



# ECBB 2018

# LIVERPOOL

European Conference on Behavioural Biology

9 - 12 August 2018

## Abstract Book



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Study of  
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*Corrections:*

**Talk cancellation:** *E. Millesi; M. Nemeth; D. Schuster; B. Wallner. Effects of dietary fatty acids on cortisol secretion, postnatal development and social behaviour in guinea pigs.*

**Abstract in poster section now presented as a talk:** *V. Puehringer-Sturmayr, J. Hemetsberger, K. Kotrschal, D. Frigerio. Paternal stress in successful Northern bald ibis males: Behavioural, physiological and parasite load evidence.*

## Welcome to Liverpool



Liverpool is a friendly and vibrant city with a rich history. It was awarded European Capital of Culture in 2008, and this year we celebrate the 10th anniversary of receiving this status. As a consequence, there are many events on across the city; so, there will be plenty going on to keep you entertained.

We're sure you'll enjoy exploring Liverpool and its surroundings. From museums and art galleries to football stadiums and The Beatles, whether you're into sport or music, there are plenty of attractions to suit your interests.

For enthusiasts of The Beatles, visit the place where it all began and hear some live music at the Cavern Club, or learn more about the band at 'The Beatles Story' - the world's largest permanent exhibition devoted to the group.

You can also visit one of Liverpool's two beautiful cathedrals: the Liverpool Cathedral and the Liverpool Metropolitan Cathedral. If the weather is nice, be sure to get a ticket and go up the tower of Liverpool Cathedral for fantastic views of the city.

Also, visit one of Liverpool's several museums to learn about Liverpool's contribution to the world or visit the World Museum and see the Terracotta Warriors of China's First Emperor.

For more information go to <https://www.ljmu.ac.uk/conferences/ecbb/things-to-do-in-liverpool>

## General Info

### The ECBB venues

The European Conference on Behavioural Biology's main venue is the Arena and Convention Centre (ACC) Liverpool. However, the **Welcome Reception** takes place at the Redmonds Building.

#### **Thursday, 9<sup>th</sup> August:**

Registration, Welcome Reception and plenary – Redmonds Building, Brownlow Hill, L3 5UG

#### **Friday – Sunday, 10<sup>th</sup> – 12<sup>th</sup> August:**

All sessions – ACC Liverpool, Kings Dock, L3 4FP

### Social events

#### **Thursday, 9<sup>th</sup> August:**

Dough Bar – Grand Central, Skelhorne Street, L3 5GA

#### **Saturday, 11<sup>th</sup> August:**

Social event – Royal Liver Building, Liverpool Waterfront, L3 1HU

To get maps and directions go to <https://www.ljmu.ac.uk/conferences/ecbb/getting-to-the-venues>

### WiFi

**Redmonds building:** When you have EDUROAM at your University you can lock into our WiFi with your full email address and password.

**ACC:** free WiFi is provided. Go to FREE\_WIFI and press accept when it brings up the ACC welcome page.

### Parking

Liverpool Convention Bureau have teamed up with **Q Parks** to offer 10% off parking across 6 different locations in the city centre. Discount code: MEETLIV10 <https://www.q-park.co.uk/en-gb/cities/liverpool/>

## Plenary Talk Abstracts

### Andrew King



**Come Together: Sociality, Heterogeneity, Organisation and Leadership in Animal Societies**  
**A. J. King<sup>1</sup>, the SHOAL group<sup>1</sup> & SHOAL group collaborators<sup>2</sup>**

<sup>1</sup>Department of Biosciences, College of Science, Swansea University, Swansea, SA2 8PP, UK

<sup>2</sup>Various Institutions, Worldwide.

I will give an overview of the research my team conducts on the social behaviour of animals. I will likely include interesting findings on the social behaviour of fish, birds, ungulates, and primates. I will explain how technological advances are providing us with the opportunity to quantify and model the heterogeneity that exists within the groups we study, and within the environments in which these groups live. My aim is to provide a perspective that can steer us towards answering fundamental and outstanding behavioural and ecological questions, while also tackling pertinent conservation challenges.

## Mike Mendl



### **Animal affect and decision-making**

#### **Mike Mendl and Elizabeth S. Paul**

Animal Welfare and Behaviour Research Group, Bristol Veterinary School, University of Bristol, Langford House, Langford, BS40 5DU, UK

There is growing interest in the study of animal emotion (affect) in animal welfare science, behavioural biology, neuroscience, and psychopharmacology. In order to study animal emotion scientifically, and in the absence of definitive knowledge about whether such states are consciously experienced in other species, we use an operational definition of emotions as states elicited by rewarding or punishing events, where a reward is anything that the animal will work for and a punisher is anything that it will work to avoid (Rolls 2005). The evolutionary function of affective states has been the subject of much speculation and one common proposal is that they play a key role in guiding behaviour and decision-making in order to obtain rewards, avoid harm, and maximize survival chances. In this talk we consider how affective information may influence decision-making processes. We take a dimensional core-affect view of emotions as being characterised by valence (positivity/negativity) and arousal and integrate this with a reinforcement learning perspective on decision-making. Within this framework we discuss the putative role of both short-term ('emotions') and longer-term affective states ('moods'). A pragmatic outcome of these considerations is the suggestion that alterations in decision-making can themselves be used as objectively measurable indicators of an animal's affective state, with cross-species applicability.

## Judy Stamps



### **Bayesian Development for Empiricists**

#### **J. A. Stamps**

Evolution and Ecology, University of California Davis, Davis, CA, USA

In recent years, theoreticians have demonstrated that information about the environment can come from many different sources (e.g. genes, inherited epigenetic factors, parental effects, personal experiences), and that Bayesian models of development can be used to predict how information from different sources and different times should be combined within lifetimes and lineages to affect the development of phenotypic traits. Bayesian models of development provide general explanations for several widely-observed empirical phenomena, e.g. why sensitive periods often occur early in life. More important, they make specific predictions about individual or genotypic differences in developmental trajectories. For instance, Bayesian models predict that if different genotypes express a wide range of scores when naive, their scores will converge on a similar score following exposure to the same informative cue. This prediction of GxE is supported by results from a recent study of the responses of wild-derived genotypes of *Drosophila melanogaster* larvae to aversive olfactory conditioning. The same models show why indices often used to measure individual differences in learning ability will produce erroneous results if the subjects began with different initial scores. Bayesian models also make predictions about relationships across genotypes between within-individual and trans-generational plasticity, some of which are supported by data on responses of *Daphnia* clones to exposure to cues from predators in the parental and offspring generation. These and other recent studies suggest that Bayesian models of development have much to offer empiricists in search of testable predictions about individual and genotypic differences in within- and trans-generational developmental plasticity.

## Barbara Taborsky



### **Social evolution: accounting for plasticity can reverse theoretical predictions**

#### **Barbara Taborsky**

Division of Behavioural Ecology, Institute of Ecology and Evolution, University of Bern,  
Wohlenstrasse 50A, CH-3032 Hinterkappelen

In cooperative breeders, young decide whether to stay in the natal territory and provide alloparental care or to disperse and breed independently. To understand the evolutionary mechanisms underlying this decision researchers have focussed mainly on the role of dispersal for the kin structure of populations. Theory unanimously predicts a negative relationship between cooperative behaviour and dispersal tendencies, which seems to match empirical observations. This negative relationship is usually explained by the fact that philopatric, cooperative individuals accrue indirect fitness benefits through interactions with relatives, whereas 'selfish' dispersers are more likely to interact with unrelated individuals. However, all these models assume a heritable basis of dispersal and cooperation, and an important role of indirect fitness benefits through interactions with relatives. Using highly social cichlid fish as model, I will present evidence that if the assumptions of high within-group relatedness and genetic determination of behaviour do not hold, the relationship between cooperation and dispersal may go into reverse and become positive. If behavioural strategies are determined plastically, divergent life history trajectories resulting in distinct social types can emerge, where cooperative helpers disperse early whereas less helpful individuals stay as subordinates in the group. Which of these alternative social trajectories is pursued is determined by social and ecological contexts early in life. At the neural level, these behavioural differences go along with differential gene expression and stress axis programming in the brain. I will discuss alternative explanations for the emergence of social types that do not require within-group relatedness and narrow-defined inheritance of behaviour.



## Amanda Seed



### **Seeking the Origins of Inquiring Minds - Studies of Causality and Control in Primates and Children** **Amanda M Seed**

School of Psychology and Neuroscience, University of St Andrews

A suite of cognitive skills have been suggested to be unique to humans, such as representing the thoughts of others (theory of mind); remembering the past and planning for the future (episodic thinking); or drawing inferences about invisible causes from the pattern of relationships between events (causal cognition). All of these skills rely on a rich mental life, requiring not only abstract representations with specific content (e.g. beliefs, future times, causation), but also the ability to control and manipulate that content (executive functions). With so many seemingly unique characteristics, disentangling how cognition evolved since the split from our ape ancestry has proved to be extremely difficult. Interpreting adult human success and animal failure on any test is problematic – because there can be many explanations for the cognitive difference. Some of the previous negative results from apes may have revealed more about differences in executive function than differences in representation between humans and other apes. It is possible that commonalities in causal cognition may have been obscured – and that our inquiring minds may owe more to the legacy of our primate ancestry than has been suggested by some authors (e.g. Penn & Povinelli, 2007). However, it also implicates interesting differences in executive function that should be further explored. This talk describes new experiments on causal cognition and executive function in human children, apes and monkeys, to better understand how their cognition may be similar in some respects, and different in others.

## Niko Tinbergen Award

### **Studying the evolution of prosociality and cooperation in birds**

**Jorg J.M. Massen**

Department of Cognitive Biology, University of Vienna, Austria

Cooperation is omnipresent in nature. Species ranging from micorrhiza to chimpanzees work together with either con- and/or hetero-specifics to obtain resources, to compete with group-members or other groups, to fend off predators or to raise young. From an evolutionary perspective (function) cooperative-, and the related prosocial-, behaviors have been difficult to explain, although in the last decades much progress has been made both from a theoretical and empirical perspective. Nevertheless, most empirical work so far has focused only on humans and other primates. To get a better understanding of its evolutionary history (phylogeny), I have studied experimentally both cooperation and prosociality in a variety of bird species, specifically several corvid and parrot species. In doing so, I have tried to link inter-specific variation in both cooperative and prosocial tendencies with the socio-ecological challenges of the respective species. Moreover, I have focused on the proximate causations underlying these behaviors. Specifically, I examined how cognition and possibly emotions (mechanism) facilitate or restrict the cooperative tendencies of an individual or species, and how such behaviours develop throughout an individual bird's lifetime (ontogeny). Finally, I have aimed at validating my studies with regard to those conducted on primates and other mammals, thereby setting the stage for a phylogenetically broad and truly comparative investigation of prosociality and cooperation.

## Oral Presentation Abstracts

### Factors affecting dolphin personality traits in captivity

**C. Acasuso-Rivero**; D.R. Sargan; G.P. Pearce

Department of Veterinary Medicine, University of Cambridge, Cambridge, UK

The study of dolphin personality aims to identify consistent differences between individuals in order to inform best practice management. Differences between the wild and captive environment may result in changes in dolphin personality phenotypes. The way in which dolphins respond to environmental changes is likely to be influenced by sex, age and origin (wild-caught vs captive-bred). This study investigated the influence of these factors on dolphin personality ratings using interviews with 140 dolphin trainers across 17 facilities in 128 individual dolphins. The Five-Factor Model was used to collect 847 personality classifications using the dimensions: Openness to Experience, Conscientiousness, Extraversion, Agreeableness and Neuroticism. LMEM and machine learning analyses showed that when age was analysed independently of origin, dolphins under 19 years old were rated as more Open to Experience ( $p < 0.001$ ) and Extravert ( $p < 0.001$ ) than older individuals. Inclusion of age and origin into the models showed that captive-bred dolphins were rated as both more Open to Experience ( $p < 0.001$ ) and Extravert ( $p < 0.001$ ) compared to wild-caught individuals. Wild-caught dolphins were rated less Open to Experience after the age of 23 ( $p < 0.001$ ). Males were rated as more Agreeable than females ( $p < 0.05$ ) and wild-caught males were rated as more Extravert than wild-caught females ( $p < 0.01$ ). PCA analysis suggested that wild-caught females tended to be rated as less Open to Experience and Extravert than all other dolphin categories. This study suggests that rearing in captive environments modifies dolphin personality traits and personality differences according to sex, origin and age should be considered in optimising captive management.

### Experimental evidence that uninvolved bystanders punish cheats in fish

**M. Aellen**<sup>1</sup>; Nichola Raihani<sup>2</sup>; R. Bshary<sup>1</sup>

<sup>1</sup>Laboratory of Behavioural ecology, University of Neuchâtel, Switzerland; <sup>2</sup> Department of Experimental Psychology, University College London, UK

Punishment as a means to stabilise cooperation has rarely been observed in nature, and punishment by an otherwise uninvolved observer has been argued to be uniquely human, evolved to outcompete rival groups. In other species, only a simple form of third-party punishment has been described in the bluestreak cleaner wrasse *Labroides dimidiatus*: larger males may chase their female partner for cheating a jointly inspected client reef fish (where cheating involves eating mucus instead of ectoparasites). In this case, clients, rather than males are the primary victims of the female cheating although males suffer immediate loss of foraging opportunities due to the client leaving. We tested whether males would also punish a female for cheating a client that she inspected alone but in his presence. In the first experiment, the female received food while the male was kept behind a barrier. In the second experiment, the couple could move freely but we provided two plates simultaneously. In trials in which male and female chose different plates, we either let the female forage on the plate or let it flee from her. For both experiments, we asked whether males were more likely to chase the females depending on the conditions. Our results provide evidence that male cleaner fish apply “proper” third-party punishment. While the interpretation of male behaviour in experiment 1 is less straightforward, experiment 2 shows that personal immediate losses are not needed for males to engage in third-party punishment. In conclusion, third-party punishment may occur without any between-group level competition.

### Personality links with lifespan in chimpanzees

**D.M. Altschul**<sup>123</sup>; W.D. Hopkins<sup>45</sup>; E.S. Herrelko<sup>67</sup>; M. Inoue-Murayama<sup>89</sup>; T. Matsuzawa<sup>10,11,12</sup>; J. E. King<sup>13</sup>; S. R. Ross<sup>14</sup>; A. Weiss<sup>12</sup>

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The quantity of, asymmetric hierarchical differences in, and quality of social bonds among animals are captured by personality dimensions which can be referred to as extraversion, dominance, and agreeableness. High extraversion and dominance are linked with survival in primates such as gorillas and baboons. In humans, however, alongside lower levels of personality dimensions related to vigilance and impulsivity (neuroticism) and higher levels of dimensions related to planning and forethought (conscientiousness), agreeableness is consistently related to health and survival. Chimpanzee survival has not previously been studied in the context of personality variation, so we examined associations between longevity and the six dimensions of chimpanzee personality. Data were collected from 538 zoo and sanctuary housed chimpanzees, using multiple ratings of personality, between 1993 and 2010. Survival status was ascertained in 2016 and 2017, yielding a follow-up period of between 7 and 24 years. We used parametric survival regression modelling to identify associations. We found that females higher in openness, and male chimpanzees higher in agreeableness survive longer. The fact that neither conscientiousness nor neuroticism were associated with survival in our sample suggests that their importance to human longevity is likely due to uniquely human health-affecting behaviors. Our results link the literature on human and nonhuman primate survival, and suggest that selection after the divergence of hominins favored the protective effects of high quality social bonds for males and exploratory behavior for females.

## Foraging for a foothold in a novel environment: using conservation translocations to test for individual variation

C.E. Andrews<sup>1</sup>; J.G. Ewen<sup>2</sup>; R. Thorogood<sup>1,3</sup>

<sup>1</sup>Department of Zoology, University of Cambridge, UK; <sup>2</sup>Zoological Society of London, UK; <sup>3</sup>Helsinki Institute of Life Science & Faculty of Biological and Environmental Sciences, University of Helsinki, Finland.

While it is now widely acknowledged that individuals within species behave differently even when faced with similar environmental challenges, few studies have identified how this variation arises and what impacts it has on the environment itself. This is critical to consider given that the ecosystems species inhabit are often under threat. The hihi (*Notiomystis cincta*), a threatened New Zealand passerine and important pollinator of native plants, provides an excellent model for investigating the causes and consequences of specialization through the lens of foraging. Following near-extinction around 1890, hihi have been reintroduced to several island and mainland sites, but habitat suitability has proved a major barrier to establishing self-sustaining populations. Here, we consider how we can increase the restorative effects of translocations by selecting individuals based on foraging traits that will i) increase their likelihood of survival and ii) promote ecosystem processes such as pollination. We tested these ideas by tracking a hihi cohort as individuals either remained on their natal island or were translocated to a novel site with more mature forest structure and less intense competition. As a whole, the translocated group broadened its diet, but individuals differed in their dietary shifts. We examine the consequences of preexisting dietary preferences for these individuals and use preliminary data on pollination-related trait variation among hihi to discuss the lasting effects a founder population can have on its habitat.

## Stress in the city: Hormonal, behavioral, and fitness consequences of urbanization in wild birds

F. Angelier

Centre d'Etudes Biologiques de Chizé, CNRS-ULR, UMR 7372, Villiers en Bois, France; <sup>2</sup>Dept. of Wildlife and Fisheries Sciences, Texas A & M University, College Station, TX 77843, USA.

In our current world, wild vertebrates have to face numerous unpredictable anthropogenic perturbations. One of the best examples of these ongoing changes is the intense and rapid urbanization of multiple habitats. Urbanization is associated with several environmental perturbations (noise, light, pollution, and disturbance) and wild animals need to adjust their behaviours and their physiology to cope with an urban lifestyle. In this context, we investigated the impact of urbanization on the behavior, the physiology and the performances of multiple urban bird species. Firstly, we sampled wild birds along an urban-rural gradient and we demonstrated that living in an urban, noisy and polluted environment was associated with hormonal changes (e.g., corticosterone) and potentially detrimental effects on physiology, behavior and morphology, especially in developing organisms. Because early-life stress could be one of the main constraints for urban populations of wild birds, we then experimentally manipulated the environment (noise) and the corticosterone levels (the primary avian stress hormone) of developing house sparrows (i.e. an urban exploiter). We found that both early life stressors and increased corticosterone levels were associated with important alteration of growth, stress physiology, anti-predator behavior, and longevity. Therefore, our study demonstrates that early life-stressors and its physiological consequences could be key mechanism to understand the susceptibility and the resilience of wild vertebrate to anthropogenic changes.

### **Goffin's cockatoos (*Cacatua goffiniana*) flexibly adjust the length but not the width of their tools to function during tool manufacture**

**A. Auersperg**<sup>1</sup>; C. Köck<sup>2</sup>; M. O'Hara<sup>1</sup>; L. Huber<sup>1</sup>

<sup>1</sup>Messerli Forschungsinstitut, University of Veterinary Medicine Vienna, Vienna, Austria; <sup>2</sup> Department of Cognitive Biology, University of Vienna, Vienna, Austria

In contrast to stereotyped tool manufacture that largely originates from heritable behavioral routines, flexible tool manufacture requires agents to actively adjust their tools depending on a current situation and is thus associated to advanced cognitive processing in the technical domain. We confronted non-specialized, yet innovatively tool making parrots, Goffin's cockatoos (*Cacatua goffiniana*), with a task featuring an out-of-reach food reward that could be placed at different distances to a tool opening in the front of the apparatus. Alternatively, the food stayed at a constant distance but the tool opening had different diameters. We used cardboard sheets as basic material for tool manufacture as they demanded an incrementally increased manufacturing effort from the actor, depending on the length of the tool required (more parallel bitemarks alongside the edge of the sheet for longer tools). We found that subjects used two strategies to succeed in this task: either by making cardboard-stripe tools using the full length of the material sheets originally offered (full-length tools) or by flexibly adjusting the lengths of their tools to different goal distances (cut-out tools). These two strategies likely evolved due to two different types of costs (cognitive versus physical). Subjects also discarded cardboard stripes that were too short to reach the goal prior to inserting them into the tool opening and discarded longer pieces when the goal was further away than when it was close. Nevertheless, likely due to morphological constraints (beak morphology), subjects failed to adjust the widths of their tools depending on the diameter of the tool opening.

### **Jealous females? Female competition over paternal care in a wild promiscuous primate**

**A. Baniel**<sup>1,2,3</sup>; G. Cowlshaw<sup>3</sup>; E. Huchard<sup>2</sup>

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Female-female competition over offspring care is well-studied in cooperative breeders, where it often takes the form of reproductive suppression. In contrast, similar patterns have rarely been investigated in promiscuous plural breeders, where discrete forms of paternal care have recently been reported despite low paternity certainty. We investigated female competition over paternal care in a wild promiscuous primate, the chacma baboon (*Papio ursinus*), where pregnant and lactating females establish strong social bonds ("friendships") with males who provide paternal care to their offspring. We tested whether females interfere with the sexual activity of their male friend to prevent new conceptions with him and the subsequent dilution of his paternal care. We found that pregnant and lactating females were more aggressive towards oestrous females when they had recently conceived themselves, and when the oestrous female was mate-guarded by, and showed greater sexual activity with, their male friend. This aggression reduced the oestrous female's likelihood of conception with the male friend. These findings indicate that females can aggressively prevent further conceptions with their offspring's carer through reproductive suppression. Competition over access to paternal care may play an important and underestimated role in shaping female social relationships and reproductive strategies in promiscuous mammalian societies.

**Shaping of behavioural phenotypes in mice: The role of experiences during the life time, serotonin transporter genotype and epigenetic modifications****C. Bodden<sup>12</sup>; S.H. Richter<sup>12</sup>; S. Kaiser<sup>12</sup>; K.P. Lesch<sup>3</sup>; N. Sachser<sup>12</sup>**

<sup>1</sup>Department of Behavioural Biology, University of Münster, Münster, Germany; <sup>2</sup>Otto Creutzfeldt Center for Cognitive and Behavioral Neuroscience, University of Münster, Münster, Germany; <sup>3</sup>Division of Molecular Psychiatry, Center of Mental Health, Laboratory of Translational Neuroscience, University of Würzburg, Würzburg, Germany

Negative and positive experiences as well as the genotype influence behavioural phenotypes. While accumulating adversity is traditionally considered to predict increased anxiety-like behaviour, the 'mismatch-hypothesis' suggests an alternative cause: a discrepancy between the environment that programmed an individual during early phases of life and the later actual environment. For clarification, our first study aimed at elucidating the effects of different life histories on anxiety-like and exploratory behaviour of mice varying in serotonin transporter (5-HTT) genotype. Male mice grew up under either mildly adverse or throughout beneficial conditions until adulthood. Then, they were further subdivided into groups exposed to environmental variation that either matched or mismatched previous conditions, resulting in four different life histories. Subsequently, mice were tested for anxiety-like and exploratory behaviour. In a follow-up study, molecular mechanisms mediating the interaction between life histories and epigenotype were investigated in C57BL/6J mice. We assessed expression profiles of selected genes and DNA methylation of the arginine vasopressin receptor 1a (Avpr1a) gene. The main results were: (1) 5-HTT genotype significantly influenced behavioural profiles, with homozygous knockout mice displaying highest anxiety-like and lowest exploratory behaviour. (2) Experiences during life history profoundly modulated (a) anxiety-like and exploratory behaviour, (b) hippocampal gene expression of candidate genes including Avpr1a, serotonin receptor 1a and glucocorticoid receptor, (c) hippocampal Avpr1a gene methylation. Notably, mice experiencing early beneficial and later adverse conditions showed lowest anxiety-like and highest exploratory behaviour, accompanied by a significantly downregulated Avpr1a expression. Altogether, this study highlights the impact of whole-life experiences on behavioural and epigenetic profiles.

