10315 Berlin, Germany.

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