**Information use in wild zebra finches – strategies of prospecting and its informational value****H.B. Brandl<sup>1,2</sup>; S.C. Griffith<sup>2</sup>; W. Schuett<sup>1,3</sup>**

<sup>1</sup>Institute of Zoology, University of Hamburg, Hamburg, Germany; <sup>2</sup> Department of Biological Sciences, Macquarie University, Sydney, Australia; <sup>3</sup> School of Life Sciences, University of Sussex, Falmer, Brighton, United Kingdom

Prospecting on the breeding site of others' to assess habitat quality has mostly been described in species breeding in highly seasonal temperate environments. Recent studies show that the mechanisms underlying prospecting and this form of social information use are complex and worthy of study in a broader range of species and ecological contexts. Zebra finches are a well-studied model species in captivity, but in the wild they breed in variable ecological contexts and in large social groups, suggesting the capacity for interesting social information transfer through nest prospecting. In an extensive two-year field study, we used correlational and experimental approaches to characterize how pit-tagged wild zebra finches prospect at the nests of conspecifics. Using PIT-tag decoders, we recorded prospecting at 60 nest boxes monitored continuously for two months across two years. We followed 239 breeding attempts and detected nearly 10,000 visits by adult conspecific prospectors. Successful, large broods were preferentially visited, especially in the late stage of chick rearing, when information on reproductive success is most reliable. This finding was supported by a playback experiment, in which we found that begging calls of large broods attracted more prospectors than those of small broods. Nevertheless, there were considerable differences in prospecting patterns between years. We discuss these differences in light of ecological factors and the broader reproductive context, which differed across the two years. Our findings build on studies of relatively few other species and contribute to expand the understanding of information use in a wider ecological context.



### Endocrine and fitness consequences of contaminants exposure in polar seabirds

O. Chastel<sup>1</sup>; P. Blévin<sup>1</sup>; S. Tartu<sup>1</sup>; A. Goutte<sup>2</sup>; F. Angelier<sup>1</sup>; C. Barbraud<sup>1</sup>; P. Bustamante<sup>5</sup>; P. Labadie<sup>3</sup>; H. Budzinski<sup>3</sup>; J.O. Bustnes<sup>6</sup>; G.W. Gabrielsen<sup>7</sup>

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Seabirds are top predators of the marine environment that accumulate contaminants over a long life-span. Chronic exposure to pollutants is thought to compromise survival rate and long-term reproductive outputs, thus inducing population decline. Although toxic effects of heavy metals and persistent organic pollutants (POPs) have been described under controlled laboratory conditions, their consequences on long-term fitness have been seldom investigated. Further, these contaminants have endocrine-disrupting properties but to date very few data are available on the endocrine mechanisms involved in the fitness consequences of contaminants exposure in free-living birds. In this talk we present studies conducted in Arctic and Antarctic seabirds to investigate the endocrine and fitness consequences of contaminant exposure. Contaminants considered here are heavy metals such as mercury, legacy POPs (PCBs, chlorinated pesticides) and POPs of emerging concern (Poly- and Perfluoroalkyl Substances, PFASs). Using long-term capture-mark-recaptures studies, we show that exposure to mercury and POPs can affect long-term fecundity and even adult survival. At the proximate levels, we show that the mechanisms underlying these deleterious fitness effects can be linked to the disruption of key endocrine mechanisms (adrenocortical stress response and pituitary hormones such as luteinizing hormone and prolactin). We also show that the different types of contaminants target specific hormonal pathways and can even exert opposite effects on endocrine mechanisms and associated reproductive behaviours. Given that these hormonal mechanisms are tightly linked to major reproductive decisions (ex: timing of breeding), endocrine disruption might affect the ability of polar seabirds to cope with environmental changes.

### Tenerife chaffinches learn songs slower than British chaffinches

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Young songbirds acquire songs through vocal imitation, in some species very precisely, but in others with frequent errors or innovations. In this study, we examined how such differences evolve by comparing song development in two closely related populations that differ in how precisely they learn. Using new computational techniques, we compared the development of song in the wild in 15 male first-year chaffinches (*Fringilla coelebs*) from Great Britain and Tenerife, Canary Islands by systematically recording their song throughout development. Song syllables were compared using an implementation of a dynamic time warping algorithm and the stereotypy of their syllable sequences was analysed using an entropy-based measure. All juvenile chaffinches began with songs lacking stereotyped sequence structure. Those from Great Britain then underwent rapid increases in stereotypy during a 20-day window in development, whereas those from Tenerife showed much more gradual and incomplete increases in stereotypy. Our results provide direct evidence for rapid evolution of song developmental trajectories and a possible example of behavioural neoteny.

### **Life in the city: behavioural adaptations of voles and mice to urban environments**

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A fundamental question of current ecological research is to illuminate the drives and limits of species responses to human-induced rapid environmental change (HIREC). Understanding behavioural responses to HIREC have been identified as a key component because behaviour links across fundamental hierarchical levels of organisation, i.e. from individual responses to population and community changes. Ongoing urbanization provides an ideal setting to test the functional role of behaviour for responses to HIREC because they occur at a fast time scale. In a first step, we aimed at testing whether urban and rural populations of four rodent species differ in mean trait expression, flexibility and repeatability of behaviours associated to risk-taking and exploration of novel environments. Using a standardized behavioural test in the field, we quantified exploration and boldness for a total of 305 individuals (the majority repeatedly) of 4 rodent species (voles: *Myodes glareolus*, *Microtus arvalis*; mice: *Apodemus agrestis*, *A. flavicollis*). We found differences in mean expression of behavioural traits and in behavioural flexibility between individuals from urban and rural populations in some species, with urban dwellers being bolder, more explorative and less flexible than rural conspecifics. In other species, no such differences existed. Therefore, behavioural responses to urbanized environments appear to be species-specific with some species adjusting behaviours to the novel environmental conditions of altered food availability and predation risk, while others retained species-specific patterns. As a result, individuals distribute themselves in a non-random way in response to human disturbance, which might play a key role in the successful coping with the challenges of human-induced environmental changes.

### **Energetic consequences of foraging in different habitats**

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Generalist species often consist of specialised individuals which utilise a subset of available prey types or foraging sites. Every prey type requires different foraging skills and habitat understanding with their own advantages and disadvantages. For instance, feeding on high caloric anthropogenic foods such as rubbish and fishery discards appears to be beneficial for reproductive success in a generalist seabird, the herring gulls. However, such resources come with relatively high foraging costs, as competition for these prey types is fierce and involve risks for injury. Other prey types that are available for the gulls, like shellfish, are less profitable in terms of calories but are easier to obtain. Here we investigate whether foraging in habitats which contain high caloric prey of anthropogenic origin is energetically costlier than foraging in habitats which contain low caloric prey such as intertidal areas or agriculture and natural areas, during chick rearing. To answer this question, we use data from GPS trackers with tri-axial acceleration measurements. These allow us to quantify time-energy budgets, representing energetic expenditure during foraging trips of herring gulls for each habitat. Our results showed that foraging in anthropogenic habitat is indeed energetically more costly and we consider the consequences of these costs through human induced changes in the food landscape.

## Attack position of two aerial fish predators: Can a generalist outcompete a specialist?

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We compared the hunting strategy of two species of fish-hunting birds that reside around sulphur streams in the south of Mexico - the Green Kingfisher, a specialist fish-catcher and the Kiskadee, an opportunistic fish-catcher. Their prey, sulphur mollies, have evolved specialised traits that allow them to withstand the otherwise toxic concentrations of hydrogen sulphide in the water. At first glance the benefits of living in these streams outweigh the costs as there are no underwater predators. However a key consequence of living in sulphur streams is the low oxygen in the water. This forces fish schools to spend long periods of time at the surface rendering them highly susceptible to avian predators. According to Hamilton's selfish herd idea, being at the centre of a group incurs lower risk, since predators are more likely to first encounter individuals at the periphery. Thus we predicted these birds would attack more frequently at the school edges. Indeed, Kingfishers preferred attacking at the periphery of a school however showed higher success when attacking at the centre. The Kiskadee employed a more generalist strategy, attacking randomly across the school, with its success not being related to position. While the Kingfisher had a higher success probability, the Kiskadee was able to compensate for its lower probability of success by attacking more frequently. This suggests that these birds have evolved different attack strategies that optimise their per-capita success rate and that predation risk for fish may depend more strongly on the predator species rather than school position.

## Disruption and disease in social networks: social behaviour, changes following culling and their implications for disease transmission

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Despite the ubiquity of wildlife management, from reintroductions and supplemental feeding to culling and habitat change, very little is known of the effects of management practices on species' social dynamics. Species' social structure has the potential to affect not only behaviour and evolution but also the transmission of information or disease. We demonstrate how similarity in movement behaviour scales with increasing social circles, how seasonality in movement and seasonality in association rates covary as well as detailing post-cull behavioural changes in a managed species, *Branta canadensis*, the Canada goose. This study demonstrates the similarities in movement behaviour and body condition that birds share with their pair and social group and explores the characteristics of 'super-spreaders' in a network.

**Long-term consequences of post-natal corticosterone exposure on metabolism and sexual attractiveness in house sparrows (*Passer domesticus*).****S.M. Dupont<sup>1</sup>**; J.K. Grace<sup>2</sup>; F. Brischoux<sup>1</sup>; O. Lourdais<sup>1</sup>; F. Angelier<sup>1</sup><sup>1</sup>Centre d'Etudes Biologiques de Chizé, CNRS-ULR, UMR 7372, 79[3]60 Villiers en Bois, France; <sup>2</sup> Dept. of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843, USA.

In vertebrates, early life is considered as a critical step of the life-history cycle because the ontogeny of organismal systems occurs during that period. Accordingly, developmental conditions are well known to influence growth, early life survival, adult phenotype and ultimately individual fitness. Importantly, the influence of developmental conditions on adult phenotype and performances are thought to be primarily mediated by endocrine systems, and more precisely by corticosterone (main avian stress hormone). In this study, we aimed to better understand how developmental exposure to corticosterone may subsequently affect adult phenotype and performances. Here, we experimentally manipulated corticosterone exposure during the developmental phase in wild house sparrows (*Passer domesticus*), we then hold these birds in captive standardized conditions until adulthood, and we investigated the long-term consequences of this manipulation on their metabolic ability to cope with a cold challenge (metabolic expenditure) and with their sexual attractiveness (secondary sexual signals: badge and wing bar surfaces). We found a significant and important effect of early life corticosterone exposure on energy expenditure. Specifically, post-natal exposure to corticosterone was associated with a better ability to cope with cold challenge. In addition, we observed that post-natal exposure to corticosterone had also a strong negative impact on the expression of secondary sexual signals (i.e., size of badge and wing bar). In conclusion, we demonstrated that early-life stress and corticosterone exposure were associated with deep and intense physiological and morphological modifications. Future studies need now to explore the costs and benefits of this developmental plasticity for individuals (i.e. fitness).

## **Social instability decreases communal care and interferes with the ability of mothers to buffer offspring**

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Social groups may experience permanent changes in adult membership that are potentially costly to the females. We examined how social instability experienced by pregnant females influence female-female interactions, and the ability of nonbreeding females to contribute with communal care and buffer offspring. Groups of three adult *Octodon degus* females were assigned to either socially stable or unstable groups. Upon birth of litters, offspring in socially unstable groups were challenged with removal of their mother, removal of nonbreeding females or removal of all adult females for 2 h daily. We quantified social interactions among adult females and care given to the offspring. Postnatally, nonbreeding females of socially unstable groups exhibited less alloparental care, and thus, offspring of unstable groups received less parental care overall. Upon weaning, the stress response to standard restraint and handling, and growth rate of offspring were quantified. Instability did not influence social interactions among the females during pregnancy. Postnatally, nonbreeding females from previously unstable groups decrease their contribution to offspring care. Neither social instability nor postnatal social challenge influenced stress reactivity of offspring. Offspring in stable groups grew faster than offspring in unstable groups, except when offspring experienced the daily removal of their mother. Thus, the ability of mothers to buffer offspring growth seems contingent upon experiencing socially stable conditions, and in the absence of the mother, nonbreeding females were unable to buffer offspring. Our findings indicate that social instability in groups of degus negatively affects alloparental care and offspring quality

**Cognition for conservation: Supplementing conservation research through insights of a specialist birds' responses to novelty**G.R.Eccles<sup>1</sup>; E.J.Bethell<sup>1</sup>; A.L.Greggor<sup>2</sup>; C.C. Mettke-Hofmann<sup>1</sup><sup>1</sup>Liverpool John Moores University, UK; <sup>2</sup>Institute for Conservation Research, San Diego Zoo Global, CA, USA

Neophobia (the fear of novelty) is an ecologically relevant fear behaviour protecting animals from harm, but can reduce resource exploitation abilities and adaptability to changed condition. It is often part of personality syndromes and is modulated by social environments and individual experience. Recent research indicates context-specificity of novelty reactions. We investigated different types of neophobia in Gouldian finches (*Erythrura gouldiae*) in relation to age, sex, head-colour and personality traits. Finches were tested in mixed and same head-colour pairs and exposed to two trials of food and spatial neophobia. Food neophobia comprised of depriving finch pairs of food for one hour then simultaneously presenting familiar and novel food on five consecutive days. Spatial neophobia testing comprised of exposing finch pairs to novel rooms, simulating either simple or complex habitat types. Finches hesitated longer to approach and feed on novel food. Younger birds demonstrated less neophobia than older birds. Moreover, red-headed birds hesitated longer to approach and feed on novel food than black-headed birds but attenuated faster. Finches entered simple habitats sooner than complex habitats with younger birds again being faster than older birds. Furthermore, birds approached sooner when partnered with a red-headed bird in trial one and approached and entered novel rooms sooner when partnered with a black-headed bird within trial two. Food and spatial neophobia were not correlated. Our results show both types of neophobia increase with age, which is consistent with age-related changes in object neophobia but different factors influence food and spatial neophobia.

**Grandmother effects in a pre-industrial human population: assessing the potential for cooperation to improve inclusive fitness****S.C. Engelhardt<sup>1,2</sup>**; P. Bergeron<sup>3</sup>; A. Gagnon<sup>4</sup>; L.Y. Dillon [4]; F. Pelletier<sup>1</sup>

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Post-reproductive lifespan (PRLS) is rare in nature. The grandmothering hypothesis proposes that the PRLS interval is long in humans because the presence of post-reproductive mothers should increase the number and survival of grandchildren. However, it is difficult to measure the cooperative potential between grandmothers and their daughters. We investigated the grandmother hypothesis in a pre-industrialized population of the first French settlers living in the St. Lawrence Valley during the 17th and 18th century. We used registers of baptisms, marriages and burials from these Roman Catholic parishes. We conducted within-family analyses of sisters to account for potential familial genetic and environmental effects. We found that the presence of grandmothers (F0, n =404) allowed their daughters (F1, n =1,272) to increase their number of offspring by +2.05 offspring, lifetime reproductive success by +1.52 offspring and age at first reproduction by +1.26 years compared to daughters who had their children when the grandmother was dead. As a proxy for the potential to help, we used the geographic distance between parish of residence between grandmothers and daughter pairs ranging between 0-325 km, and evaluated the effect of distance on the daughters' reproductive performances. We found positive effects of grandmothers on their daughters' number of offspring, lifetime reproductive success and the age at first reproduction and these effects decreased over 325 km. Our analyses provided support for the grandmother hypothesis but also suggested that geographic proximity potentially modulates the inclusive fitness benefit.

### Rhythmic signatures in the display songs of the African penguin

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African penguins (*Spheniscus demersus*) are colonial seabirds where ecstatic display songs play a crucial role in mate choice and territorial defence. Such vocalisations are uttered mostly by males during the breeding season and consist of a sequence of three stereotyped syllable types combined in a phrase. Ecstatic display songs have been demonstrated to encode individual identity information in their spectral acoustic components. However, whether the rhythmic structure of the song could play a role in completing the acoustic signature remains to be investigated. To fill this gap in knowledge, we collected 136 display songs from eight adult African penguins belonging to the ex-situ colony of the Zoological Garden of Pistoia and 268 songs from eight penguins housed at Zoomarine Italia. Vocalisations were collected during the breeding period in 2017 using a focal animal sampling method. From each song, we measured the Inter-Onset Interval (IOI) of adjacent syllables as a proxy for the rhythmic structure of the song. Using a series of Generalized Linear Mixed Models, we found a significant effect of the emitter to the IOI. We also found a significant effect of the colony to the IOI, suggesting a potential rhythmic convergence within each group of birds. Overall, our results demonstrate that the rhythmic structure of the song can provide cues to the individual identity of the emitter. Further investigations are needed to define whether the genetic component or auditory experience is responsible for determining the rhythmic structure of the ecstatic display songs at a colony level.

### The lemur baseline! How lemurs compare to monkeys and apes in a comprehensive cognition test battery

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Understanding the evolution of brain size and its link to cognitive abilities is a central question in behavioural ecology. In order to understand this link, comparable and comprehensive test batteries in several cognitive domains are required. The Primate Cognition Test Battery has been developed to address this question, and it has already been applied to two great ape and two Old World monkey species. These four species showed largely comparable cognitive skills in the physical as well as in the social domain. Since brain size increases disproportionately within the primate order from strepsirrhines to haplorhines and humans, we applied the Primate Cognition Test Battery to three strepsirrhine species, differing in brain size as well as several socioecological traits. We tested 13 black-and-white ruffed lemurs (*Varecia variegata*), 27 ringtailed lemurs (*Lemur catta*) and 19 mouse lemurs (*Microcebus murinus*), the latter having one of the smallest brains among primates. The three lemur species exhibited similar cognitive skills in the physical and social domain, and surprisingly, performed in many aspects at a comparable level to the previously tested haplorhine primates. Overall, lemurs' performance was slightly inferior in the physical domain, while they matched the cognitive abilities of haplorhine primates in the social domain. These results do therefore not support a clear link between brain size and cognitive skills, but suggest a more domain-specific distribution of cognitive abilities in primates.



## Competitive signalling and reproductive success in female house mice

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Compared to sexually selected male traits, female competitive signals often appear less costly. Consequently it has been hypothesised that females may invest less in competitive traits due to a trade-off with parental investment, such that costly signals may divert resources away from producing and rearing offspring. Here we explore this hypothesis in relation to competitive scent marking behaviour of female house mice (*Mus musculus domesticus*). Female house mice live in complex social environments and previous evidence suggests that urine marking plays an important role in their communication and competitive interactions. Although studied most extensively in relation to competitive signalling in males, the urine of female house mice also contains major urinary proteins (MUPs), which can be expressed at relatively high concentrations under naturalistic conditions. Here we show that the urinary protein concentration of female house mice increases during the lactation period and remains high after litters are weaned. Urinary protein concentration during and after breeding also predicts female scent marking behaviour in assays designed to test competitive responses. Moreover, a preliminary analysis reveals that communal nests formed by more competitive females produced more offspring, which were also heavier at weaning. These results indicate that MUPs can be adjusted flexibly and reflect competitive abilities of female house mice, with limited evidence for a trade-off between investment in a costly competitive signal and offspring production under the conditions tested here. Our study highlights that female competition is an overlooked but important selection pressure regulating the complex social lives of mammals.

## Sexual cannibalism is not part of a behavioural syndrome in *Miomantis caffra*

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Behavioural syndromes occur when different behaviours are correlated within an individual. As such, certain behaviours may in part be predicted by other behaviours rather than the environment, reducing their plasticity. Sexual cannibalism is common in predatory invertebrates and can negatively affect both individual fitness and population viability under certain ecological scenarios. This is particularly true if individuals cannot vary cannibalism rates in response to environmental cues. The aggressive spillover hypothesis (ASH) claims that sexual cannibalism is not directly adaptive, but instead occurs as a result of selection for juvenile aggression towards prey. The ASH makes the following predictions: 1) aggression towards prey will be consistent across time, 2) aggression towards prey will be positively correlated with a propensity for sexual cannibalism, and 3) juvenile aggression will be positively correlated with adult aggression. We failed to find support for any of these predictions in the highly cannibalistic praying mantis *Miomantis caffra*, but instead have shown that aggression in individuals of cannibalistic species need not be linked across contexts. This implies that sexual cannibalism is not part of a behavioural syndrome in *M. caffra*. Therefore sexual cannibalism is not always a behavioural by-product, but instead is likely to be directly selected for in some species. Identifying when sexual cannibalism is part of a behavioural syndrome will help to determine which species are likely to be unable to mitigate environmental change through plastic behavioural responses.

## Temperature-induced behavioural variation in the polymorphic Gouldian finch

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Examining behavioural variation between individuals through different environmental conditions is crucial to understand and explain the evolution and maintenance of phenotypic variability within species. In several species, colour polymorphism has been related to alternative behavioural strategies. In the context of climate change, such behavioural variation between individuals likely underlies inter-individual differences in response to extreme environmental conditions, such as heatwaves. However, how individuals of distinct colour morphs respond to fluctuating environmental conditions remains poorly investigated. Here, we experimentally examined how captive red- and black-headed Gouldian finches (*Erythrura gouldiae*) responded to artificial heatwaves. We expected morph-specific behavioural characteristics to vary with temperature conditions, which may ultimately exacerbate or reduce behavioural differences between colour morphs. Overall, the behavioural balance between colour morphs was not significantly affected by thermal conditions for most behavioural traits that we measured (aggressiveness, docility, food consumption). However, the exploratory balance between morphs was influenced by thermal conditions. Indeed, red-headed birds were more exploratory than black-headed birds before the heatwaves, but this exploration advantage disappeared during the heatwaves. To our knowledge, these results show for the first time that the behavioural balance between morphs is dynamic and depends on environmental conditions, at least for exploratory traits. How such a change in the behavioural balance between both morphs affects inter-individual dynamics in the natural habitat of birds remains to be investigated.

## Cooperative interactions in fishes.

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Cooperative interactions are a widespread phenomenon throughout the animal kingdom. Accordingly, they gather a continuous attention since the beginning of behavioural research. The occurrence of cooperative behaviour is usually explained by either generating direct benefits, for example through reciprocal interactions, mutualisms or manipulations, or through indirect fitness benefits by cooperating with related individuals. Still, our knowledge of how ecological and social factors mediate cooperative interactions is limited. Fishes inhabit a broad variety of ecological niches, from the open ocean to structurally highly complex benthic habitats. The structure of fish communities ranges from solitary- and pair-living to loose fission-fusion groups and highly complex societies. Here, cooperative interactions occur in a variety of social situation, such as reciprocal predator inspection, mutualistic foraging or alloparental care for offspring. Such interactions take place not only among relatives, but also between unrelated individuals and even between members of different species. This fascinating behavioural diversity offers ample opportunities to increase our understanding of the proximate and ultimate factors mediating cooperative behaviour, both by studying cooperative interactions within and between single species and by applying comparative approaches between taxonomic groups. This talk aims at providing a broad overview of the mechanisms, functions and evolution of cooperative behaviours of fishes in order set the stage for the symposium on Cooperative interactions in fishes.

## Extreme climate events induce foraging behavioural changes and heat stress in wild zebra finches

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There is a growing interest in the effects of heat waves on animals, given the rapid increase in both frequency and intensity of periods of extreme heat. Studies assessing this phenomenon can help to understand how animals cope with, and their potential resilience to the predicted future climate. Exposure to extreme temperature can lead to lethal hyperthermia, when individuals are no longer able to maintain body temperature within their optimal physiological range. At extreme temperatures birds rapidly adjust their behaviour, prioritising heat dissipation to maintain their body temperature against other activities, such as foraging for themselves or their offspring. Few studies have investigated temporal foraging patterns under different temperatures at an individual level and at a fine time scale. In this study we monitored the individual foraging activity of 81 zebra finches (*Taeniopygia guttata*), a species well adapted to arid conditions, in an Australian arid area during three heatwave events. We found that in extreme temperature conditions (>36°C) the zebra finches drastically reduced their foraging activity (58% less active) and preferred to forage closer to a water dam. We also investigated how different heat stress behaviours are related with high temperature. Our results indicate that extreme temperature impacts on individual zebra finches' foraging activity, with consequences on their food intake, with potentially negative implications for reproduction and survival.

## Acoustic cues to species and caller identity in the short- and long-distance vocalisations.

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Research on animal communication showed that acoustic cues to identity might be encoded in both short- and long-distance calls and that such features play a crucial role in social behaviour. In this work, we analysed how cues to species, sex, and individual identity are present in the calls of lemurs in the perspective of source filter-theory. We examined short- and long-distance calls of Lemur catta, *Eulemur rubriventer*, and *Indri indri*. We used acoustic analyses to characterise the spectral structure of calls, for which we measured the fundamental frequency, the temporal characteristics, and the formants. From anatomical casts, we generated vocal tract models resembling the configuration of the vocal tract during short- and long-distance vocalisations. We collected formant estimates to describe the output of the different models. We found that short-distance calls retain most of their potential for individual and species coding in the vocal tract filtering, while the information concerning individuality and sex in the long-distance calls is encoded in the variation of the fundamental frequency. Moreover, vocal tract modelling showed that the tract configurations used during the emission of the short-distance calls generated a more conspicuous between-individuals formant variation when compared to those of long-distance calls. Our results indicate that short- and long-distance signalling in lemurs may evolve under different selective pressures.

### **Punctuated evolution of information in a communication signal**

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Although there is a consensus that information has a pivotal role in biological evolution, whether and how information evolves is still matter of debate. As they function as information carriers, animal communication signals may provide models to understand the evolution of information and its underlying mechanisms. Woodpeckers' drumming emerged as an exaptation from poorly informative stochastic tapping behaviour used to find preys into structured rhythmic signals where information supports species recognition during mating and territorial defense. Here we show that the increase of information during the evolutionary radiation of the woodpeckers' clade has been marked by sudden jumps due to innovations in signal structure. We first reconstructed the evolutionary history of drumming strategies, and then used Shannon's theory to calculate the information about species identity embedded in these acoustic signals. It appears that, while limited changes in the amount of information were paramount during woodpeckers' radiation, the random emergence of novel drumming strategies created sudden and strong bursts in the evolutionary history of information. Examining ecological woodpeckers' communities of temperate and equatorial forests and performing playback experiments with natural and re-synthesized signals, we found that this punctuated evolution has important consequences at the community level where it optimizes the acoustic discrimination between sympatric species that seldom belong to the same lineages. Our study provides the first evidence that punctuated, randomly distributed, increments in the amount of information can be major actors in the evolution of non-signalling behaviors into species-specific markers.

### **Territorial defence participation and post-conflict relationship management in a cooperatively breeding cichlid**

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In many group-living species, social groups are typically composed of individuals of both sexes, a variety of ages and sizes, and different social ranks. When social groups encounter and engage with other groups or out-group individuals, such interactions can therefore pose distinct challenges to group members depending on their individual attributes. These, in turn, may impact subsequent within-group interactions, continued group membership and overall group stability. Yet, we still lack a comprehensive understanding of the potential impacts of out-group conflict on within-group dynamics. Using a laboratory population of *Neolamprologus pulcher*, a territorial cooperative breeding cichlid species from Lake Tanganyika, we simulated territorial intrusions to assess how intruder size influences conflict participation and post-conflict group dynamics. Female-only intruders that matched 1) the dominant female, 2) the subordinate female, or 3) were smaller than both females, were presented in alternated order to 12 uniform social groups (dominant pair and a subordinate of each sex). Intensity of participation in territory defence was dependent on intruder size: dominants defended the most against large intruders, both subordinates defended more against medium sized intruders, and female subordinates defended the most against small intruders. Furthermore, subordinate females displayed more affiliative behaviours towards dominant females following intrusions by small females but not by the other female intruders. Together, our results show that participation in territory defence and investment into relationship management following conflicts with outsiders are dependent on careful assessment of the level of threat that intruders pose to one's position in a social group.

## **Males paving the way to polyandry? Parental compensation in a monogamous biparental nesting cuckoo**

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Social monogamy in combination with biparental care is the most common breeding system of birds. Why this is so is still not well understood. I studied the importance of female and male contributions to offspring care in white-browed coucals (*Centropus superciliosus*), which belong to a group of nesting cuckoos and have a monogamous and biparental breeding system. In this species, females occasionally become polyandrous – presumably when a surplus of males becomes available – and nest with an additional male. In these cases, the secondary males raise their offspring without or with only little help from the female. To study the effect of female and male contributions to care in white-browed coucals I conducted a removal experiment, during which one partner was temporarily removed for 3 days to see whether the remaining parent compensates for the loss of the removed parent. Both female and male white-browed coucals approximately doubled their feeding rates when their partner was removed, thus fully compensating the number of feeding visits to the nest. However, the growth rate of nestlings was maintained only upon female removal. When the male was removed nestling growth declined. Hence, only male white-browed coucals can fully compensate the loss of the partner. This suggests that females may benefit from nesting with additional males, if these should become available, and that the monogamous breeding system of white-browed coucals is maintained because of a relatively balanced sex ratio.

## **Prenatal embryonic plasticity in hormone regulation: a potential tool for adaptation to anthropogenetic change?**

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The unprecedented anthropogenetic influence on our planet has made the question whether evolution would be rapid enough for species to adapt a key question in biology. One rapid way of adaptation can be obtained by phenotypic plasticity. Hormonal systems can play a crucial role here as they have pleiotrophic effects, coordinating the change in different aspects of the phenotype. Such hormonal effects can be especially important early in development, as during that period the organism is especially sensitive to environmental and hormonal influences that can induce long term organizing effects on the phenotype. Egg laying species are interesting models for studying prenatal hormonal adjustments as the embryo is relatively easily assessable for measuring and manipulating hormone exposure and production. Hormone mediated maternal effects have been studied extensively in such species and I will discuss to what extent such effects can contribute to adjustment to changing environments. However, in this field the role of the embryo itself has been somewhat neglected, assuming the embryo is just a passive responder to the mother's signal or endocrine disrupters. However, recent work by us and others indicates that the embryo plays a much more active role. I will review work of others and my own group suggesting that the embryo may adjust its own hormone production to environmental signals, and converts hormones from the mother or the external environment to other hormones that would affect its own development and discuss to what extent this may be adaptive for responding to environmental change.

### **New Caledonian crows use planning to solve metatool problems**

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The extent to which animals mentally represent different sequences of behaviour before solving complex problems is currently unclear. Here we presented individual New Caledonian crows with 3-stage metatool problems where each stage was out-of-sight of the others and the crows had to avoid a distractor apparatus that housed a non-functional tool. We found that all six crows solved a stick problem where they had to use a stick tool to get a stone tool and then use the stone to get food while avoiding a distractor object (another stick). These results show that New Caledonian crows can mentally represent the sub-goals of metatool problems: the crows were able to keep in mind the location and identities of the out-of-sight functional tool and distractor tool while planning and performing a 3-stage sequence of tool behaviours.

### **Development and function of animal personality in wild cavies**

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The study of individual differences in behaviour (i.e. personality) has flourished over the last decades because it has been recognised as a major contributor to differences in survival and fitness among individuals. Animal personality is often tightly linked with individual life histories and represents an adaptation to the current or expected environment. Recently, it has also been recognised that individual differences in behaviour are linked to individual differences in cognition, suggesting that life history, personality and cognition might form an integrated suite of traits facilitating the individual to cope with its environment. Finding links between these seemingly different domains suggests that they may at least in part be shaped by the same underlying mechanisms. Wild cavies (*Cavia aperea*) born in different seasons of the year strongly differ in their life history. Animals born early in the year grow fast, mature early and heavily invest into early reproduction while animals born late in the year delay reproduction to the next year. Here I show that depending on the timing of birth individuals develop a different personality and differ in cognitive performances such as learning speed and problem solving ability. Furthermore, I show that these seasonal adaptations in behaviour and cognition are brought about by differential glucocorticoid concentrations in early life. Together, these findings will help us to understand the existence of individual differences across multiple disciplines of animal behaviour.

## Social learning within and across predator species facilitates the evolution of aposematic prey

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Aposematic prey signal their unpalatability to predators with conspicuous warning signals. The evolution and maintenance of aposematism, however, is still a puzzle because conspicuous prey are expected to suffer high predation by naive predators. Recent research suggests that predators observing conspecifics might help explain this evolutionary paradox but predator communities are complex and the effect of social transmission on prey evolution could be even stronger if predators also learn socially across species boundaries. We tested this using blue tits (*Cyanistes caeruleus*) and great tits (*Parus major*) as predators. We used video playback to present individuals i) conspecific or ii) heterospecific social information about novel unpalatable prey, or iii) a control video with no information about prey palatability. We then investigated if social information influenced birds' foraging choices using the novel world method where birds were presented novel palatable and unpalatable prey items. Both species learned to avoid unpalatable prey faster after receiving either conspecific or heterospecific information, compared to the control group. We predicted that birds would learn more quickly from conspecifics but there was no difference in avoidance learning between the two social information treatments. Our results show that social transmission about novel unpalatable prey signals occurs in multiple predator species and across species boundaries. Therefore, social information use by predators is likely to be an even stronger selective agent in the evolution of aposematic prey than previously thought.

## Personality and foraging specialisation in an Arctic predator species

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Individuals within a population often show specialisations in behavioural strategies, exemplified by intraspecific variation in the foraging behaviour of predatory animals. The degree of specialisation or variability shown by an individual may in part be explained by intrinsic factors such as age or sex, but other sources of variation are less well known. Personality traits such as boldness, activity and exploration are often strongly linked to differences in movement behaviour, and separately have been shown to link to variability in behaviour. Here, we examine personality differences and foraging specialisations in an Arctic seabird, the black-legged kittiwake (*Rissa tridactyla*). Using novel object tests, we assayed boldness in kittiwakes breeding at five different colonies in Svalbard, and deployed GPS loggers on birds to capture data on their repeated foraging trips at sea. Firstly, we examined the relationship between boldness and foraging behaviour in kittiwakes. Shy birds tended to range further from the colony, but otherwise showed no differences in their foraging trips compared with bold individuals. We then measured the variability individual kittiwakes show in their foraging behaviour, and the relationship between this variability and boldness. Bold individuals exhibited lower variability in their range and locations of foraging patches, indicating bold individuals are more specialised in their behaviour. Associations between personality and foraging specialisations may be an important mechanism underlying relationships between personality and fitness.

**Social instability: A mini-review**L.D. Hayes<sup>1</sup>; L.A. Ebensperger<sup>2</sup><sup>1</sup>Department of Biology, Geology, and Environmental Science, University of Tennessee at Chattanooga, Chattanooga, TN, USA; <sup>2</sup> Departamento de Ecología, P. Universidad Católica de Chile, Santiago, Chile

The composition of animal social groups may vary permanently due to mortality, individuals leaving the group (i.e., emigration), or individuals joining a different group. Such changes can disrupt social hierarchies, influencing physiological pathways underlying behaviour and reproductive success. The aim of this talk is to summarize the impacts of social instability on physiology and reproductive success of social vertebrates, providing a conceptual framework for the symposium 'Social instability: Direct fitness consequences and underlying physiological mechanisms (S1)'. Biomedical studies suggest: (i) individuals experience costly cardiovascular, immune, and neuroendocrine effects following changes in group membership and (ii) stressors to offspring, such as maternal separation, cause physiological and behavioural effects that can persist into adulthood. Lab studies based on evolutionary theory suggest that unstable conditions result in offspring phenotypes (e.g. behavioural masculinisation or infantilisation) that maximize fitness under stressful conditions. Field-based studies have focused mostly on (i) factors contributing to social instability (familiarity, kinship) within groups and social networks, (ii) how periods of instability influence HPA stress pathways, and secondarily on (iii) fitness consequences of instability. In primates, the most well-studied taxonomic group, physiological responses depend on rank; high ranking males experience greater physiological costs during periods of instability while low ranking males experience greater costs during periods of stability. Limited studies in birds and small mammals suggest that social instability is associated with fitness costs to females.

**The evolution of masturbation in birds**C. Heys<sup>1</sup>; K. Arbuckle<sup>2</sup>; T.A.R. Price<sup>1</sup><sup>1</sup>Institute of Integrative Biology, University of Liverpool, Liverpool, UK; <sup>2</sup>Biosciences, University of Swansea, Swansea, UK

A key assumption of research on mating is that sexual behaviour should generally be adaptive. However, one common sexual behaviour, masturbation, appears to be a Darwinian puzzle with no adaptive value, instead wasting time, energy and potentially sperm. Yet masturbation is widespread in vertebrates, being reported in lizards, tortoises, mammals and birds. An abundance of theories have been proposed to explain this prevalence, but there have been few empirical tests. Here we examine key current hypotheses about why masturbation occurs, using a phylogenetically broad dataset on the presence or absence of masturbation across 120 bird species. We surveyed scientists and zoo-keepers on whether the bird species they work with masturbate and combined this with published reports of masturbation. We find that masturbation is widespread across birds, but shows strong phylogenetic inertia, typically being fixed or nearly so within broad clades. We find little evidence that masturbation is a maladaptive response to captivity, and indeed masturbation is common in wild birds, both male and female. Nor is it prevalent in juveniles, making it unlikely to represent practice copulations. We find that mating system is the strongest predictor of masturbation, being rare in socially monogamous species but common across indiscriminately mating species. Two key evolutionary explanations are consistent with our data. Masturbation may be a neutral side-effect of high sex drive. Alternatively, it may increase fitness by enhancing access to non-reproductive benefits of sex. We hope this work will stimulate further research in this inexplicably understudied area of evolutionary biology.



## **Integrating leopards into the landscape of fear: impact on chacma baboon range use and behaviour**

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The nonlethal effects of predation risk can impact on almost every aspect of prey behaviour, with spatial variation in predation risk one of the key drivers of these nonlethal effects. These risk effects on prey ecology can be as large or even larger than the direct effect of predation, but are also more challenging to quantify. In previous work we have shown that alarm call distributions can be used to map the 'landscape of fear' for primates, with spatially explicit models subsequently showing that predation risk from specific predators is more important than other ecological factors such as food availability in determining the ranging behaviour of vervet and samango monkeys within the Soutpansberg Mountains, South Africa. Here we apply this landscape of fear technique to chacma baboons (*Papio ursinus*) inhabiting the same montane environment, but extend this approach through integrating detailed information on the habitat utilisation of their primary predator, leopards (*Panthera pardus*), assessed through resource selection functions. Chacma baboon alarm call distributions are better explained by the probability of encounter with other baboon groups rather than the landscape of fear from predators. Nevertheless, the probability of leopard presence, as indexed by their utilisation distribution, was a key driver of baboon ranging behaviour and avoiding leopards was more important than other ecological factors such as food availability in determining habitat use. Similar results were obtained when exploring spatial patterns in the baboons' vigilance, highlighting the critical importance of the non-lethal effects of predation in shaping animal behaviour.

## **Polymorphic MUPs (major urinary proteins) provide individual identity signatures in murine scents**

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Odours play a key role in social recognition in many vertebrates and invertebrates. Are individuals recognised through variation in odours that arise incidentally from a wide variety of genetic and non-genetic differences, or do animals evolve distinctive polymorphic signals to advertise identity reliably that might be exploited? We have shown that house mice (*Mus musculus domesticus*) recognise individual scent owners using a combinatorial set of highly similar MUPs in urinary scent marks, using these signatures regardless of other genetic differences that influence urine scents. MUP signatures are both individually distinctive and highly stable, even over extreme environmental changes that alter scent investment. MUP signatures are encoded by a tight cluster of >20 functional genes on mouse chromosome 4, which has expanded through a process of concerted evolution. Individuality arises through a combination of limited variation in amino acid sequences and differential MUP gene expression across individuals. Tight linkage between Mup genes may help to maintain the stability of MUP signatures when investment in MUP output changes. MUP signatures show high heritability, but heterozygosity, dispersal from natal territories and multiple paternity minimise signature sharing between local territory owners. Mice detect MUP signatures on nasal contact with scents via MUP-specific receptors in the vomeronasal organ. In addition, MUPs bind volatile signalling molecules, releasing these slowly from scent marks. On contact with urine, mice learn volatile odours that are directly shaped by the MUP signature due to differential ligand-binding affinities. MUPs then also signal identity through airborne odour signatures recognised without further contact.

### **Regulation between personality traits: Individual social tendencies modulate whether boldness and leadership are correlated**

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Although consistent behavioural differences between individuals (i.e. personality variation) are now well established in animals, these differences are not always expressed when individuals interact in social groups. Individuals consistently differ in how social they are (their sociability), so if other axes of personality variation, such as boldness, can be suppressed during social interactions, this suppression should be stronger in more sociable individuals. We measured boldness (latency to leave a refuge when alone) and sociability (time spent with a conspecific) in three-spined sticklebacks (*Gasterosteus aculeatus*) and tested whether leadership in pairs of these fish was positively associated with boldness. Both boldness and sociability were repeatable, but were not correlated with one another. When splitting the data between the 50% most sociable and 50% less sociable fish, boldness was more strongly associated with leadership in less rather than more sociable individuals. This is consistent with more sociable fish conforming to their partner's behaviour due to their greater social tendency. One axis of personality variation (sociability) can thus modulate the relationship between others (boldness and leadership). The expression of personality variation in groups can vary between individuals, with potential implications for selection on personality variation in social animals.

### **Bottlenose dolphin signature whistles are learned, representational identity signals**

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Bottlenose dolphins are versatile vocal learners that use individually distinctive signature whistles to stay in contact with group members. In laboratory and field studies, we found that signature whistles were used for individual recognition, negotiating reunions and, when copied by other dolphins, for addressing conspecifics. In developmental studies, we have shown that signature whistles are formed early in life and that their modulation pattern does not relate to sex, age or size of the animal. Thus, new signature whistles types are introduced de novo into the communication repertoire of the group. In captive bottlenose dolphins, we have now shown that infants use their mothers' signature whistles as model sounds when developing their own distinctive signature. We found that while unique in a group's repertoire, the crystallised signature whistles of 8 out of 12 infants had high similarity scores to their mothers' signature whistles but not to whistles of their fathers or other pool members. This is the first clear demonstration that vocal production learning is used in the development of signature whistles. To investigate whether signature whistles are representational signals, we conducted cross-modal experiments with bottlenose dolphins in which we played a signature whistle of a known conspecific after presenting a urine sample of the same or a different individual for chemosensory exploration. Dolphins spent less time investigating the stimulus pair when they did not come from the same individual, indicating that dolphins have a modality-independent representation of identities of known conspecifics.

### **Insights into the behavioural flexibility to spatial alterations in the courtship dance of golden – collared manakins (*Manacus vitellinus*).**

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The courtship display of golden collared manakins is one of the most elaborate displays in the animal kingdom. Each male within the lek performs the so called “jump – snap” display in their individual court, which contains between 3 and 4 saplings on the forest ground, to attract females. To be able to perform the display with higher speed and precision they practice their routine throughout the mating season. In this study we tried to investigate how fast males could adapt their display to disturbances in their court. A piece of bark, too heavy to be removed by the birds, was put on the mating sapling for 4 consecutive days. On the 5th day the bark was taken off and the bird’s behaviour recorded. It took two days for most of the birds to build a new routine in their display. Some males were already copulating with females on the 2nd day even though their original mating sapling was blocked by the bark. After taking off the bark most males return to their previous routine within a couple of trials. The study shows that even though the routine needs to be rehearsed and has very fixed patterns there is still the possibility to adapt to environmental disturbances and flexibility in their behaviour.

### **Predation risk affects polygyny in cooperative breeders**

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The evolution of polygyny is usually assumed to involve conflicting interests between the sexes. Several factors have been proposed to select for polygyny, including a clustered distribution of resources, a female biased operational sex ratio, and low needs for parental care. Furthermore, levels of polygyny often vary between populations, indicating that environmental effects mediate the occurrence of such mating patterns. Thus far, only few studies have addressed the influence of ecological differences between populations on mating patterns and the involved sexual conflict. The aim of our study was to understand potential selective drivers of polygynous mating patterns in a cooperative breeder. We monitored social systems in 8 populations of the facultatively polygynous cichlid fish *Neolamprologus pulcher*. Our results indicate that low levels of predation risk and close neighbour distances facilitate the monopolization of more than one female by a male, thereby leading to higher rates of polygyny. Large, high quality females respond to higher risk of polygyny by avoiding territories near neighbours. Furthermore, females sharing their mate with others reduce their investment in territory defence against predators, which is neither compensated by helpers nor by dominant males. Thus, females decrease the risk of being paired to a polygynous male, but potentially increase the risk of predation due to reduced shared defence. Our study highlights the importance of ecological factors on the mating pattern of cooperative breeders and provides evidence that females adjust their behaviour by increasing the costs of males depending on their degree of polygyny.

## Macroecology of reef fish aggression

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Behaviour has traditionally been explored in depth at small spatial scales. Yet it is becoming increasingly clear that behaviour is a critical component of ecological patterns and processes at larger spatial scales, determining macroecological patterns such as species abundance, distribution, and co-existence. In the current era of global change, behavioural flexibility can provide an important buffer against negative effects of changing environmental conditions, buying time for species to develop longer-term evolutionary solutions or to await ecosystem recovery following pulse disturbances. Therefore, combining behavioural ecology with that at larger spatial scales is essential to enable us to incorporate behaviour explicitly into predictions of species responses to global change. Here, I present an example of this approach using observed changes in coral reef fish aggression and feeding behaviour across a broad geographical extent from Japan to Australia in response to mass coral bleaching events. Probability of aggression decreased significantly following the 2016 mass coral bleaching event. Shifts in diet from prey with high nutritional value, which are disproportionately affected by the bleaching, to those with lower value suggests this drop in aggression could be the result of nutritional deficit leading to the cost of aggression outweighing any benefits.

## Social partner preference for communal nursing in house mice – the role of oxytocin

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Female house mice (*Mus musculus domesticus*) are selective in social partner choice for communally nursing litters. Oxytocin (OT) has been implicated in the facilitation of social and cooperative behaviour, either increasing positive and cooperative social interactions, or facilitating bond formation. We administered OT to pairs of unfamiliar females (controls were saline-treated), which did not significantly affect the socio-positive and socio-negative behaviours between females during the three initial cohabitation days. We subsequently tested for the formation of a social preference. Contrary to expectation, control but not OT females demonstrated a significant preference for their cohabitation partner. In a follow-up experiment we investigated whether OT affects the propensity of females to cooperate. OT did not affect the females' ability to reproduce. However, OT treated females took significantly longer to establish a successful communal litter than control females, due to higher pup mortality and loss of first-born litters in the OT group. We conclude that administration of exogenous OT during the early stages of the female relationship hinders the formation of a preference for this new partner and delays the tendency to affiliate and cooperate in the formation of a communal litter. Our study does not support the hypothesis that OT acts to facilitate familiarization, and suggests that when administered in house mice during early social interactions with a stranger OT even delays cooperation with that partner. We hypothesize that increased circulating OT levels are not the cause but the consequence of interacting with preferred social partners.

**Olfactory training in mice.****A. Kokocińska-Kusiak<sup>1</sup>; T. Jezierski**

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Pathological processes involve production of either new volatile organic compounds (VOCs), that were not present in healthy individuals, or changes in the proportion of particular VOCs. VOCs produced during disease circulate with blood and are excreted with breath, urine, sweat, saliva, vaginal secretion or faeces. Odour from sick conspecifics usually evokes an avoidance response in odour-recipients. Due to the ability to recognize odour associated with infection and sickness, animals can reduce the risk of contagion (Thomas et al. 2005; Arakawa et al. 2009). Trained mice have been shown capable to distinguish urinary odours from conspecifics with and without experimentally induced cancer, for example lung cancer tumors (Matsumura et al. 2010), but the process of training is very complicated and hard. In this research we trained mice to distinguish melanoma and healthy samples by odour. The methodology of mice handling before, during and after training was developed. An effective training methodology to show the samples with melanoma has been developed. The training was considered completed when the mice indicated at least 83% of the correct answers in the last test (6 trials). During the training the arrangement of samples (healthy-(a) and unhealthy-(c)) was random. Before training mice show the samples with melanoma in 47,92% , and without melanoma in 52,08%. After training mice chose sample with melanoma in 86,67% (samples without melanoma- 9,17%, no choice- 4,17%). Chance of mice indications of urine samples from mice with tumour is 91% higher after training than mice indications before training.

**Correlated changes in behavior and cognition during artificial selection on schooling behavior in the guppy****N. Kolm**

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Selection on behavior is expected to affect many aspects of an organism. For instance, social behavior is expected to be tightly linked to brain anatomy and function, but the direction of this association is not straight forward. In primates, living in larger groups has been suggested to lead to larger brains and higher overall cognitive ability. In eusocial insects, group living has instead been suggested to lead to division of cognitive tasks and reduced individual cognitive ability. Here we test how selection on schooling behavior affects a suite of other behavioral and life history traits in the guppy (*Poecilia reticulata*). After three generations of selection on polarization, the tendency to swim in the same direction as your school mates, we have assayed several aspects of behavior and cognition between selected lines and control lines. We find that the polarization selected lines school more tightly and move in a more coordinated fashion. We also report on the response to a predator model and on individual performance of the selection lines in reversal learning cognitive tests and offspring number. Our results show that selection on schooling behavior affects a number of important fitness related traits in the guppy.

## Flexibility of social networks in zoo chimpanzees

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Within stable groups animals are part of a network of dynamic inter-individual interactions. Network dynamics are not well understood and little is known about the influence of social or ecological change on individuals' social positions. Here I investigated the impact of social change on individual grooming network positions in a group of zoo chimpanzees. The social change was a gradual change in the alpha male that began at the start of the study and lasted two and a half years. Data on grooming partners were collected using instantaneous scan sampling. I identified three periods of varying stability in the male hierarchy, extracting a three-month subset of data from each period: (1) unstable with no clear alpha male; (2) recently stable with the new alpha male in position for one month; and (3) stable, when the new alpha male had been in position for two years. I created weighted and unweighted grooming networks analysing changes in degree, eigenvector and betweenness centrality using repeated measures ANOVA with bootstrapped p values. Stability in the male hierarchy affected network metrics (degree only) for females but not males. Both weighted indegree (grooming received) and outdegree (grooming given) were significantly higher for females in the stable period compared to the unstable or recently stable periods. The same was true for unweighted degree in females. Thus females were better connected within their grooming networks in the stable period. The findings are consistent with the view that female chimpanzees exhibit greater flexibility in their social strategies than males.

## From genotype to phenotype: influence of the gut microbiota in Japanese quails (*Coturnix japonica*)

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Gut microbiota (GM) manipulation is an emerging approach for studying animal behaviour and its underlying mechanisms. The aim of our study was to test the hypothesis that the GM of the Japanese quail can influence its behavioural phenotype. In a first experiment, we compared the behavioural responses of 36 germ-free quails (devoid of GM) of a line genetically selected for its high emotionality trait (E+ line) and 36 germ-free quails of this same line colonised at birth with GM from the E+ line. Results showed that compared to colonised quails, the germ-free quails had a lower tonic immobility duration and traveled a smaller distance during the social isolation test, suggesting that the absence of GM reduces emotional reactivity of the quails. In a second experiment, we hypothesised that the GM of a quail line with a low emotionality trait (E- line) would reduce emotional reactivity of the E+ line. After hatching in germ-free conditions, chicks of the E+ line were distributed in two isolators and inoculated at Day 1 with the GM of quails of their line (group E+ / GM+) or with the GM of the line with a low emotionality trait (group E+ / GM-). Tonic immobility duration of the group E+ / GM- was lower than that of the group E+ / GM+ at Day 15. In conclusion, the absence of GM or the colonisation with a foreign GM are able to influence the development of relevant behaviours of the host in birds.

**Cellular composition and processing capacity of reptile brains in comparison with other amniotes**

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Reptiles account for almost one third of extant amniotes and interest in their cognitive abilities is growing. However, little quantitative data is available on reptile brains, although needed to shed light on amniote brain evolution and to put behavioural data in the context of underlying neural substrates. We processed 30 brains of squamates and turtles using the isotropic fractionator, estimating the numbers of neurons and glia in whole brains and six brain parts, including the olfactory bulbs, cerebral hemispheres, diencephalon, tectum, cerebellum, and brainstem. At a comparable size, reptile brains contain 3.5-8 times fewer neurons than those of other amniotes, while the number of other cells remains similar. It is therefore likely that birds and mammals independently increased their neuronal densities. Reptiles seem to be constrained by the metabolic cost of brain tissue, which scales linearly with the number of neurons. The telencephalon harbours 21-45% of brain neurons, which is similar to gallinaceous birds and pigeons (23-32%), but higher on average than in mammalian cortex (10-32%). While this is not directly comparable, low percentage of brain neurons in the telencephalon seems to be a derived characteristic of mammalian brains, connected to the expansion of the cerebellum. Cerebellar neurons outnumber telencephalic neurons only in some turtles and crocodiles. Since this condition is also found in basal birds, it points to an evolutionary trend of increasing cerebellar neuronal fraction in *Archelosauria*. Neuronal distribution furthermore reflects sensory specializations of different species, and the complete dataset will allow for testing of specific evolutionary hypotheses.

**Losing the ability to learn: evolution of song learning in island populations of chaffinches**

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In many species of songbirds, precise song-learning leads to stable, long-lasting cultural traditions. But in others, songs are not learned precisely at all, with errors, improvisations and innovations occurring in each learned song. Such diversity in learning styles can provide valuable comparative data about the evolution of precise cultural transmission, but as yet this has not been exploited. In this study, we addressed this by comparing the precision of song learning in mainland and 5 genetically isolated Atlantic Island populations of common chaffinches (*Fringilla coelebs*) and in the island endemic blue chaffinch (*F. teydea*). To make quantitative estimates of learning precision, we first recorded the song repertoires of more than 700 adult chaffinches across the six populations. We compared song syllables and songs using an implementation of the dynamic time warping algorithm. We then developed cultural evolutionary simulations of song learning for each population, and fit them to the field data using Approximate Bayesian Computation. We found that fitted models in mainland European coelebs populations and in teydea had an estimated cultural mutation rate of  $<0.01$ , at least 10 times lower than any of the island coelebs populations. The island coelebs populations, which were colonized from the mainland and which are the most evolutionarily derived populations thus appear to have lost the ability to learn song precisely. I discuss this in light of proposed communicative functions of precise learning.

### **Snakes as emotionally salient stimuli for humans: Fear and disgust emotions evoked by snakes**

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Snakes are ancestrally prioritized stimuli that preferentially attract human attention and evoke fear due to the past risks they pose to us. Some snakes also elicit not only fear, but also disgust. We tested the subjectively perceived level of fear and disgust elicited by 80 pictures of snake species and tested the associations with scores on self-report questionnaires measuring snake fear (SNAQ) or disgust propensity (DS-R). For some snakes, we measured physiological fear and disgust correlates as triggered by pictures presented to respondents individually or in a block design. Results from cluster analysis demonstrate that people perceive fear- and disgust-evoking snakes as two distinct stimulus groups. Analysis of morphological traits of snakes revealed that fear is mostly triggered by viper and rattlesnake body form, while disgust is mainly associated with subterranean snakes with a worm-like body shape. The physiological parameters (changes in skin conductance) in a reaction to fear-evoking snakes are repeatable despite the different style of stimuli presentation (individually vs. block), but reaction to disgusting snakes is not. Subjective evaluations according to the given emotion are positively correlated with scores on the SNAQ and less on the DS-R. People are subjectively aware of the two emotions, although only the physiological reaction to fearful snakes was repeatable. This is in accordance with the hypothesis of snakes as prototypical stimuli for activation of fear module. Only certain morphotypes of snakes serve as a specific prototypical stimulus though, which raise further reflections on the co-evolution of some snake taxa and mankind.

### **The developmental and social drivers of behavioural individuality in a clonal fish**

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Individual behavioral variation is ubiquitous across the animal kingdom. The presence of this variation has shifted the focus in behavioral and evolutionary ecology from one of trait means to one of trait variances. Classic quantitative genetics predicts that such phenotypic variation, including behavioral variation, should arise as a result of variation in genetics and the environment. However, here I show results that challenge this classic paradigm: considerable individual behavioral variation develops even among genetically identical clonal fish raised under identical conditions. This suggests that the traditional theory explaining the presence of individual phenotypic variation is limited by only focusing on what generates this variation but not how. Using the clonal fish, the Amazon molly, I explore how early life experiences, in particular social experiences can generate feedback mechanisms that ultimately drive the emergence of behavioral individuality even among otherwise identical animals. Such developmental processes provide a potentially general mechanism to explain the widespread presence of such incredible behavioral diversity we see in the world.



### **Bumblebees distinguish floral scent patterns, and can transfer these to visual patterns**

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Flowers act as multisensory billboards, guiding the pollinator to the flower using visual patterns, heat, electrical interactions, tactile surfaces, humidity patterns and scent. Floral scents are composed of a huge variety of differing volatile compounds, and different organs within the same flower may release differing compositions and quantities of these volatiles. Early experiments showed that pollinators may be able to distinguish between the scents of differing regions of the same flower, but little is known of the effects that these potential patterns of scent have upon the behaviour of a pollinator visiting the flower. Here, we show that bumblebees can learn to discriminate between flowers with different spatial patterns of the same scent, that they are better at learning to distinguish between flowers when the scent pattern corresponds to a matching visual pattern, and, most surprisingly, that once bees have learnt the spatial arrangement of a scent pattern, they then prefer to visit novel unscented flowers that have an identical visual arrangement of marks. Mismatching scent and visual patterns reduce learning speed, suggesting that the arrangement of olfactory signals within flowers could yield new insights into plant-pollinator interactions, and the transfer of a learnt pattern across sensory modalities suggests that these multimodal floral signals may exploit the mechanisms by which learnt information is stored by the bee.

### **Cultural evolution and artificial dialects in zebra finches (*Taeniopygia guttata*)**

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Vocal learning allows oscine songbirds to differentiate from one another, especially with inter-individual variability in the song, but it can also lead to an entirely or partially shared vocal repertoire between individuals. This can lead to the establishment of geographical variations in song, called dialects. In wild and domesticated populations of zebra finches, only very weak populational song variations have been found. In the wild, frequent dispersal and exchanges between groups of birds probably prevent the formation of local song dialects. Moreover, frequent learning errors could favour within-population variability in the field and the laboratory. In most studies, song analysis focuses on the constitutive structure of the zebra finch song: the motif, defined as a short and stereotyped sequence of sounds called syllables. However, the zebra finch song is produced in bouts; each bout is formed by introductory syllables, followed by one or several motifs, sometimes separated by other syllables. Here, we studied cultural evolution of song in the laboratory, in three different colonies, founded by males originally trained to produce the same song motif. We observed that despite some copy errors, most of the males produce a rather similar version of the original song model. We also noticed a high inter-individual variability in the bout structure. Our results show that it is possible to create artificial dialects in the laboratory and that the information provided by the song bout has been underestimated in studies on the Zebra Finch song, a reference model to study neuro-ethological aspects of vocal learning.

### Feeling lucky? Dairy calves don't like to gamble when in pain

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Judgment bias testing uses responses to ambiguous stimuli to infer emotional states in animals. However, with multiple exposures animals can learn to recognize test stimuli, rendering the test less effective. In this study, we have attempted to avoid this problem by training calves (n=8) in a spatial discrimination task to associate 5 locations with a specific probability of reward/punishment (Reward: 100%/0%; Near-Reward: 75%/25%; Middle: 50%/50%; Near-Punishment: 25%/75%; Punishment: 0%/100%). As intended, at the end of the training period calves showed a gradual increase in latency as the risk of punishment increased (Curvilinear model:  $P < 0.001$ ). To validate that the methodology was able to detect changes in mood, we subjected animals to hot-iron disbudding, a routine procedure on dairy farms. On our research farm the acute pain is mitigated using sedation and local anesthesia, but calves still experience post-operative pain in the hours following the procedure. As expected, calves showed an increased latency to approach intermediate probe locations (consistent with a pessimistic judgement bias) 6 hours after disbudding (Fisher-Pitman permutation tests;  $P < 0.01$ ). In addition, the latency to reach the rewarded location also increased ( $P < 0.01$ ) indicating a decreased motivation to consume the reward. We conclude that pain associated with dehorning might trigger both pessimism and anhedonia in dairy calves.

### How to measure individual identity in animal signals

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Acoustic individual identity signals have been studied for over 50 years but there is no consensus as to how to quantify individuality. While there are a variety of different metrics to quantify individual identity, or individuality, these methods remain un-validated and their relationships unclear. We contrasted three univariate and four multivariate metrics (and their different computational variants) and evaluated their performance on simulated and empirical datasets. Of the metrics examined, Beecher's information statistic was the best one and could easily and reliably be converted into the commonly used discrimination score (and vice versa) when accounting for number of individuals and calls per individuals in the dataset. Although Beecher's information statistic is not entirely independent of sampling parameters, this problem can be removed by reducing the number of parameters or increasing the number of individuals. Because it is easily calculated, its superior performance, it can be used to describe single acoustic variables and multiple variables, and because it tells us the maximum number of individuals that can be discriminated given a set of measurements, we recommend that Beecher's information statistic is preferred over other existing metrics to quantify individuality.

### **Characterizing functional consequences of the Ruff inversion: tissue-specific gene expression across three genetically determined male morphs**

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Structural variants, such as inversions, provide genomic substrate for phenotypic diversity to arise. Examining how these variants impact gene expression is important for identifying the proximate mechanisms underlying phenotypic variation at the level of behavior and physiology. In the Ruff *Philomachus pugnax* the evolution of a balanced mating polymorphism is facilitated by a large autosomal inversion. Three male reproductive morphs can be easily distinguished during the breeding season based on discrete variation in plumage and behavior. Most male Ruffs typically compete aggressively for females on leks and are called Independents. An autosomal inversion that arose about 4 MYA created the Faeder morph, a sneaker female mimic. Through a rare recombination event between inverted Faeder and ancestral Independent alleles a third morph, Satellite, arose 0.5 MYA. Satellite males therefore have genomic and phenotypic features of both Faeders and Independents. I will present ongoing work that details how gene expression differs across morphs in liver, gonads and adrenal glands for genes within the inversion as well as outside the inversion. As predicted, we found profound differences in gene expression across morphs and the magnitude of these differences varied across tissues and genes. Contrary to our expectations, patterns of gene expression in inversion morphs did not appear to be influenced by gene location or degree of sequence similarity. Altogether, this work will contribute to our understanding of how gene expression varies as a consequence of inversions and how complex traits, including behavioral differences, can evolve from inversions.

### **Repeated disturbances affect the social dynamics of group behaviour in a colonial bird**

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Group stability is often associated with the evolution of complex behaviours. However, whether complex behaviours are robust to periods of social instability, such as when groups split and recombine, is virtually unknown. Disruption events can affect the patterns of social interactions, and thus generate a cost if changes in social interactions affect group-level outcomes. We experimentally split replicated groups of zebra finches (*Taeniopygia guttata*) that had lived in stable colonies, and quantified the effects of social instability on social organisation and group-level performance (foraging efficiency). We found that the disruptive events affected the social organisation of the colonies. The average group size while foraging was smaller after the splitting events and the social network structure of the colonies changed relative with the pre-treatment period. Changes resulting from splitting events subsequently reduced the efficiency of groups at foraging on ephemeral resources. Our results show that single a disruptive event can impact group performance and social dynamics, and that repeated periods of social instability can cause long-lasting effects. By quantifying group-level costs of social instability, we have identified that extrinsic disturbances are a potential limiting factor for the expression of complex social behaviours, and thus the resilience, of stable animal societies.

## **Integrative biology: a critical step forward to unravel the molecular mechanisms generating behavioural plasticity**

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Phenotypic plasticity can be broadly defined as the capacity of a genotype to diversify the individual's phenotype in response to different environmental contexts. It includes a large diversity of kinds of variability that living organisms can show during their lifetime course, such as the environmentally-dependent responses to early life stressors that alter developmental trajectories to the rapid reversible morphological, behavioural and physiological switches that become operational during specific life history stages such as migration and reproduction. The study of the differing forms of phenotypic plasticity is of central importance for behavioural and evolutionary biologists as it is thought to be one of the most compelling promoter of adaptation to environmental heterogeneity. However, the proximate mechanisms driving such ubiquitous phenomenon remain elusive. In this talk, we aim to give an overview of the main emerging molecular approaches and techniques that could dramatically advance our broader understanding of phenotypic plasticity. Specifically we will focus on recent studies that have employed a range of novel approaches in a variety of model and non-model organisms, such as transcriptome profiling, epigenomics, and imagine techniques. Finally we will propose potential ways to integrate information from these techniques in order to enhance our understanding of the different mechanisms through which plastic changes may have evolved.

## **Prosociality enhances dyadic cooperation in common marmosets (*Callithrix jacchus*)**

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The evolution of prosocial preferences has been hypothesized to facilitate the initiation and maintenance of cooperation, including the emergence of social systems reliant upon costly forms of proactive helping behavior. This hypothesis has been indirectly supported by research demonstrating the importance of sensitivity toward signs of need in eliciting reactive helping behavior, as well as higher degrees of proactive prosocial motivation in species exhibiting more frequent allomaternal care. Currently, however, direct evidence that prosocial motivation enhances cooperative behavior is lacking in non-human animals. To test this hypothesis, we experimentally investigated the association between prosocial motivation and cooperative behavior in common marmosets (*Callithrix jacchus*; n = 21), as assessed by previously validated group service and loose string paradigms. Given that this cooperatively breeding species has been found to exhibit relatively high degrees of proactive prosocial behavior, we expected that more prosocial individuals would also achieve higher rates of dyadic cooperation. Consistent with our predictions, prosocial dyads were found to more successfully cooperate than dyads without a prosocial partner. In particular, our Bayesian multilevel model suggests that dyads containing a prosocial partner are expected to have on average 2.2 times higher odds of successful cooperation, with a 0.95 posterior probability of a positive effect. These results provide experimental evidence that prosocial motivation enhances cooperation in non-human animals, supporting the broader claim that prosocial preferences are likely to evolve in response to selection for highly cooperative social interactions.

### **Individual variation in cognitive styles is reflected in foraging and anti-predatory strategies in a small mammal.**

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Balancing foraging gain and predation risk is one of the most fundamental trade-offs in the life of animals. Among-individual variation in cognition might affect how individuals balance these conflicting necessities, but the processes underlying individual differences are still unclear. Here we empirically assessed consequences of cognitive styles for fitness-determining behaviours, such as foraging and risk-taking behaviour, using a semi-natural setting. We initially assessed bank voles (*Myodes glareolus*) for associative learning speed and flexibility. We then exposed 21 fast/inflexible learners and 18 slow/flexible learners to enclosed landscapes with different risk levels at two food patches. We quantified foraging behaviour, individual giving-up densities for food (a measure for perceived predation risk), and vigilance behaviour, which in a species with high predation pressure directly relate to fitness. Fast learners consumed up to 20% more food than slow learners in the high-risk area, increasingly exploited both food patches, and spent up to 75% of their visit foraging. Slow learners progressively avoided the high-risk area and spent approximately 50% of their visit exercising vigilance even in the low-risk area. Our results indicate that among-individual differences in risk-reward bias related to cognitive styles are indeed reflected in different foraging and anti-predator strategies, providing insights into fitness consequences and differential selection pressures based on individual differences in cognition.

### **Does habitat use influence social behaviour and cognition in marine cleaning gobies?**

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There is evidence that variation in the complexity of both the ecological and social environment may influence the cognitive performance of individuals. The facultative cleaning goby species *Elacatinus prochilos* appears to provide an ideal system to study such environmental effects on individual cognitive performance. In this species, sponge-dwellers live in large groups and hardly clean other reef fishes, while individuals living openly on reef substrate live in small groups (often pairs) and obtain most of their food from cleaning interactions. We conducted two paired-choice experiments in which gobies had to identify and seek a food-providing plate either due to its pattern or due to its location in the aquarium. We predicted the former to be more ecologically relevant to cleaners (as client patterns may indicate their food value) and the latter to be more relevant for sponge-dwellers (finding food locations in a 3-dimensional space). Contrary to our expectations, both cleaners and sponge-dwellers largely failed in the cue task and performed similarly well in the spatial task, including reversal learning of the rewarding location. In line with these results, additional laboratory observations indicate that gobies are very similar in both intraspecific social behavior and interspecific cleaning behavior, independently of the habitat they live in. This might explain why they have similar performance in both tasks. Finally, *E. prochilos* have less frequent and less complex cleaning interactions with their clients compared to cleaner wrasse of the genus *Labroides*, which might explain why the gobies performed poorly in the cue task.

## The Comparative Neurobiology of Gentle Touch: From Lowly Worm to Social Man

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Mechanotransduction (touch) provides the basis for many biological processes critical for survival. Building on research into this modality in relatively simple organisms such as *C. elegans*, through insects (ant and the locust), out to mammals (rat, monkey and human) a case will be made for the role of a particular type of touch neurone in the evolution of the human social brain. The growth of preterm and institutionalised infants is compromised due to a lack of nurturing touch – over above nutrient requirements being fulfilled. This impact of isolation on development is seen in *C. elegans* which grows to its normal adult length when in a colony, but in isolation its growth is stunted. This worm has 302 neurones, 6 respond to gentle touch. The solitary grasshopper is transformed into a gregarious locust by gentle touch to its body, a stimulus that is also correlated with a 3-fold rise in serotonin. (In humans we see a similar ‘phenotypic switch’ to gregariousness with the use of MDMA.) An ant deposited into a rival colony will appease its aggressor by gently stroking the combatant’s antenna. Physical stimulation by the cleaner wrasse reduces stress in surgeon fish. Pups from low licking grooming mothers grow up to be anxious adults – an epigenetic mechanism drives this outcome and gentle touch is the stimulus. Harlow’s infant monkeys, deprived at birth from maternal care, seek the comfort of a soft surrogate. And ultimately it is proposed that the human social brain is shaped by gentle touch.

## Fear or food: what is driving the formation of mixed species groups?

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Living in mixed-species groups can provide essential survival benefits by increasing predator detection and dilution benefits. However, so far little is known about the principles that determine which species group together and why. Morphological, behavioural and ecological characteristics are likely to determine the social compatibility between species. For instance, dilution benefits are expected to vary substantially between species, depending on predator overlap and the relative vulnerability of species to shared predators. Accordingly, marked asymmetries are expected in the payoffs that individuals of different species gain from forming groups with each other. To understand which species characteristics facilitate the formation of MSGs, we conducted a community-wide study on African savanna herbivores, assessing the relative importance of predator detection, dilution and resource competition on social affinities between species. To quantify association between species pairs we developed a new association index that considers the group sizes as well as the proportion of heterospecific individuals in each group. Using a multi-layered network approach we compared the association index to species-specific attributes, thus unravelling the relative importance of predator avoidance in comparison to resource competition. Such information is crucial to understand the importance of interspecific interactions as they may affect the resilience of ecosystem to environmental perturbations.

### **Hormonal and behavioural responses of coral reef organisms to anthropogenic stressors**

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Organisms can behaviourally, physiologically and morphologically adjust to environmental stressors via the neuroendocrine system enabling rapid individual phenotypic adjustments to maximize survival, and ultimately allowing animals to cope with environmental change. However, the stress response to environmental changes commonly promotes survival at the expense of reproduction. Here, we report the endocrine and fitness responses of individual coral reef fish to a range of environmental perturbations: a recent large-scale sea-warming event that caused worldwide bleaching on coral reefs; motorboat noise, a global pollutant; and artificial light at night. We report the pathway of effects from the endocrine response, steroid hormones, behaviours, physiology, to reproduction and fitness consequences. Physiological stress responses could play a vital role in changes in population demography following such environmental perturbations. Plasticity in such endocrine responsiveness may therefore be a key mechanism enabling individual acclimation to environmental change.

### **Effects of dietary fatty acids on cortisol secretion, postnatal development and social behaviour in guinea pigs – TALK CANCELLED**

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Early developmental processes are highly sensitive to hypothalamic-pituitary-adrenal (HPA)-axis activities and related glucocorticoid secretion. Dietary polyunsaturated (PUFA) and saturated (SFA) fatty acids could play a major role in this context because PUFAs positively affect HPA-axis functions while SFAs may have opposite effects. We investigated the effects of dietary SFAs and PUFAs on postnatal development and social behaviour in guinea pigs. We compared juveniles supplemented with either SFAs or PUFAs and individuals maintained on a control diet. Saliva cortisol concentrations, body mass gain, structural growth rates and, in males, testes width and testosterone secretion were monitored for 120d. Social interactions in the groups and during confrontations with unfamiliar individuals were recorded. The tests were repeated at an age of 6-7 months to investigate the persistence of adrenal activity and social behaviour during adulthood. The results revealed positive effects of PUFAs on body mass gain and social behaviour in males, while SFAs led to elevated cortisol concentrations, accelerated testes maturation but limited mass gain and lower first-year survival rates. The developmental differences were reflected in highly increased conflict rates and instable dominance hierarchies in SFA males, while PUFA males outperformed the other groups during social confrontations. In females, however, no diet-related effects were detected. The results highlight the potential of dietary PUFAs and SFAs to modulate postnatal developmental patterns in relation to cortisol secretion thereby affecting behavioural phenotypes in males. The absence of these effects in females demonstrate the sex-specific impact of dietary PUFA and SFA intake in guinea pigs

### Multi-level gorilla society

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Modern human societies have a complex, hierarchical structure in which lower order units like nuclear families are nested inside ever larger units up to the level of nations and multi-national alliances. It has been argued that this multi-level structure evolved independently and after the chimpanzee-human split due to greater recognition of, and bonding between, dispersed kin. We used network analysis and hierarchical clustering to quantify community structure within western lowland gorilla populations visiting two forest clearings in Republic of Congo. In both populations, we detected previously unquantified grades of post-dispersal association amongst gorilla groups and solitary males. In one population, these grades of social association were well predicted by genetic relatedness. Using gorilla movement patterns, reconstructed from camera trap data, we then investigated this social structure across gorilla ranges, assessing its potential effect on territoriality and cooperation, and its possible consequences for disease transmission. Our results indicate that the multi-level social organization observed in humans is likely to have evolved far earlier than previously asserted and highlight the importance of gorillas as a model system for human evolution.

### Closing the can of worms - disentangling risk and protective factors for gastrointestinal parasite infections in a nonhuman primate

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Parasite infections are ubiquitous throughout the animal kingdom and their capacity to impact health and fitness are well studied. While both exposure and susceptibility are known to contribute to parasite transmission and infection risk, both are rarely studied in combination. In this study we aimed at obtaining a comprehensive picture on the factors driving strongyle nematode infections in Barbary macaques (*Macaca sylvanus*), utilizing experimental anthelmintic treatment to study predictors of reinfection after parasite clearance in 57 individuals. Using a combination of faecal egg counts and patch occupancy modelling to measure reinfection, we assessed the roles of animal behaviour (social bonds, grooming networks and ground use) and physiology (faecal glucocorticoids, urinary c-peptides and neopterin, coinfection with gastrointestinal helminths) for transmission. We used information criterion-based model selection to determine the best models predicting reinfection patterns and found that coinfection with GI helminths was the strongest risk factor, whereas a strong social bond with opposite sex partners decreased the likelihood of reinfections. Our results also suggest both environmental and social components of parasite transmission, as time spent on contaminated soil and a higher number of grooming partners both tended to increase reinfection risk, whereas we found no evidence for a role of faecal glucocorticoids. Studying the effects of both exposure and susceptibility simultaneously, we not only add causal information to the current knowledge on the parasite-behaviour-physiology link, but also take a step towards assessing the relative effects of behaviour and physiology on gastrointestinal helminth infection risk.



### **Individual flexibility in group foraging behaviour of Reef Manta Rays (*Mobula alfredi*)**

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In spatially and temporally dynamic environments, animals need to vary their foraging strategies to optimise effort and reduce metabolic costs. Group foraging should be beneficial to increase efficiency of exploitation, but may be costly in terms of intra-specific competition particularly at low prey abundances. This cost-benefit trade-off will vary dynamically within and among individuals. Reef manta rays are large filter-feeding elasmobranchs which feed in aggregations on ephemeral upwellings of plankton. Within aggregations, individuals fed either solo or in groups, forming feeding chains with a clear leader and on average one follower. We filmed 881 foraging events involving 200+ individually identifiable manta rays over three years in the Maldives. Our study investigated whether various biotic and abiotic factors affected individual foraging strategies. Manta rays were significantly more likely to forage in groups than solo at high zooplankton levels, and at certain locations. Within groups, manta rays foraged in larger groups when more food was available and when the overall aggregation was relatively small. Both biotic and abiotic factors contributed to variation in group foraging. However, we found little evidence of among-individual differences in group foraging. For all traits, residual within-individual variance explained over 55% of the variance. Our results indicate that individual manta rays cannot be classified into personality types for group foraging and instead each individual is capable of considerable behavioural flexibility.

### **Reshaping of neuroendocrine profiles beyond adolescence**

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Phenotypic plasticity describes the ability of individuals to change phenotypic traits in response to the environment. After focusing on pre- and postnatal development as sensitive phases, recently adolescence has been identified as another time window for adjustment of the phenotype in mammals. In a previous study, male guinea pigs kept at low and high individual numbers during adolescence were found to develop two different neuroendocrine profiles. These profiles further built the basis for two completely different adaptive behavioural strategies. The aim of the present study was to investigate, whether these neuroendocrine profiles can be reshaped after transfer to another social environment in adulthood. To test this, after weaning male guinea pigs were either kept in heterosexual pairs (P) or in large mixed-sex colonies (C). At 240 days of age, neuroendocrine profiles were assessed including testosterone levels and cortisol responsiveness to novelty. Within one week after testing, males of both conditions were individually placed into heterosexual pairs with an unfamiliar female. One month later, hormonal measures were taken again. The major findings were that before transfer, P-males were shaped for low testosterone levels and high cortisol responsiveness, whereas C-males showed the opposite pattern: high testosterone levels and low cortisol responsiveness. After transfer to a P-situation in adulthood, neuroendocrine profiles of C-males were reshaped towards low testosterone levels and high cortisol responsiveness, whereas P-males maintained their original profile. The present study clearly shows that neuroendocrine profiles can still be reshaped beyond adolescence, most likely in an adaptive way.

## Division of Labour in Cooperative Breeders

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Reciprocal altruism can explain cooperation between unrelated individuals, but hitherto division of labour in highly social animals has been investigated primarily for groups of relatives. In cooperatively breeding cichlids, unrelated subordinates trade alloparental care for the right to stay in the territory of dominants, and such groups may exhibit division of labour reminiscent of eusocial insects. We investigated division of labour between unrelated group members in the cooperatively breeding cichlid *Neolamprologus pulcher* and asked whether same or different commodities may be exchanged reciprocally among unrelated social partners. We experimentally engineered the ability of subordinates to contribute to alloparental care by manipulating two helping behaviours independently from one another in a full factorial design, and we recorded the effects of this manipulation on the reciprocal exchange among the involved social partners. We found that shelter maintenance and defence behaviours were regulated completely independently from one another. After being prevented from defending the territory against a predator, helpers doubled their defence effort as if making up for the experimentally induced debt. After being prevented from maintaining the territory, helpers doubled the frequency of submissive displays instead of increasing their helping behaviour. Contrary to the predictions of commodity trading, preventing one helping behaviour had no effect on the effort of showing the other helping behaviour, but it affected alternative behaviours (submission) suited to reduce dominants' aggression. This is consistent with the pay-to-stay scenario demonstrated in this species, and it implies that different helping behaviours in these cichlids may not share the same regulatory mechanisms, but are governed by rather independent decision rules.

## Neuronal Numbers in Avian Pallium: Implications for Evolution of Bird Intelligence

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Using the isotropic fractionator, we determined numbers of neurons and glial cells in major brain divisions in 115 bird species representing ten avian orders. This unique data set allowed us to establish and compare cellular scaling rules among major bird clades and between birds and mammals. Brains of birds belonging to distantly related clades differ in relative structure sizes, neuronal densities, neuronal numbers and allocation of neurons into brain compartments. While the relative proportions of major brain structures seem to reflect behavioural and perceptual specializations, neuronal scaling rules are rather conservative and strongly phylogeny-dependent. Songbirds, parrots and owls share high neuronal densities and disproportionately large numbers of neurons in the pallial telencephalon. In contrast, birds representing basal lineages, such as paleognathous and galliform birds, have lower neuronal densities, a proportionally smaller telencephalon, small telencephalic and dominant cerebellar neuronal fraction. Brains of birds situated phylogenetically in between these two groups, such as pigeons or birds of prey, exhibit intermediate characteristics. Compared to mammals, avian brains are built in a more economical, spatially efficient way; even the lowest neuronal densities observed in brains of basal birds are equal to or higher than the highest densities found in homologous brain regions in mammalian species investigated so far. Songbirds and parrots feature extremely high neuronal densities and have a high proportion of neurons allocated in the pallial forebrain. In fact, numbers of pallial neurons in large-brained parrots and songbirds (especially corvids) equal or exceed those found in primates with much larger brains.

### **Smelling the bun in the oven: Pregnancy is detected by odour in a wild cooperative breeder**

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Among mammals, scent has long been known to encode sexual receptivity (i.e. oestrus); however, few studies have addressed the possibility that pregnancy may be detectable via scent. Through odour presentation experiments on a wild population of cooperatively breeding banded mongoose, *Mungos mungo*, we show that pregnancy is discernible via scent by both sexes. Males spent more time investigating and were more likely to scent mark the odours of non-pregnant females, compared to pregnant females. Females showed increased levels of scent marking when odours were of the same reproductive state as themselves. These results present the first direct demonstration that pregnancy is detectable via scent in wild mammals. Detecting pregnancy may be particularly important in cooperative breeders as, in addition to the competition between males for receptive mates, there is also intense competition between females for access to alloparental care. Consequently, dominant females benefit from targeting reproductive suppression towards subordinates that represent direct threats, such as pregnant females.

### **Effects of progressing age on social selectivity and behavioural predictability in Barbary macaques**

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With progressing age, humans reduce their social activity and become increasingly selective in their partner choice biasing social interactions towards more valuable partners. This social selectivity has been attributed to the human awareness of limited remaining time, as one grows older. Studies on nonhuman primates that lack this awareness provide comparative insights into the effects of age on sociality. We studied 2 groups of Barbary macaques (*Macaca sylvanus*) at “Affenberg Salem”, Germany, comprising a total of 77 adult individuals ranging in age from 5 to 29 years and recorded data on social interactions using focal animal observation (3,245 focal hours). Preliminary analyses indicate that with progressing age females have a decreasing number of grooming partners and increasingly focus on fewer, specific partners, whereas this pattern is absent or less pronounced in males. Further analyses will focus on the directionality of social interactions (grooming given vs. received, approach vs. depart) and the predictability in social interactions (in response to own preceding behaviour (intra-predictability) and to the partner’s preceding behaviour (inter-predictability)). These data will contribute in clarifying, (i) whether aging individuals actively withdraw from social interactions or are being isolated by others, and (ii) whether a declining ability to predictably interact with others may explain part of the observed decline in social activity.

## Do dolphin whistles carry information about species identity?

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Acoustic signals play a function in species recognition in many taxa. Species recognition requires stability in at least some acoustic features, which raises questions for species with high vocal flexibility. Sound is the primary communication modality for dolphins and so it has been hypothesized that these animals use their whistles to communicate species identity. However, dolphins are one of the most flexible mammalian vocal learners and so it is unclear what the stable whistle features are that would allow for species recognition. Here, we compare whistle repertoires of six delphinid species found in the tropical Pacific Ocean to evaluate whether species-specific whistle types exist. We used dynamic time warping and neural network code called ARTwarp to organize whistle contours into categories for each species based on frequency content and modulation patterns. The sizes of the resulting whistle repertoires varied significantly by species, with bottlenose, common and striped dolphins having the largest repertoires and rough-toothed and spinner dolphins having the smallest repertoires. ARTwarp was also used to compare repertoires between species. Many whistle types were shared between species, but whistles that were unique to each species were also produced. Unique whistle types comprised between 12% (spinner dolphins) and 40% (bottlenose dolphins) of the whistle repertoire of each species. Some unique whistle types may represent signature whistles in these species, but others appear to be shared across individuals within species and may be used to communicate species information.

## Role of phenotypic plasticity for animal welfare and contrasting stress coping styles

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In animals as well as humans, repeated or prolonged exposure to stress can potentially compromise the physiological and psychological basis of health and welfare. The impact of stress largely depends on the inherent stress coping style of the affected individual. Stress coping style can be defined by the set of behavioral and physiological responses to stress that is consistently employed by one individual across unrelated and temporally separated situations. For instance, the steroid “stress hormone” cortisol is responsible for a range of stress induced pathologies. High heritability of the cortisol response has allowed for the generation of two strains of rainbow trout (*Oncorhynchus mykiss*) that differ consistently in stress-induced cortisol production and consequently in morphology, endocrinology, behavior and cognition. Low responding (LR) fish were initially selected for low post-stress cortisol levels and subsequently display proactive behaviors and endocrine profiles. High-responding (HR) fish, on the other hand, were selected for high post-stress cortisol levels and display reactive behaviors and endocrine profiles. Here I will review the use of the LR-HR model to study the proximate mechanisms behind genetically linked behavioral and physiological trait characteristics. The observation that routine-dependent and inflexible behavior in proactive individuals is associated with limited neural plasticity will be discussed with reference to implications for animal welfare, as well as the potential to illuminate the biological background for stress-related neurobiological disorders.

### **Locomotor activity and feeding rhythms of indoor and outdoor cats living in captivity**

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The activity and feeding rhythms of the cat, a solitary predatory species, are still debated issues and have not been clearly demonstrated. While feeding on ad-libitum pet food, one could wonder if the activity and feeding rhythms of the cat are influenced by the living conditions, i.e. outdoors vs indoors. In order to investigate this issue, two groups of cats, 13 living in a large outside enclosure and 16 living in an indoor cattery, have been studied on a three-week period. Their locomotor activity and feeding behaviour were recorded using precise automatic tracking pioneer technologies via equipped collars: passive RFID to record their feeding behaviour, active RFID to record their locomotor activity. We observed peaks of activity and food intake around dawn and dusk, and when humans were present. The feeding rhythm was less robust (activity rhythm amplitude:  $555 \pm 44$ ; feeding rhythm amplitude:  $104 \pm 14$ ;  $p < .001$ ) and stable (activity rhythm inter-daily stability:  $0.38 \pm 0.02$ ; feeding rhythm inter-daily stability:  $0.23 \pm 0.02$ ;  $p < .001$ ) than the activity rhythm, likely confirming the opportunistic feature of cat's behaviour. Most cats showed a rhythm's period of 24 hours, especially indoors. Finally, the indoor group, possibly more prone to routine, showed stronger and less variable overall rhythms than the outdoor group ( $p < .001$ ). This study allowed us to demonstrate the existence of feeding and activity rhythms in the cat, whatever the environment. Nevertheless, as seen in the literature, a great inter-individual and intrinsic variability was observed, some cats being arrhythmic at times and others showing a tendency toward rhythmic bimodality (12h rhythm period).

### **Living in a landscape of fear: behavioural flexibility of an aboreal primate in response to the spatial and temporal variation in predation risk and resource**

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Risk of predation varies spatially throughout the home range, creating a "landscape of fear". Prey animals respond to this landscape of fear not only by modifying how they use their habitat, but also how they display certain behaviours. In multi-predator habitats which experience high variability in the spatiotemporal distribution of resources, minimising predation risk whilst maximising food intake is a key ecological problem in terms of a species' fitness. We collected behavioural scan data on two habituated groups of samango monkey (*Cercopithecus albogularis schwarzi*) between 2012-2016 through full-day follows. We used acoustically distinct alarm calls to create annual "landscapes of fear" and created monthly food availability maps from phenological and vegetation plot sampling. We used generalised linear models accounting for spatial autocorrelation to explore how behaviour varied spatially according to the landscape of fear and resource availability, whilst incorporating elements of habitat structure into the model. Samango monkeys did not display behaviours evenly across their home range, instead disproportionately displaying behaviours according to perceived predation risk and food availability. Predation risk was the most influential factor driving behaviour; as feeding, resting and social behaviours occurred at low frequencies in "high-risk" areas, regardless of food availability. Whilst other studies have demonstrated the role of predation risk in habitat use, we show here that the landscape of fear also influences behaviour across the home range.

## The trade-offs of honest signals

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The evolution of reliable signals has been a major problem in evolutionary biology and behavioural ecology, and the leading explanation is the Handicap Principle. This principle assumes non-Darwinian claims that signals evolve because of their wastefulness. Its popularity is due to confusing it with a different, though related idea, called the handicap hypothesis ('costly signalling'), which proposes that signal cost can maintain honesty. This hypothesis is theoretically viable, but it is a limited claim and it has numerous problems. Here we argue that the variety animal signals – including peacocks' trains and other highly conspicuous displays – can be understood within a Darwinian framework. There is no need for non-Darwinian mechanisms such as 'signal selection' or selection for 'handicaps'. We argue that the key feature of models known as 'costly signalling' theory are not the costs of signalling per se, but rather signal trade-offs (e.g., signals need not be costly to be honest; it is the cost/benefit ratio that matters and there is no reason to emphasize the costs more than benefits). Accordingly, we propose that signal honesty is selectively maintained when there are greater trade-offs for cheating than honesty, which we call the "Trade-off Principle". We discuss how the trade-off framework offers clearer terminology, a better methodology, and more testable predictions.

## Individual acoustic monitoring as a tool to study behavioural ecology of passerines

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In field studies, it is often necessary to identify individuals. In birds, colour rings are frequently used; however, they are often difficult to observe, especially in small species and dense habitats. Acoustic-based monitoring detecting individuals by their characteristic vocalization is a potentially suitable alternative, but this approach is challenging in species with complex songs. On a small migratory passerine - the Tree Pipit, we demonstrated that acoustic monitoring can be very efficient tool for monitoring individuals and their behaviour. During a 3-year study, we obtained over 500 recordings from more than 60 males from one study population to evaluate pros and cons of individual acoustic monitoring. The acoustic-based data increased the overall estimated number of territorial males at the locality and improved the estimates of the period of their presence. They revealed dynamic within-season changes in territory occupancy; and allowed identification of returning birds (including non-ringed ones and those actively avoiding approaching humans). Our results suggest that some commonly used methods may substantially underestimate return rates of migratory bird species. We successfully tested our method on two other species with individually stable song, the Tawny Pipit and the Yellowhammer. In the latter species, individual vocal behaviour can be conveniently studied by passive automatic recording. We can extract information on singing interactions of particular males obtained without presence of human observer, and thus analyse natural vocal behaviour of the species.

## Female incubation attendance and nest vigilance reflect social signalling capacity: a field experiment

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Due to the reduced conspicuousness of female signals, their evolution has traditionally been interpreted as a by-product of sexual or natural selection in males. Recent studies have argued that they may be the result of sexual or social selection acting on females. Here we explored the role of the white wing patch during the incubation period in female-female competition contests in a migratory cavity-nesting songbird, the pied flycatcher *Ficedula hypoleuca*. At this stage female investment is crucial for offspring survival, while competition among females for nest cavities is still operating. We experimentally performed an extreme reduction of signalling capacity by covering the wing patch with dark paint in a group of females, and compared their incubation attendance and social interaction patterns (vigilance and aggression at the nest as defence variables) during simulated territorial intrusion tests with female decoys, with those of an unmanipulated group of females. Tests were performed both before and after the manipulation. We hypothesized that these patches constitute signals of social dominance in female-female interactions allowing them to maintain high levels of incubation attendance by reducing the need for vigilance. We found a marked decrease in incubation attendance in experimental females after manipulation, a change that was not found in the control group. Moreover, vigilance decreased in the control group after the manipulation, a change not detected in manipulated females. Female wing ornamental traits would act as a badge of status in social interactions allowing more intense incubation and reduced vigilance. Implications of social interactions on incubation patterns should be incorporated in future studies.

## Conceptualizing dimensions of sociality reveals both gaps and opportunities

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Sociality is widespread in animals, and can take many different forms. Studies across different organisms or taxonomic groups have used varying conventions and terminology to classify social systems. While previous comparative research has generated new insights into specific aspects of sociality, such as cooperative behaviour or mating systems, synthesis of sociality more broadly across species has been limited by a lack of definition and terminology that is open to interpretation. We have developed a framework composed of eight dimensions, including aspects of group attributes, quality of interactions between individuals, and temporal patterning, that can be used to describe different features across all types of socially living vertebrate societies. The aim of the framework is to be a descriptive guideline to social attributes, while focusing exclusively on quantifiable relationships and group traits regardless of their function. By applying our framework across more than hundred species, we find that sociality represents a rich multidimensional landscape of trait combinations. Correlation analysis reveals that the dimensions have relatively high independence, suggesting that social systems are able to evolve different aspects of social behaviour without being tied to particular traits. We also find consistent taxonomic biases in reporting particular types of traits, resulting in large gaps in knowledge. Our multidimensional framework is easily applied to all vertebrate societies by just using basic quantitative information on their natural history and social structure. We anticipate this will not only facilitate comparative analyses, but will aid the detection of drivers of social patterns and the evolution of sociality.

### Optimal scent marking strategies for African leopards

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Scent marking, where signallers deposit signals on objects in the environment, is a common form of chemical signalling in mammals and is thought to play a critical role in maintaining social organisation within wide-ranging, spatially-dispersed populations. Signallers, however, can incur scent marking costs through mark production, time investment in patrolling and depositing/maintaining mark sites, and increased risk of detection by predators and prey. To mitigate these costs, signallers can adapt spatial patterns of scent marking behaviours to increase the probabilities of scent marks being encountered by intended recipients. Relatively little, however, is known of the spatial scent marking placements of many wide-ranging felid species, with most studies focussing on scent mark form and function. Here, we used detailed observational data collected from over seven years of focal follows and high-resolution GPS radio collar data to investigate the spatial placement of scent marks within a leopard population in northern-Botswana. We found that leopards exhibited a boundary scent marking strategy by increasing investment in the maintenance of marking sites in peripheral areas of their home range. We also found that leopards had higher scent marking and investigating frequencies when travelling on roads than when travelling along natural routes, suggesting that roads may function as hotspots for olfactory information. Compared to leopards from less productive ecosystems, such as the Kalahari, our results suggest that leopards can be highly flexible in their marking strategies, with optimal strategies impacted by the surrounding environment.

### Oddity, predation risk, and social decisions in aquatic invertebrates

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Group living is widespread across animal taxa, incurring several benefits for individuals, such as increased foraging efficiency or an enhanced chance of surviving a predator's attack. This latter benefit can be caused by predator confusion or dilution effects, which both will be lowered for odd looking individuals. While this "oddity effect" has been frequently postulated, it has been tested experimentally only for a few species, mainly in fish. We examined the oddity effect and swarming preferences in two differently sized species of freshwater planktonic crustaceans in large *Daphnia magna* and small *D. pulex*. We experimentally investigated whether odd individuals in a swarm of heterospecific *Daphnia* were more vulnerable to predation by a natural occurring predator, the three-spined stickleback (*Gasterosteus aculeatus*). Furthermore, *Daphnia*'s swarming preference was tested by providing either conspecific or heterospecific odour stimulus versus 'no odour' one. In contrast to the predictions of oddity effect, our study shows that odd individuals were not always preyed on earlier, but sticklebacks preferentially preyed upon large more nutritious individuals first. Interestingly, *Daphnia* of both species reacted towards the odour of shoaling con- and heterospecifics. Generally, *D. pulex* avoided other daphnids, while *D. magna* based their choice on the species of the odour donors, preferring the odour of heterospecifics and avoiding conspecifics. These findings provide new insights into swarming strategies and social preference of an invertebrate and how this behaviour can influence predation risk.



## Comparing the acoustic structure of agonistic vocalizations in tolerant and intolerant macaques: a test of the social complexity hypothesis

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According to the "social complexity hypothesis", social systems characterized by complex relationships require communicative complexity. We test this hypothesis using the social diversity reported in macaques. Some macaque species display a high degree of social intolerance, with a steep gradient of dominance, which leads to clear winners and losers in conflicts. Other species are more tolerant, they exhibit more balanced relationships: subordinates can protest or counter-attack against dominant individuals, which increases the level of uncertainty – and thus complexity in the sense of Shannon's information theory – regarding the outcomes of conflicts. We compared agonistic vocalizations in two species of macaques differing by their social style: intolerant rhesus macaques (*Macaca mulatta*) and tolerant Tonkean macaques (*Macaca tonkeana*). We recorded vocalizations emitted by adult females in 16 rhesus macaques and 13 Tonkean macaques kept in captive conditions, collecting 12 hours of focal sampling per individual. We used cluster analysis to discriminate call types based on the following acoustic features: call duration, energy quantiles features of fundamental frequencies, entropy, jitter, shimmer and harmonic to noise ratio. This revealed that Tonkean macaques emitted calls characterized by a higher number of acoustic features compared with rhesus macaques, with a number of call types two times larger in Tonkean than in rhesus macaques. Moreover, the vocalizations of Tonkean macaques showed a higher degree of overlap between call types, meaning that they used a wider number of intermediate calls. These results support the hypothesis that tolerant macaques have more complex communication signals than their more intolerant counterparts.

## Phenotypic engineering alters stress axis programming and social competence

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In many vertebrate species, early social experience generates long-term effects on later-life social behaviour. These effects are accompanied by persistent modifications in the expression of genes implicated in the stress axis. It is unknown, however, whether stress axis programming can affect the development of adaptive behavioural plasticity (aka 'social competence'), and if so, by which mechanism. Here we used phenotypic engineering to persistently reprogram the hypothalamic-pituitary-interrenal (HPI) axis of juvenile cooperatively breeding cichlids, *Neolamprologus pulcher*. During the first two months of life, juveniles were repeatedly treated with cortisol, the major stress hormone in fish, mifepristone, a selective gr1 blocker, or a blank control. Three months after the last manipulation, we tested for treatment effects on (i) cortisol levels, (ii) social competence and (iii) the expression of three key genes of HPI axis, corticotropin-releasing factor (crf), glucocorticoid receptor (gr1) and mineralocorticoid receptor (mr) in the telencephalon and hypothalamus. Social competence was reduced in cortisol-treated juveniles exposed to a social challenge, which complies with previous work applying early-life manipulations by using different social experience. Nevertheless, mifepristone treatment together with cortisol levels interactively influenced the outcome of this experience. Cortisol treatment induced a persistent down-regulation of crf in the forebrain, whereas mr was up-regulated by both treatments in this brain area. In conclusion, the experience of early-life stress as simulated by cortisol exposure impaired later life social performance and generated persistent changes in stress gene expression. We discuss how the altered gene expression could act as effective physiological mechanism for stress coping.

## Investigating Protean Anti-Predator Behaviour Using Virtual Reality

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Prey animals have evolved a wide variety of behaviours to combat the threat of predation (e.g. avoiding detection, warding off attack, fleeing) which are generally well studied and understood. However, commonly observed and taxonomically widespread 'protean' antipredator behaviour (i.e. sufficiently unpredictable behaviour that prevents predators anticipating the future position or actions of prey) has received almost no experimental investigation. The primary approach of this project utilised human 'predators' who participated in 3D virtual reality simulations to test how protean (i.e. unpredictable) variation in prey movement affected visual tracking (a key determinant of successful predation). We found that prey movement path complexity significantly predicted tracking accuracy. Furthermore, when more movement rules (i.e. prey speed, turn angle and distance between turns) were protean; movement path complexity and tracking difficulty also increased. Moreover, specific movement rules had varying impacts on tracking accuracy, with the efficacy of protean variation in one element depending on the remaining elements' values. Indeed, the protean components highlighted here as particularly effective occur in real animal escape strategies, including the spiralling or erratic zig-zag flight often exhibited by insects evading predators. Our findings therefore provide important insights into the understudied phenomenon of protean movement, which are applicable to predator-prey dynamics within a broad range of taxa. Current efforts in this project are utilising these findings to inform studies into other important elements that frequently interact with protean behaviour, for example, morphological and cognitive factors (e.g. the effects of colouration and predator learning on protean behaviour efficacy).

## **Coping with strangers: how familiarity and active interactions shape group coordination in *Corydoras aeneus***

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Social groups whose members have had sustained prior experience with each other exhibit better coordination and outperform groups of unfamiliar individuals. The ways familiarity assists coordination are not well known. Prior social experience may simply allow individuals to learn the behavioural tendencies of familiar group-mates and coordinate accordingly. In the absence of prior social experience, it would be adaptive for individuals to develop strategies for coping with unfamiliar others. To explore how familiarity can shape group behaviours, we used a highly social catfish, *Corydoras aeneus*, that utilizes a distinctive, observable tactile interaction style. We describe this behaviour, physical “nudges” deployed to initiate and maintain contact with others during group movements, and report two experiments investigating the relationship between nudges and coordination. In triplets of two familiar and one unfamiliar fish, we found no difference in nudging rate based on familiarity. Despite this, unfamiliar individuals coordinated worse than their familiar group-mates and were more frequently absent from group movements. However, in pairs of familiar or unfamiliar fish, we found no coordination difference. Instead, we found that unfamiliar pairs exhibited significantly higher nudging rates, suggesting that unfamiliar pairs could compensate for their unfamiliarity by nudging more frequently. In contrast, familiar individuals coordinated with comparatively little nudging, presumably because they were experienced with each other. Overall, these results suggest that nudges can be used to improve coordination of group activities, but that their usage is reduced in the case of familiar individuals, which suggests that these potential signals may be costly.

## **Windows into How the Brain Learns Vocalizations: Imaging and Optogenetic Methods in Songbirds**

**T.F. Roberts**

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Birdsong has emerged as one of the best-studied motor behaviours and a leading model for studying the neural mechanisms for behavioural imitation and vocal learning. Optical methods, including longitudinal imaging of structural changes to neurons, optogenetic manipulations of neuronal activity, and functional imaging of neuronal population activity have begun to reveal how birdsong is first learned from social experience and how it is ultimately perfected through vocal practice. This presentation will provide an overview of the rapidly evolving imaging and optogenetic methods for studying birdsong and how these methods inform the study of ethological relevant behaviours in a controlled laboratory setting.

### **The cost of producing sexual chemical signals by male Carpetan rock lizards: consequences for reproductive success**

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Sexual signals that males produce to attract females may be honest if they are costly and dependent on the condition and quality of the male. In the Carpetan rock lizard (*Iberolacerta cyreni*), the characteristics of males' chemical signals (femoral secretions) may constitute an honest signal in the context of female mate choice. Those males able of bearing the cost of producing or allocating expensive chemical compounds to the signals would be more attractive to females and would have a greater reproductive success. To test this hypothesis, we conducted a field experiment in which we increased the production costs of chemical signals by means of an immune challenge. We injected males with a bacterial antigen without pathogenic effects (lipopolysaccharide, LPS) and, through a capture-recapture field study, examined its effects on characteristics of sexual signals. Further, to test the relationship between the quality of males' signals and reproductive success, we captured females and kept them in captivity until egg laying. We incubated the eggs and determined the paternity of offspring using microsatellites. Our hypothesis predicts that, if there is a relationship between the production of high-quality chemical signals and their attractiveness to females, LPS-treated males will have chemical signals of lower quality and less reproductive success than untreated controls. Results will be discussed in the context of trade-offs between survival and reproductive investment.

### **Social learning by following? Testing for communal foraging of mother-pup pairs in a flower-visiting bat species**

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During transition from parental care to independent life, the development of adequate foraging skills is a major challenge for juvenile mammals. However, participating in their parents' knowledge by applying social learning strategies might facilitate this task. For several mammals, communal foraging of adults and offspring is suggested to be an important mechanism in mediating this vertical social transmission of foraging related information. Bats face the same challenges, but among this large mammalian taxon, there is almost nothing known about social learning processes during ontogeny. It was suggested that following their mothers during first foraging flights would represent a valuable option for juveniles to socially learn about foraging (e.g. where to find food), but explicit tests on communal foraging of mother-pup pairs are scarce. We investigated the foraging behaviour of juvenile flower-visiting bats (*Glossophaga soricina*) in a dry forest in Costa Rica. We tested whether recently volant, but still nursed pups perform first foraging flights alone, indicating rather individual learning strategies, or whether pups follow their mothers, which would enable pups to learn socially. For that, we performed a field experiment using artificial flowers with RFID reading system and tested for communal and independent visits of RFID tagged mothers and their pups. Unexpectedly, artificial flowers near the day-roost were almost entirely visited by pups, while mothers seemed to forage somewhere further away. Our results demonstrate that juveniles perform first foraging flights apart from their mothers and might apply individual learning strategies while exploring the environment in spatial proximity to their day-roost.

## Considering behaviour 24/7; nocturnal activity and animal welfare in the zoo

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Inference of welfare state from diurnal time-activity budgets is commonly performed in captive animal collections, but little consideration is given to how animals behave outside of zoo opening hours. Assessment of nocturnal behaviour can provide more detailed information on how animals use the space provided to them, and highlight how enclosure areas not commonly occupied during the day may still be important for inhabitants at other times. We examined whether flamingos at WWT Slimbridge Wetland Centre changed their enclosure usage and behaviour overnight compared to that observed during daylight. Using three night-vision remote cameras, the behaviour and enclosure usage of a flock of over 270 greater flamingos (*Phoenicopterus roseus*) was recorded from March to July 2016. Results showed that flamingos had higher rates of foraging at certain points during the night, and their enclosure usage was more even when compared to daytime. Change in pool use was apparent throughout the course of the day and night. Flamingos preferentially utilised different areas of the pool available and that birds increased nocturnal foraging in their pool during the breeding season. A large enclosure size, with varied features has enabled these flamingos to follow daily activity patterns similar to those observed in wild birds. Such a difference between daytime and nocturnal behaviour patterns should be considered when designing enclosures and general management routines for flamingos. Methods used to collect data are widely applicable to other captive taxa whose wild counterparts are documented to spend large amount of time engaged in active behaviours overnight.

## The effects of social instability on behavioural phenotype: neuroendocrine mechanisms and adaptive significance

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Animals frequently have to cope with unstable social environments. Understanding the corresponding mechanisms and consequences is a current and timely topic not only in biospsychological and biomedical research, but also in fields studying the adaptive significance and evolution of behaviour. Using a comparative approach my contribution focusses primarily on social instability during early phases of life. I summarize the effects of instability that acts upon the mother during pregnancy and lactation on offspring social strategies and discuss underlying neuroendocrine and behavioural mechanisms. In addition, the question of adaptive significance will be addressed. I argue that the shaping of social strategies by social instability during early phases of life represents an effective mechanism for rapid adaptation.

## **The case of *Neolamprologus caudopunctatus*: why the greatest house doesn't make you a cooperative fellow**

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The widespread occurrence of animals caring for unrelated young has challenged evolutionary biologists for decades. We investigated ecological and endocrinological parameters, to identify key factors that permit or constrain cooperative breeding in two fish species. We performed parallel experiments with two congeneric, sympatric cichlid species: the biparental cichlid *Neolamprologus caudopunctatus* and the cooperative *Neolamprologus pulcher*. First, we investigated if competition for complex breeding sites excludes *N. caudopunctatus* from its preferred, multi-chambered breeding-site by *N. pulcher*, which could cause the inability to develop a more complex breeding system. The competitive pressure exerted by *N. pulcher* resulted in fewer and less stable pair-bonds and changed the frequency of polygyny and monogamy in *N. caudopunctatus*. However, when *N. caudopunctatus* pairs are given a head start, they were able to defend their preferred complex breeding-site. Therefore, it is unlikely that such competitive limitation for complex breeding-substrate alone prevents *N. caudopunctatus* from developing cooperative breeding. Second, we carried out further experiments and showed that the biparental *N. caudopunctatus* is a vicious egg cannibal. Only the act of spawning and the presence of a brood nearly always maintained parental care and inhibited cannibalism. In this phase of the reproductive cycle, parents showed parental care when supplied with complete or with half-cross-fostered young. Third, we investigated in how far hormones like isotocin, vasotocin, galanin or prolactin could be responsible for the abrupt switch between egg eater and loving parent *N. caudopunctatus* and whether those hormones are correlated with the subordinate, helping status in *N. pulcher*.

## **Encoding individual identity in mammalian vocalizations: A comparative approach**

**M. Scheumann**

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Indexical cues in human speech and non-verbal vocalisations convey information about the physical characteristic of the speaker and thereby encode speaker identity. Research on mammalian voices also provides evidence that vocalizations potentially encode sender identity. Based on the homolog mammalian vocal production system it is assumed that the same mechanism work for human and animal voices. According to the source-filter theory it is argued that the larynx (e.g., fundamental frequency) and the superlaryngeal tract (e.g., resonance frequencies) play an important role in encoding indexical cues. However, the acoustic structure of animal vocalizations varies across mammalian species containing low frequency noisy calls, tonal calls as well as high frequency or ultrasonic calls with widely spaced harmonics. To date, it is not fully understand how the different acoustic structures of vocalizations across mammals affect the general principle of encoding individual identity. In the study I will compare the encoding of individuality in different mammalian taxa communicating in different frequency ranges: mouse lemurs communicating in a high frequency/ultrasonic range, cats communicating in the audible range and white rhinoceros communicating in a low frequency range. By performing a multi-parametric acoustic analysis focusing on spectral cues related to the larynx (fundamental frequency) and the supralaryngeal tract (e.g., resonance frequencies), I will compare the importance of these parameters for encoding individual identity in different mammalian taxa. The results will help to clarify to which extent general mechanism encoding individual identity exists and whether these rules might be affected by differences in body size and call structure.

## Using personality data to improve the management and welfare of a semi-captive population of Asian elephants of Myanmar

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It has been shown that animal personality has many important consequences regarding a wide range of evolutionary and ecological processes. It is important to be aware of consistent differences in behaviour between individuals in a population when planning conservation strategies, as personality can have extensive implications for animal welfare. Asian elephants (*Elephas maximus*) are a major focus of conservation as their numbers have been rapidly declining in recent decades, including the one third of Asian elephants living in semi-captive conditions. We have previously assessed personality structure in a population of semi-captive Asian elephants working in the timber industry across Myanmar. While the population demography largely resembles wild elephants, our study population provides a large dataset on individual animals which allowed the scoring of a relatively large number (257) of individuals. Data were collected from 2014 to 2017 with questionnaires, where elephant handlers (mahouts) scored 28 behavioural traits for each elephant on a scale of 1 (behaviour expressed very rarely) to 4 (behaviour expressed most time). We also collected faecal and blood samples from these elephants to assess stress levels, parasite loads and several health parameters, as well as their mahouts' experience. In this talk I will present several studies in which we assess the link between personality, parasite load, stress, health and the elephant-mahout relationship. The results of these studies allow us to understand how an elephant's personality affects the way it copes with stressors, enabling us to improve elephant management and welfare in this unique semi-captive Asian elephant population.

## Mother – offspring communication in three ungulate species: which factors might influence the individuality of contact calls?

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Ungulates use individualized contact calls for mother-offspring communication. Degree of individuality of calls might depend on call type (open-mouth oral vs close-mouth nasal), age (mother vs young), neonate anti-predator strategy (follower vs hider) and degree of discomfort during call emission. We analyzed contact calls of three species of ruminants: goitred gazelle *Gazella subgutturosa*, saiga antelope *Saiga tatarica* and red deer of two subspecies, the Iberian red deer *Cervus elaphus hispanicus* and the Siberian wapiti *C. e. sibiricus*. Individual identity was well expressed in all the three species and exceeded two-to-three times the random value. Oral calls were more individualized than nasal calls in saigas, goitred gazelles and Iberian red deer. The mothers had more individualized calls than the young in saiga and Iberian red deer, the young had more individualized calls than the mothers in goitred gazelle. In Siberian wapiti, mothers and young did not differ in the degree of call individuality. The follower species (saiga) had most individualized calls and one of the three hidiers (Iberian red deer) had significantly least individualized calls (discriminant analysis based on 6 acoustic variables accurately classified individual identity in 100% and 66% calls of these species respectively); two other hider species displayed intermediate values of call individuality. In young goitred gazelle and saiga, individuality of calls differed between contexts of distress (capture by predator) and discomfort (feeding anticipation) only in goitred gazelles but not in saiga, probably because difference in maternal defense against predators between these species. Supported by the RSF, grant 14-14-00237.

## The lasting effects of 'dear enemies': stable social relationships have fitness benefits for a territorial squirrel

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An important question in evolutionary biology is how conflict between interacting conspecifics can be resolved, allowing the evolution of various forms of stable social organization. In group-living species, social bonds among group members help to mitigate conflict and enhance fitness. Similarly, long-term social relationships in solitary, territorial species may help to minimize conflict between neighbours (and thus costs of territoriality), though the fitness benefits of these social relationships are poorly understood. In this study, we used 21 years of data from a population of territorial North American red squirrels (*Tamiasciurus hudsonicus*) to assess how familiarity with neighbours affected the reproductive success and survival of individuals. We also modelled how kinship influenced fitness, to determine the importance of mutualistic interactions relative to kin-selection. We found that familiarity with neighbours had substantial benefits for survival, and increased both the number of pups sired and the number of pups recruited annually. These effects were particularly pronounced in the 'senescent' period (i.e. squirrels aged 4 and older) suggesting that familiarity may play an important role in buffering squirrels against effects of age-related declines. Relatedness among territorial neighbours was not an important driver of survival or reproductive success. This study is among the first to show that familiar relationships among territorial neighbours can have direct fitness benefits. Mutually beneficial interactions among unrelated individuals may therefore play an important role in the evolution of social systems.



### **Pre-natal exposure to anthropogenic sound generates a risk prone post-natal phenotype in the Japanese quail**

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Recently studies have shown that pre-natal exposure to acoustic stimuli can alter post-natal phenotypes. This is especially pertinent to living in anthropogenic environments as often animals experience ‘unnatural’ soundscapes. We still have much to learn about the importance of different types of acoustic stimuli in shaping later phenotypes. Here we present data from an experiment using the Japanese quail, where we exposed fertile eggs to one of three acoustic stimuli types during the latter stages of incubation: conspecific maternal calls, anthropogenic ‘beeps’ and silence. After hatching (post-natal day 4) we assessed behavioural responses to social isolation in a novel environment. At post-natal day 10 we also assessed the changes in corticosterone following an acute handling stressor. Our results show that exposure to conspecific sounds reduced the latency to enter a ‘safe’ covered area within the novel environment and caused birds to elicit a more prolonged corticosterone release in response to acute stress. Anthropogenic stimuli increased the latency to feed in the novel environment and reduced the amount of time the birds spent in the ‘safe’ area. These novel results suggest that exposure to conspecific calls during pre-natal development can program the stress response resulting in a more risk averse phenotype, which perhaps prepares the chick for the post-natal environment. Anthropogenic stimuli may alternatively program risk prone behaviours, which may incur costs in later life depending on the environmental context. Further work is required to elucidate the longer term effects and the fitness consequences of such pre-natal acoustic stimuli.

### **Social networks and welfare in captive Livingstone’s fruitbats**

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Captive breeding programmes are an essential management tool for conserving endangered and threatened species. This is especially true for the Livingstone’s fruitbat *Pteropus livingstonii*; this Endangered species is highly threatened by changes in land use and vulnerability to tropical cyclones in its natural habitat, meaning its ex situ population is potentially an extremely important resource for the future. Various effects of the social environment on individual reproductive success have been recently highlighted in a number of species; however, relatively little is known regarding social dynamics in the Livingstone’s fruitbat and instances of infanticide have previously been reported in this species in captivity. Here we apply social network analyses to explore female social relationships in a key breeding group at Durrell Wildlife Park, Jersey, in order to determine how individual social experiences vary and to explore how social network analysis can be used to improve reproductive success in captive breeding populations by influencing management practices. We found that females tended to form positive relationships with those of a similar age class and that close kinship also increased relationship strength. Older females were more highly central in the association network, but age class did not predict centrality in the aggression and affiliation networks. Females with dependent offspring were more highly central in terms of aggression received, yet more peripheral in terms of affiliation received. We use these results to suggest management changes to safeguard the welfare of breeding females and maintain population reproductive success.

### **The formation male-female good relationships after male immigration in rhesus macaques**

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There is ample evidence that good relationships provide fitness benefits, yet empirical evidence how these relationships are formed is absent. A computer model indicates that early affiliative behaviour may form the starting point of good relationships. In rhesus macaques, males immigrate into groups and have to establish new relationships. Good relationships among a resident male and females have been documented. We explored whether initial behaviour predicted relationships at a later date. We recorded in captive rhesus macaques the behaviour during four introductions of a new male in an established naturalistic group containing multiple females and their offspring. The interactions between all females and the new male were recorded at the start of the introduction process and after the male had been accepted in the group. The presence of early interactions predicts the presence of later good relationships. These early interactions concerned a combination of aggression and affiliation or mating. Consistent with the computer model, early behavior seems to predict later social relationships. This is the first study that determines how particular individuals may start the formation of good relationships.

### **Machine learning for general bioacoustic individual identity recognition: perspectives**

**D. Stowell**

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Many animals embed individual identity in their calls, as evidenced by the ability of their conspecifics to distinguish them from others. Automatic recognition of such information, high-quality and applicable to any species, would be of great benefit to the study of individual distinctiveness as well as to applications in wildlife monitoring. Based on my experience leading bird sound recognition projects for many different purposes - detection, classification, interaction modelling - I will discuss the prospects for general bioacoustic identity recognition as a tool for the field. With a focus on songbirds, I will show results on automatic discrimination of individuals across multiple species, and will also discuss perspectives from deep learning paradigms and my experience leading international "data challenges" to develop methods. I will discuss how as a field we can advance this work.

### One problem, too many solutions: How costly is honest signalling of need?

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The “cost of begging” is a prominent prediction of costly signalling theory, suggesting that offspring begging has to be costly in order to be honest. Seminal signalling models predict that there is a unique equilibrium cost function for the offspring that results in honest signalling and this cost function must be proportional to parent’s fitness loss. This prediction is only valid if signal cost and offspring quality is assumed to be independent. Here we generalize these models by allowing for signal cost to depend on offspring condition. We demonstrate that in the generalized model any signal cost proportional to the fitness gain of the offspring also results in honest signalling. Moreover, it can be shown that any linear combination of these two cost functions (one proportional to parent’s fitness loss, one to offspring’s fitness gain) also leads to honest signalling in equilibrium, thus yielding infinitely many solutions. Furthermore, we show that there exist linear combinations such that the equilibrium cost of signals is negative. It follows, contrary to previous claims, that the existence of parent-offspring conflict does not imply costly equilibrium signals. As an important consequence, it is meaningless to measure the “cost of begging” as long as the dependence of signal cost on offspring condition is unknown. Any measured equilibrium cost in case of condition-dependent signal cost has to be compared both to the parent’s fitness loss and to the offspring’s fitness gain in order to provide meaningful interpretation.

### Wildlife tourism impact on wild African elephants, *Loxodonta africana*

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Eco-tourism and human-wildlife interactions can lead to changes in behaviour, and spatial behaviour and affect physiological stress in many species, however, studies investigating wildlife viewing are scarce. We present the first results investigating the impact of wildlife viewing on African elephants, *Loxodonta africana*. We studied a population of over 1200 wild elephants in Madikwe Game Reserve, South Africa, for 18 months, collecting behavioural observations, dung samples and satellite collar data. Data were analysed in R Statistical Software, using generalised linear (mixed) models. We found that, during high tourist pressure, individually identified elephants had an increase in physiological stress levels by 112% and that conspecific-directed aggression became increasingly likely to occur. When investigating direction of movement of randomly encountered herds in relation to observers in game drive vehicles, bull groups and lone males, but not cow-calf or mixed groups, were more likely to retreat from observers with increasing numbers of vehicles present. Herds also became more likely to retreat with increasing numbers of vehicles present in shrub and at waterholes but not in dense shrub. Spatial behaviour by three adult females revealed that increasing tourist pressure was related to increased road crossings between 1-6am and increased hourly journey length between 8pm-1am compared to daytime ranging behaviour. We also found that 95% isopleth home ranges were larger during the wet, compared to the dry season. We discuss these results and possible welfare implications for other populations of wild elephants being viewed by tourists across Africa as well as management implications.

### **Olfactory communication of need and helpfulness in reciprocal cooperation of rats**

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Reciprocal cooperation is a powerful mechanism by which generous help can be established and stabilized among individuals interacting repeatedly with one another. Norway rats have been shown to reciprocate received help to obtain food in an iterated prisoner's dilemma paradigm. In so doing, they take account of their own costs of providing help and the benefits to the receivers of help. Here we ask how rats obtain information about the generosity and need of their social partners. In a series of experiments we provided rats with odour from helpful or unhelpful rats while these were combined with a different social partner. In response to these odour cues, focal rats showed a higher propensity to help a neutral stooge to obtain food if they had received odour from a helpful conspecific than if they received odour from a conspecific refusing help. Moreover, focal rats provided food to a neutral stooge more readily if they received odour from a hungry conspecific than if receiving odour cues from a satiated rat, even if these virtual partners were kept in a different room. These data demonstrate that rats can chemically communicate helpfulness and need to a social partner, thereby increasing the latter's propensity to cooperate. Apparently, unexpected but straightforward proximate mechanisms help regulating the reciprocal altruism of wild-type Norway rats.

### **Host versus parasite: recent changes in the host-parasite interaction between Darwin's finches and the invasive ectoparasite, *Philornis downsi***

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The newly established host-parasite interaction between Darwin's finches and the invasive fly *Philornis downsi*, whose larvae suck blood from nestlings, allow the monitoring of potential adaptations in hosts and parasites. Our long term data on parasite intensity and host mortality revealed that the parasite has forwarded its time window for attacking nests. Before 2012, *P. downsi* larvae were found only in nests with chicks. However, since 2012 we have recorded larvae also in incubating nests. This may be an adaptation to resource competition between flies. Additionally, we observed a reversal in infestation patterns in two closely related hosts: 20 years ago Warbler finch (WF, *Certhidea olivacea*) nests had higher *P. downsi* intensity than Small tree finch (STF, *Camarynchus parvulus*) nests, but in the last 10 years this pattern has reversed. We also found indications for host preference depending on nest stage: Prevalence during incubation is higher in WF than STF. However, once chicks hatched prevalence was nearly 100% in both species but STF had higher parasite intensity and more larvae reached pupation. Mean age of chick death in both species lays between 5 – 7 days which is the minimum time for pupation. The change in infestation pattern could be a result of selection on the optimisation of the trade-off between number of larvae that reach pupation and time of host's death. With the decrease in mean age of chick death near the parasite's developmental limit the fly should show a stronger preference for the host that allows faster development.

### Hummingbirds change their foraging routes to avoid low concentration flowers

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The travelling salesman problem, where an individual moves through several locations using the shortest possible route including the return to the origin, is common to many central place foragers. For example, in order to maintain their high metabolism and expensive flight, hummingbirds feed from hundreds of flowers every day often revisiting flowers within their territories. Eventually, hummingbirds will develop a route or “trapline” that connects all profitable flowers in a shorter route. Since flowers vary in quality however, hummingbirds are expected to use the information about the quality of the flower to prioritize visits to high quality flowers over low quality ones while also keeping track of the total travelled distance with in a trapline. In order to determine if hummingbirds would modify the total distance flown in a trapline by changing the order in which they visited different quality flowers, we first trained wild rufous hummingbirds (*Selasphorus rufus*) to feed from five equally rewarded artificial flowers within a hummingbird’s territory. Once a bird had an established trapline we manipulated the quality, increasing or decreasing the sucrose concentration, in either the first, second or third flower in their established traplines during four separate experiments. As expected, hummingbirds changed their routes to avoid the less profitable locations by switching the origin and direction of the route but the birds did not alter their routes to prioritize high quality flowers. These data suggest that, by remembering the location and the quality of different flowers, hummingbirds can optimize the distance travelled of traplines.

### Anthropogenic pressure and social networks in urban vervet monkeys

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Changes in landscape profiles, caused by anthropogenic pressures, directly influence both ecological and social challenges to many species. Generalist species, such as the vervet monkey, have been shown to adapt and thrive under anthropogenic changes, exploiting the urban landscape for its desirable resources yet facing the detriment of human-wildlife conflict. A developed understanding of an animal’s social structure is paramount to understanding how animals are able to exploit their environment; social network analysis has been suggested as a powerful tool that can aid conservation and our understanding of socioecological pressures. In this study, we assessed social metrics of five different troops of vervet monkeys living in an urban suburb of KwaZulu-Natal, South Africa. Over six months we conducted scan samples every half an hour of all group members. All troops lived in a similar urban matrix, however, their ecological pressures and how they chose to exploit these resources differed. Our results present the first understanding of social adaptations in an urban landscape. We showed that both group and individual social metrics are influenced by anthropogenic pressures. We present the interplay between natural food and human food availability on group metrics, overall displaying the strong role of human food and raiding on group cohesion. In general, our results show the social flexibility of these urban dwellers under anthropogenic ecological pressures providing useful guidance for future management plans.

### Does strategic sperm production depend upon male quality?

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Increasing evidence shows that sperm production is phenotypically plastic and males adjust sperm numbers according to their risk of sperm competition. Here, we tested whether such 'strategic sperm production' is dependent on male quality in wild house mice (*Mus musculus musculus*) and whether an up-regulation in sperm number has a negative impact on sperm quality or is otherwise traded-off. We manipulated male quality by experimental inbreeding for 2 generations of full-sib matings. Inbred and outbred control males (n=36) were then exposed to either a high or low risk of sperm competition by altering the number of rival males in their environment. Social manipulations lasted for 11 weeks before epididymal sperm was collected to conduct computer assisted sperm analysis. Surprisingly, we found no evidence that males under a high risk of sperm competition increased sperm numbers compared to low risk controls (i.e. no strategic regulation), nor did we find an effect from 2 generations inbreeding. Overall, males that produced more sperm also produced proportionally more motile sperm (i.e. no trade-off between quantity vs. quality). Sperm number was not related to sperm swimming velocity, but faster swimming sperm showed a faster decline in motility over time, suggesting a trade-off between sperm velocity and longevity. In summary, we found no evidence that males strategically adjusted sperm production, and no evidence that inbreeding impaired sperm swimming traits. We found a trade-off between quantity and quality in one but not another measurement of sperm traits.

### Exploring the role of *Macaca nemestrina* as seed dispersers

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Seed dispersal provides a means for plant seeds to escape competition and density-dependent seed predators and pathogens and to colonize new habitats. Ninety percent of all primates found in tropical regions are dependent on the forest; this makes the effectiveness of frugivorous species in the seed dispersal process an important topic. The overall objective of this study is to examine the ecological role of Southern Pig-tailed macaques (*Macaca nemestrina*) as seed dispersers at the Segari Melintang Forest Reserve, Perak (Peninsular Malaysia). In demonstrating their role in facilitating forest regeneration in the Segari region, an economic argument for conservation and protection of this threatened primate species can be presented. The study has been conducted on two habituated groups of 40 and 55 individuals, respectively. My protocol includes the identification of food plant species, distances of dispersed plant seeds, assessment of feeding ecology, seed handling strategies and seed fate. To characterize the pattern of dispersion I examine the seed shadow and I investigate the post-dispersal seed fate in situ (for dropped or spat seeds) and ex situ (for swallowed seeds in faecal samples). I found macaques dispersed seeds via swallowing, spitting and dropping with different fruits and seeds handling behaviours. For most of the fruit species the effect of spitting, swallowing and dropping was positive. This proves that Pig-tailed macaques are seed dispersers and confirms the mutualism between plants and Pig-tailed macaques. I conclude remarking the importance of conservation for this vulnerable species.

### **Cognition and personality in dogs**

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Understanding the role of personality on cognition can help to improve the interpretation of individual differences, and to enable an individualised approach to wellbeing and welfare in animals. Recent research in humans has uncovered links between trauma (adverse experiences), personality, health and cognition. However, to date very few studies have examined how these factors might affect cognitive ability in non-human animals. We utilised three questionnaires to measure demographics, personality and cognitive ability in a cross-sectional sample of 1207 pet dogs. An exploratory factor analysis on the cognitive questionnaire resulted in one factor labelled Cognitive Dysfunction (CD: items commonly described by owners of dogs suffering from Canine Cognitive Dysfunction). The internal reliability of the factor was good (Cronbach's alpha = 0.759). We carried out a regression tree analysis to reveal complex interactions among the variables. The regression tree analysis for the CD factor revealed significant effects of sensory problems, previous trauma, and of the personality traits fearfulness, and responsiveness to training (all  $p < 0.002$ ), but not of age. Dogs that were allocated the highest CD scores had sensory problems, the lowest scores in responsiveness to training, the highest scores in fearfulness, and had previously suffered trauma. Age related declines in cognitive ability are less pronounced than declines cause by sensory issues, previous trauma, and fearfulness. Our results mirror those from humans, indicating the complex inter-relationship between cognitive ability, personality and health. Behavioural therapy to reduce fear responses to stressful stimuli, could improve the wellbeing and welfare of pet dogs.

### **Behavioural responses to conspecific vocalizations in carrion crows: effects of caller identity and context**

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Vocal communication is important for coordinating several aspects of social life, such as group movement, vigilance behaviour and cooperative interactions. In many social species, sound characteristics depend on context and emotional valence. Here, we investigated how context and social relationships influence vocal communication in captive groups of cooperatively breeding carrion crows (*Corvus corone corone*). We studied the specific context in which vocalisations are emitted and qualities of behavioural responses to conspecific calls, e.g. any visible reaction (yes/no), latency to respond. Further, we investigated how individuals responded to different call-types and caller characteristics, e.g. sex, kinship, group membership. We recorded a total of 698 calls in 178 sequences, in an unambiguous behavioural context, such as aggression, begging, approaching others, response to vocalisation. Calls were categorized into 13 different call-types. The behavioural context of most call-types indicates that they function as contact calls. Crows showed a behavioural response to 48 % of calls. Relationship to the caller but not call-type did affect the time of response. Intra-group coordination via vocalizations may have evolved to increase effectiveness in the context of territory defence, predator mobbing, or during competition for shared food resources.

### **Sensory mechanisms of social information transfer between parents and offspring in a cooperatively breeding cichlid**

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Socially acquired information about predation risk can play an important role for the development of anti-predator behaviour early in an animal's life. While brood caring parents may deliberately provide information to their offspring, in the absence of parental care offspring may benefit from indirect cues obtained from defensive acts by parents. In Lake Tanganyika cichlid, *Neolamprologus pulcher*, evidence suggests that young can acquire cues about environmental risk from adult group members and that they choose a suitable developmental trajectory accordingly. However, it remains unknown which sensory channel they use and thus which cue or cue combination is most informative for offspring. To answer this, we split sibling groups of 3-week old *N. pulcher* into five groups. Three of the groups received either visual, olfactory or both of these cues from the parents while two groups acted as control with either full or no contact with parents. The parents and the two control groups were subjected to visuals of a predator or a blank tank three times a week for 4 weeks. After the 4-week experience phase all sibling groups were raised without parents and any external cues for another three months and then tested for their anti-predator and social behaviour. Based on previous finding, we expect olfactory cues to be of highest importance in risk perception, but visual cues should play an important role in amplifying the information. By systematically disentangling the information acquisition channels, our experiment allows unravelling the sensory mechanisms of social information transfer between parents and offspring.

### **A vortex of inbreeding depression: the interplay between inbreeding depression and offspring care in a cooperative mammal**

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Selection pressures generated by the costs of inbreeding are fundamental to the evolution of patterns of dispersal and mating systems, and hence underpin the evolution of animal social systems. Despite this, we know very little about the impact of inbreeding on the evolution of a key social trait - cooperative behaviour. Using a >20 year behavioural and genetic dataset, we investigate the interplay between inbreeding and cooperation in a wild population of cooperatively breeding banded mongooses (*Mungos mungo*). In this species, inbreeding is surprisingly common, with 8% of pups resulting from inbreeding between father-daughter or full sibling pairs. We demonstrate that inbreeding depression in juvenile survival is eliminated when offspring receive high levels of alloparental care, which may explain why banded mongooses show greater levels of inbreeding tolerance than most other cooperative breeders. However, particularly high levels of care are not directed towards inbred pups (outbred pups are just as likely to receive care), thus limiting the potential of care to fully mitigate inbreeding depression. Furthermore, as adults, inbred individuals show a reduced propensity to provide alloparental care, which in turn reduces the ability of care to mitigate inbreeding depression in subsequent generations. This study is the first to demonstrate (1) that alloparental care can buffer inbreeding depression, and (2) that inbreeding depression negatively impacts on the provision of alloparental care in a mammal. Together, these results suggest that inbreeding depression in care may act as a break on the evolution of highly cooperative closed inbreeding systems, such as those seen in social spiders.



### Lateralised eye use during social information acquisition

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Lateralised eye use, the predominant use of one eye over the other, is widespread among vertebrates. It is thought to increase brain efficiency and is thus considered adaptive. To investigate eye use during information acquisition, we showed bearded dragons (*Pogona vitticeps*) videos of a conspecific demonstrating a social learning task and a control video in which the same individual was present but did not solve the task. There was a significant left eye preference when watching a conspecific demonstrator during the social learning task, but no eye preference was found during the control trials. This suggests that lateralisation is more pronounced when animals receive meaningful information and that there are differences in information processing between the brain hemispheres during social learning. However, in a follow-up experiment, when the subjects were only able to use one eye to observe the demonstrator (due to the application of eye patches), we found no difference in the efficacy of social learning between animals with the left or right eye available. This suggests differences in information processing between the brain hemispheres of reptiles during social learning, while at the same time demonstrating the brain's flexibility to learn using either hemisphere.

### The relationship between stress, motivation and cognitive performance in Kune Kune pigs

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Cognitive abilities are considered to have a major influence on the well-being of animals. They can play an important role regarding the ability to cope with physical and social challenges. However, the cognitive performance of individuals can differ widely, even if they are genetically similar and reared under the same conditions. Two important factors are arousal and excitement, which depend on the fluctuating activity of the hypothalamic–pituitary–adrenocortical (HPA) system. Therefore, the investigation of the relationship between cognitive performance and HPA axis activity is likely to contribute important insights into this topic. We measured saliva cortisol of 40 *Kune Kune* pigs kept under semi-natural conditions. Saliva samples were taken over a period of 24 weeks, during which the pigs were confronted with a difficult visual categorisation problem. The pigs had on average 46 (range: 17 – 146) training sessions (of 10 trials each), and the samples were taken before, during and after each of those training units. We found that quickly learning individuals (with less trials until criterion than the group median) were more likely to show a significant increase in cortisol levels than slow learners ( $p=0.034$ ). However, we did not find higher values of saliva cortisol during successful sessions (more than 70% correct choices) than sessions with chance performance ( $p=0.63$ ). We interpret these findings as the result of varying motivation and of the correlation between positive arousal and attentiveness. Frustration due to little success and rare reinforcement during training did not seem to play a major role.

## Does commensalism and subspecies affect exploratory behaviour in mice: A comparison of three populations in a battery of five exploration tests

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Animal populations adopting a commensal way of life, e.g., house mice in buildings and stores, are subjected to different selection pressures and different trade-offs than those living in a non-commensal environment. This may radically affect their behaviour. This study investigated the effects of commensal way of life on exploratory behaviour in mice. The focal population was non-commensal *Mus musculus musculus* from Iran (n = 39). To assess the effect of commensal way of life on exploratory behaviour, it was compared with commensal *M. m. musculus* from the Czech Republic (n = 24) and to assess the effect of subspecies, it was compared to non-commensal *M. m. domesticus* from Syria (n = 38). We compared their behaviour in five tests of exploratory behaviour and boldness: open field test with 1) free exploration and 2) forced exploration, 3) hole board test, 4) test of vertical activity and 5) elevated plus maze (EPM). The inter-population differences in exploratory behaviour were significant in all types of tests ( $p \leq 0.05$ ). *M. m. musculus* were overall less bold (longer latency to leave shelter etc.) and less active than *M. m. domesticus*. Commensal mice were characterized by higher level of vertical activity (time spent climbing, rearing, jumping) and lower fear in the EPM. These results suggest that the specific selection pressures of commensal lifestyle select mice for higher affinity towards elevated places and heights. Further studies of this phenomenon should however consider the subspecies of their subject, because the subspecies identity can also affect exploratory behaviour.

## Adaptive shaping of behavioural and neuroendocrine phenotypes during adolescence

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Environmental influences during prenatal and early postnatal life can profoundly shape an individual's phenotype, thus adjusting it to prevailing or predicted future conditions. More recently, adolescence has been recognised as another crucial phase during which phenotypic development may be adaptively shaped in response to environmental stimuli. We have shown in previous studies that male guinea pigs living in large mixed-sex colonies develop a low-aggressive phenotype as part of a queuing strategy that is adaptive for integrating into large unfamiliar colonies. By contrast, males living in mixed-sex pairs during adolescence become highly aggressive towards strangers, which prevents integration into groups of unfamiliar conspecifics. In the present approach, we examined whether the high-aggressive phenotype is adaptive in situations with a limited number of competitors for access to females. For that purpose, we established groups of one pair-housed male (PM), one colony-housed male (CM) and two females after both males had reached late adolescence and examined their social behaviour, endocrine responses and reproductive success. PMs were found to direct more aggression towards the male competitor and more courtship and mating towards females than CMs. In consequence, PMs attained the dominant position in most cases and sired significantly more offspring. The high-aggressive strategy of PMs was accompanied by substantially elevated cortisol levels and significantly higher testosterone concentrations compared with CMs, which probably promoted the enhanced aggression while mobilizing necessary energy. Combining these findings with our previous results, we provided the clearest evidence to date for adaptive shaping of the phenotype by environmental influences during adolescence.

**Acoustic individuality in a culturally transmitted trait: time and geographical scale dependency on different organization levels in the song of collared flycatcher (*Ficedula albicollis*)**

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In many species, it has been shown that acoustic signals are individually distinct in classical features like frequency and time parameters, while in other species individuals may show difference in the repertoire usage, where the elements of the repertoire are learnt through social learning. However, it is largely unknown how cultural processes shape the repertoire content of individuals, especially in natural conditions. We studied the individuality of the song of the collared flycatcher (*Ficedula albicollis*) on different song organisational levels, through different time (within day, between days, between years) and geographical scales (up to 10 km) based on 300 individuals' observational data and additional playback experiments in a Hungarian population. We used diverse analytical approaches, like repertoire overlap calculations, randomization techniques and network analysis methods. We show that individuals learn not only the smallest elements (syllables) from each other but also syllable sequences. However, individuals share only small fraction of their repertoire, and therefore they show considerable differences in repertoire content that makes their individual identification possible based on a small sample of five songs only. We further show that individuals change their repertoire continuously in their life, but the individual-specificity remains over years with age-dependent repertoire plasticity. Based on these results, we propose that individuals actively change their repertoire according to their social environment in order to remain individually distinct. In our presentation we provide more details about the possible underlying process of this phenomenon by considering mechanisms due to sexual selection and the consequences to cultural evolution in acoustic signals.

## Poster Abstracts

### **Anxiety as a personality trait in the zebrafish, *Danio rerio***

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The term “personality” has been used to describe behavioural variations that are consistent over time and context. There has been much recent interest in these traits and their fitness consequences. At least some of these traits appear to be genetically determined but little is known about how these traits are controlled. Here, I investigate one personality trait, anxiety, in the zebrafish, *Danio rerio*. Specifically, I use three tests to assess the repeatability of this trait, and then use individuals of known anxiety to determine heritability. This work will increase our knowledge of how this personality trait is controlled and should increase our understanding of how and why variable traits coexist in populations

### **The application of a cognitive bias paradigm in empathy research**

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Understanding another’s emotional state is critical for facilitating adaptive behavior in complex social groups. Previous studies have proposed that emotional contagion, an essential component of empathy, aids group members in rapid information sharing, which is necessary to cope with challenges such as predator risk and stabilising positive affiliative bonds. While research on empathy in non-human animals is currently a popular topic, the underlying mechanisms of emotional contagion remain unclear. Previous studies have emphasized the importance of behavioural mimicry, however, this phenomenon does not necessarily imply emotional or affective matching. For this reason, the systematic quantification of an animal’s affective state, including both behavioural and physiological arousal as well as emotional valence, will substantially enhance emotional contagion research. Inspired by the methods used in the field of animal welfare, I apply and extend the well-established cognitive bias paradigm to study emotional contagion in birds and primates. This paradigm may allow us to distinctly investigate both the arousal and affective valence element of an emotion, and thus further capture the affective valence of emotional contagion. In my talk I will provide empirical data demonstrating the successful application of a cognitive bias paradigm in common ravens (*Corvus corax*) and common marmosets (*Callithrix jacchus*), and present experimental evidence of emotional contagion assessed by means of this paradigm.

## **Non-genetical inheritance of early-life effects on social behaviour across generations**

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Developmental plasticity has pervasive effects on phenotypes, but the degree to which these effects carry over to future generations is largely unexplored. Cooperatively breeding cichlids, *Neolamprologus pulcher*, pursue one of two alternative life history trajectories depending on early social experience: dispersing early or staying in the natal group and help. We ask whether early life effects on the social behaviour of a parental generation can be non-genetically inherited to the offspring generation. In a 2x2 factorial design, we generated F0 breeder pairs that had been reared either with or without parents in early life. They produced F1 broods, half of which were reared with foster parents and half were reared without parents. This resulted in four lines, in which F1 fish either experienced the same (+F0/+F1 and -F0/-F1) or the opposite social environment as their parents (+F0/-F1 and -F0/+F1). Juvenile F1 were tested in an asymmetric competition test, in which a preassigned owner of a resource (stimulus fish) competed with a preassigned intruder (focal F1 fish) over access to the resource. All social behaviours were recorded. Based on previous work we predicted additive effects of the presence of parents in the F0 and the F1 generation on submissive behaviour. Results indicate effects of the F0 generation only. Contrary to prediction, this non-genetic inheritance affects aggressive behaviour. Our results show that parental early-life effects are non-genetically inherited by the offspring and that parents can shape their offspring's behavioural phenotype according to their own early environmental experiences.

## **Human risk behaviour: disentangling risk-taking and risk-aversion across ages and between sexes**

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The propensity of humans to take risks varies dramatically between individuals, and many attempts have been made to understand the factors influencing decisions in the face of risk. Previous research has revealed that sex and age are important determinants of risk-taking behaviour such that men are more likely to take risks than women and risk-taking decreases with age. However, prior work has rarely considered the effects of age and sex jointly, and disentangling risk-taking (actively choosing to take a risk) from risk-aversion (actively choosing to reduce risk) behaviour has been challenging. In this study we use an extensive dataset derived from a television game show ('The Chase') which is structured in a way that allows us to address these issues and control for additional contributors to decisions concerning risk. Because the financial pay-off of the game show varies based on player's performance (which also gives the players an immediate indication of their ability in the context of the game), we can also control for different individual's ability and cost-benefit trade-offs to investigate the influence of age and sex on both risk-taking and risk-averse behaviour. We find robust evidence that males are more prone to take risks and less likely to actively reduce risks. In contrast to previous research, we find that risk-taking peaks around middle-age and risk-aversion is highest in younger adults and decreases non-linearly with age. We discuss these results in the context of equality issues surrounding career progression of women in science and suggest possible (partial) solutions.

### **The influence of early life socialisation on contest behaviour.**

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Animal contest models are based on particular assessment strategies ranging from self assessment whereby an individual only uses information on its own fighting ability (Resource Holding Potential, RHP) to mutual assessment involving a comparison of own ability to that of an opponent. While the influence of experience on contest outcome has been well studied, identifying so-called winner and loser effects, the influence of experience on contest assessment strategies has remained unexplored. By examining the welfare issue of aggression in pig production our group has been able to use this as a model system to address fundamental questions from contest theory. In this regard we recently demonstrated the role of experience in the development of mutual assessment (Camerlink et al. 2017, *Scientific Reports*, 7, 14492). Here we focus on the effect of early life experience. This comprised an early life manipulation, termed socialisation, during which adjacent litters of piglets were allowed to mix (14-28 days of age), with control litters remaining unmixed. Socialisation was hypothesised to equip individuals with enhanced social skills in terms of assessment ability in later life agonistic encounters. In resident-intruder tests at seven weeks of age socialised pigs had a shorter attack latency, while in dyadic contests at eight weeks of age they had shorter contests, with fewer skin lesions consistent with enhanced assessment. While furthering our fundamental understanding of contests, these results also highlight that early life socialisation offers a potential intervention that can be used in an applied animal welfare context to reduce aggression.

### **Gene-by-gene interaction in a clonal invertebrate**

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Inter-individual differences in behaviour have been demonstrated in many taxa. Although individual behaviour depends on a wide array of environmental factors, it is also commonly heritable. However, little is known about the genetic mechanisms underlying behavioural differences, particularly in the context of social traits where variation might be driven by interacting genotypes. To investigate the adaptive value of individual differences, we look at the genetic mechanisms underpinning variation in a facultatively clonal invertebrate, the sea anemone *Anemonia viridis*. We created clonal lines in the laboratory by natural or artificial fission of individuals collected in the wild, and forced competitive interactions between clone mates and non-clone mates. Using genetically identical individuals, and experimentally manipulating the social environment, we test for gene-by-gene interactions on behaviour while negating the need for complex breeding lines or pedigree-based analysis. Using clonal lines developed from individuals collected in different geographic locations, we additionally test for the effect of relatedness. We show that the expression of individual behaviour is affected by focal and opponent genotypes, and by their interaction. This study adds to the growing but still sparse evidence on the genetic basis of the adaptive value of individual behavioural differences, until now difficult to demonstrate.

### **Acoustic signatures in Asian elephant High Frequency Vocalizations**

**V.C. Beeck, A.S. Stoeger**

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Asian (*Elephas maximus*) and African elephants (*Loxodonta africana*) use individual distinct low frequency "rumbles" (fundamental frequency < 20 Hz) to coordinate social interactions within their complex fission-fusion society. Both species' repertoires also include high-pitched "trumpets", but only Asian elephants produce specific high-frequency vocalizations, termed "squeals" and "squeaks". They are suggested to signal arousal and to function as alarm signal to summon up conspecifics and/or as a submissive signal. If so, we predict acoustic variation among individuals in order to be identified by supportive bond partners. This was studied by acoustic recordings and behavioural observations of captive Asian elephants (Nepal, N=14). Only four elephants produced "squeals/squeaks" in the context of begging, avoidance in elephant-handler interactions and alarm. Acoustic differences appeared among individuals and contexts. Only the latter triggered support and consolation only in bond partners, indicating that Asian elephants can perceive individual and context-dependent acoustic variation and react adequately. The study will include further data collection to enlarge the sample size and questionnaires to the handlers on the elephants' personalities, social status and social relationships to comply the behavioural observations. In addition, we will investigate sound production using an acoustic camera to visualize sound emission (oral or nasal).

### **The use of color and location cues by foraging sunbirds.**

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Foraging requires animals to search for food that may be variably distributed. Learning and following cues (e.g. visual and olfactory) while relocating food sources may enhance foraging efficiency. Nectarivorous birds have high energy requirements due to their small body size and high metabolic rate. Therefore, they often need to feed from hundreds of flowers a day to satisfy their energy demands. If a bird can remember distinctive cues (e.g. specific flower color or location) that help to find and relocate rewarding flowers, it will increase the certainty of foraging decisions. The objective of this study was to investigate the use of location and color cues of flowers by Palestine sunbirds when learning to discriminate and remember rewarding and non-rewarding flowers. Using an array of artificial flowers, we found that sunbirds' performance is similar when learning a location cue or a color cue but significantly higher when both cues are available. These results imply that the combination of information when using both cues result in more reliable knowledge about floral nectar. Such information increases bird performance by helping them to avoid non-rewarding flowers, thus indicating an added value when using both cues as opposed to just one. Palestine sunbirds are territorial, thus learning location cues of flowers in one's territory can be beneficial. However, Palestine sunbirds also wander outside their territory looking for food sources when food is scarce. Thus, other cues (e.g. color) in unfamiliar environments, especially when location cues are not available, could help in identifying rewarding food sources.

### **Insight into the Vocal Communication of the Neotropical River Otter**

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Most aquatic mammals have complex social and communication systems. Otters form a group of carnivores highly adapted to aquatic life but sociality differs across species. Interestingly, very little is known about their vocal communication compared to other aquatic mammals. Here, for the first time we acoustically describe vocalizations of *Lontra longicaudis*, a solitary (and highly endangered) otter species. We recorded vocalizations and behavioural context from seven captive neotropical otters at Projeto Lontra, Santa Catarina Island, Brazil. Analysis of source and filter related acoustics parameters were used to classify the vocalizations according to structure and context. We describe 7 vocalization types emitted in different behavioural contexts. We found highly tonal as well as chaotic vocalisations ranging from 90 to 2500 Hz. Additionally we observed sex variation on the frequency of occurrence of different call types (e.g. scream and whistle). Preliminary results suggest that the neotropical river otter has a rich vocal repertoire similar in complexity to other solitary otter species but less complex than that of the social giant otter. This supports the correlation between vocal complexity and sociability found in other mammalian species. Despite differences in habitat and sociality, *L. longicaudis* seems to possess vocalizations also found in other otters (e.g. hah or whistle), suggesting phylogenetic inertia in their communicative repertoire. Otters thus offer an interesting but neglected group to explore the evolution of communication systems.

### **Love, not food, could have paved the path for dog domestication – A lesson from free-ranging dogs.**

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Domesticated dogs (*Canis lupus familiaris*) share special bonds with humans. Their high levels of social communicative skills and hypersocial behaviours have made them “man’s best friend”. While pet dogs’ formation of trust towards their owners stand strongly on positive reinforcements, little or nothing is known about the free-ranging dogs (~ 80% of the world’s dog population). Free-ranging dogs provide an excellent model system to investigate the dog-human relationship in various social contexts. In India, they share every possible human habitat, interacting frequently with humans. The free-ranging dog-human relationship is quite complex and portray both positive and negative counterparts. Humans provide food and shelter, but also create considerable window of conflict for the dogs. Scattering garbage while scavenging, barking, biting are some of the behaviours of dogs that antagonize humans, leading to chasing away, beating and even killing of dogs by people. Hence, dogs’ assessment of unfamiliar humans is primary key step in forming a mutualistic relationship. We tested 103 adult dogs in urban environments to investigate their response towards immediate social (petting) and long-term food and social rewards. The dogs were provided a choice of obtaining food either from an experimenter’s hand or the ground. Results revealed that most dogs avoided making physical contact with the unfamiliar human. While immediate social reward was not effective in changing this response, the long-term test showed a fairly strong effect of petting over food. We conclude that these dogs tend to build trust based on affection, not food, through a process of learning.



### **Ontogeny of play and problem-solving competences: a longitudinal comparative study in three species of corvids**

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The development of tool use competences is likely to be pre-announced, and probably influenced, by style and intensity of object-directed playing, especially when involving combinatorial actions. We investigated the relation between individual combinatorial activity during free play and during performance in problem-solving situations, using juveniles from three corvid species: the tool-using New Caledonian crow (*Corvus moneduloides*, n=3), and the non-tool-using jackdaw (*Corvus monedula*, n=4) and raven (*Corvus corax*, n=3). In each species, some subjects were repeatedly exposed to a human demonstrator manipulating and combining objects while others (controls) were exposed to a similar amount of manipulatory actions but without object combinations. All subjects were later tested on a battery of tool and non-tool problem-solving tasks. We found that the demonstrations influenced the choice of objects manipulated by the birds, but not the type of manipulatory actions they performed (combinatorial vs simple actions). Object play differed between species even a few weeks after fledging, confirming data from existing literature: there were more object combinations in toolusing crows, and more object caching in ravens, as compared to the other two species respectively. While only the tool-using New Caledonian crows developed tool competences, we found no species differences in performance in non-tool tasks, and no within-species differences between our juvenile subjects and typical adult performance in each species.

### **Recognition of artificial predators on a long-term basis in common ravens (*Corvus corax*)**

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A common predator-response behaviour among birds is mobbing. Learning about novel threats allows individuals to adapt this behaviour to new threats. Previous studies showed wild American crows to be capable of remembering newly introduced artificial predators on a long term basis. We used a similar approach on another member of the corvid family, the common raven. Two groups of captive non-breeders (n=16) were exposed to masked humans subsequently walking past the aviary. The “predator mask” was carrying a dead raven, while the “control mask” was not. After four initial training presentations all following presentations were conducted without the dead raven over a time span of six years. We were interested in i) how quickly the ravens would start to mob the predator mask, ii) how long they would display mobbing selectively and iii) how their performance might be influenced by social dynamics. Our results indicate a quick learning process and a long-term fidelity. Type of raising, kin and dominance status influenced the birds’ participation in mobbing. In a second study, we investigated the mobbing performance of a group of naïve ravens (n=10) that arrived one year after the initial training phase. The aviary layout permitted the new arrivals to observe the group response of their trained neighbours, providing valuable information on both masks and giving opportunity for cultural transmission. Similarities and differences in mobbing responses between trained and naïve birds will be discussed.

### Proximity sensors reveal nocturnal activity patterns in a wild rock hyrax population

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Monitoring nocturnal activity of diurnal species is challenging because observations are limited, and individual may be hidden in foliage or underground. As a consequence, publications on nocturnal behaviour are underrepresented in the scientific literature and a gap remains in our knowledge. To overcome these limitations, we used automatic proximity loggers to investigate social behaviors in wild rock hyraxes living in the Ein Gedi Nature Reserve, Israel. Thirty-one devices continuously recorded animals' encounters over a period of 4 months and provided us with high-resolution accurate data on nocturnal interactions. We expected hyraxes to have longer interactions at night than during daytime. In addition, theory predicted animals would enter deep sleep stages in the beginning of the night while shifting to lighter sleep afterwards, which should translate into longer interactions in the first night hours. Finally, social sleep might be a strategy to increase the chances to wake up near potential foraging partners the next morning. Our results demonstrate a sharp day/night contrast with significantly longer interactions at night, although hyraxes exhibited sociality peaks at dawn and dusk. We found a strong correlation between the amount of time spent interacting during the day and at night, thus supporting the hypothesis of 'foraging partners proximity'. However, in contrast to predictions, the duration of interactions was not longer in the beginning of the night, suggesting that hyraxes do not modify their patterns according to sleep cycles. These results call for the development of new theory regarding nocturnal activity. They also demonstrate the potential of new tracking technology to open new areas of research, such as nocturnal social networks.

### Do wild fledgling tits mob in response to adult mobbing calls?

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Mobbing, a behaviour where birds harass a predator through a combination of vocalizations and stereotyped behaviours (wing flicking, flip-flopping, etc.), is an effective anti-predator behaviour for many species. As they are often more vulnerable than adults, mobbing may be particularly important for juveniles. Although mobbing behaviour itself is often considered to be an unlearned behaviour, there are few confirmatory data, and the developmental trajectory of this behaviour is unknown. In this study, we tested whether either conspecific or heterospecific mobbing calls initiated mobbing behaviour in juvenile blue tits. We located wild adult, and recently fledged juvenile, blue tits *Cyanistes caeruleus* and presented them with playback recordings of adult conspecific (blue tit) and heterospecific (great tit) mobbing alarm calls. Although adult birds readily mob in response to these types of playback experiments, juveniles did not exhibit characteristic mobbing behaviour. Some juveniles did exhibit some of the component behaviours found in mobbing but they did not produce adult-like mobbing behaviour in response to either conspecific or heterospecific playback. These results suggest that, while birds might be capable of producing mobbing behaviour as juveniles, the associations between the non-vocal stereotyped mobbing behaviours and mobbing calls, may be learned.

### **Prenatal maternal stress impairs the development of cognitive abilities in Japanese quail (*Coturnix c. japonica*)**

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It is well established that the prenatal environment can have profound and long-term influences on individual behavioural development. The exposure of a gestating or laying female to stressful events, affects their offspring's emotional reactivity and social behaviour through hormonal modulations of fetal environment or yolk contents. In mammals, this prenatal maternal stress can also impact offspring's cognitive abilities but in birds such effects have rarely been explored. This study aimed to evaluate the effect of prenatal maternal stress on Japanese quail's learning capacities. For 24 days, laying quails were either submitted daily to unpredictable and repeated aversive stimuli (physical restraint, unexpected sounds, overcrowding, air or water spurt, etc.) or left undisturbed. Then, the emotional reactivity and learning abilities of females' offspring were analyzed. Our results confirm that prenatal maternal stress affects emotional reactivity as stressed females' offspring were more emotive in emergence and novel object tests than those of controls. But, we show also that prenatal maternal stress impairs offspring's learning abilities. Firstly, stressed females' chicks were less efficient during the probe test of a spatial learning task. Secondly, they failed in a conditioned place preference test as contrary to the control birds, they were not able to learn the rewarded place. Here we evidence that prenatal maternal stress impacts offspring's behavioural development and cognitive abilities that may impair individual's capacity to adapt to their environment.

### **Competitive ability and scent mark investment in groups of male bank voles, *Myodes glareolus***

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Animals repeatedly encounter multiple conspecifics in wild populations creating complex competition networks between groups of individuals. However, most studies investigating competition between males have focused on short dyadic encounters between pairs of males. Frequency of scent marking is often linked to competitive ability in male rodents, with dominant males depositing significantly more marks than subordinates. Further, scent marks often differ in quality, with rodents increasing investment in specific components, such as urinary proteins, under competitive conditions. Here, we investigate the relationship between competitive ability and scent mark investment in groups of male bank voles housed in enclosures. Although male bank voles are solitary, they live in overlapping territories, presenting an ideal opportunity to investigate competition between multiple males. Male bank voles were regularly allowed to interact with other members of the group and scent marking rates were measured before and after interactions. Competitive ability and activity patterns were determined through behavioural observations and RFID tag data. Changes in urinary protein output and investment in glareosin, a male-specific urinary protein upregulated during the breeding season, were also explored. Combining video footage and RFID tag data with protein analysis and scent mark counts has allowed us to investigate competition between multiple males and address the relationship between individual competitive ability and male investment in scent marking.

### Attention bias tasks: A cognitive welfare indicator for Sulawesi crested macaques?

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Good primate welfare requires minimizing negative emotions and promoting positive ones. This poses the challenge of how to recognize subjective states in non-verbal animals. One emerging method is to study emotion-modulated attention biases. Previous research has shown that primate attention is biased towards potentially threatening or emotional stimuli. To test this, we trained a group of critically endangered Sulawesi crested macaques (n=5) to perform three touchscreen tasks, involving images containing different levels of social threat. Adapted from human studies, the tasks were: 1) a simple matching-to-sample, 2) a 9×9 visual search, and 3) a dot-probe. Each was flexible, cost-effective, and could be easily reproduced. Biases were quantified using task accuracy and latency to respond to the images. This research was the first to explore attentional bias in this species. A classic dot-probe effect was observed: disengagement from threat was slower when the probe replaced non-social stimuli. Whilst stimulus type influenced accuracy in matching-to-sample and visual search tasks, no effect was found for response times. In all three experiments, responses slowed over time, indicating habituation to the tasks. Altogether, this proof-of-concept study validates the dot-probe task as a measure for attentional bias in macaques. Applications of these methods as welfare indicators are discussed.

### Individual consistency in flight response to human-disturbance: The case of a roe deer population inhabiting a heterogeneous landscape

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Because avoiding predation is crucial for fitness, foraging animals must trade acquisition of high-quality resources against risk avoidance, and exhibit escape behaviour accordingly. Indeed, flight behaviour has been found to depend on context, highlighting some behavioural plasticity. However, individuals within populations can also differ in how they respond to disturbance according to their individual sensitivity or personality. Since 2010, flight responses to human approaches were performed repeatedly on marked European roe deer, *Capreolus capreolus*, inhabiting a heterogeneous and agricultural landscape in the South-west of France. The detection, assessment and flight initiation distances as well as the individual behaviour during flight were recorded for 83 individuals with a mean of  $5 \pm 2.5$  approaches per animal (N=465 approaches, range: 3-20 per individual). Behavioural consistency is a key assumption when evaluating how between-individual differences in behaviour influence life history tactics. Hence, evaluate how predictable different behaviours are and which factors influence their level of consistency is crucial. Here, we first aimed to assess the consistency of individual flight response to human-disturbance in a free-ranging population of roe deer. Secondly, since few studies of wild populations have investigated variation in repeatability in relation to individual status (e.g. sex, age, condition) and over different timescales, we also aimed to assess within population variation in the repeatability of flight response. First preliminary results have shown a relatively low overall repeatability of flight distances, highlighting the need of a deeper understanding on how and why repeatability in flight behaviour may vary according to individual or temporal factors.

### **Maternal influences on vocal development in a precocial bird, the Japanese Quail (*Coturnix c. japonica*)**

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In many mammals and birds, the mother play a major role in the development of their young through pre- and postnatal influences. As early as prenatally, the embryo is exposed to olfactory, visual and auditory stimulations that are likely to affect the behavioural expression of the young during postnatal life. In particular, several studies have shown the effects of auditory stimulation in ovo on perceptual responses or hearing preferences for maternal vocalizations after hatching. The mother can also influence the behavioural phenotype of her young at the postnatal stage through her presence and behaviour. In this study, we explored both prenatal and postnatal maternal influences on the vocal development of a precocial bird, the Japanese quail (*Coturnix c. japonica*). To do this, fertilized eggs were incubated in the laboratory, and they were stimulated (s) or not (ns) by maternal vocalizations during the last days of incubation. After hatching, the stimulated group and the control groups were paired, and were raised with (M) or without an adoptive mother (NM). The vocal development of chicks from four experimental groups were thus compared: Ms, Mns, NMs and NMns. Vocalizations were recorded in situation of social isolation (separation from the familiar chick (all groups) and from the mother (Ms and Mns), during the mothering period and until the age of two months. The first results indicate pre- and postnatal maternal influences on vocalizations' structure. This confirms that vocal plasticity exists in the Japanese quail, a species that is traditionally considered as a non-vocal learner.

### **Field experiment investigating social integration strategies in wild dispersing male vervet monkeys**

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In a species with female philopatry, male vervet monkeys face the challenge of dispersing from their natal group to avoid inbreeding. Whilst some males attempting to join a new group often face challenging hostility from group residents, others integrate more easily. Investigating strategies that male vervet monkeys use to socially integrate into new groups is of great interest. Evidence suggests that males adapt aspects of their behaviour to match that of the majority of their new group, including switching their own food preferences. This indicates that they socially learn from their new group. Evidence also suggests that, generally, females are preferred social models, but this is flexible and varies between individuals. Whilst philopatric females can be expected to have the best knowledge of their territory, groups must also adapt to unexpected changes in the environment. As males tend to disperse into neighbouring groups with highly overlapping territories, they could be a potential source of novel information for the group. This field experiment aims to test whether showing special knowledge about a large novel food source aids male social integration and status acquisition in a new group. One study group will be trained to travel to the source of a novel sound to access a large sharable amount of food. When males disperse to other study groups, we predict that showing this knowledge to their new group will correspond with an increase in their centrality in social networks, or an increase in social status in the dominance hierarchy, or both.

## The evolution of mate choice

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Mate choice is an incredibly important evolutionary process that is observed in almost all animal groups. Nevertheless, we see huge variation in how choosy animals are when selecting mates, and we still do not understand why. One reason for such variation could be that the costs and benefits of mate choice vary in different environments. A particularly important factor that influences the costs and benefits of mate choice is the population sex ratio. The population sex ratio influences the amount of competition for access to mates faced by each sex, and individuals of the rarer sex are predicted to be choosy, as they have greater mating opportunities. Changes in the population sex ratio have been shown to influence mate choice in the short term. However, few studies have looked at long-term changes in mate choice in response to changes in the population sex ratio, or in response to consistent environmental change more generally. We will measure the strength of male mate choice in populations of the Indian meal moth, *Plodia interpunctella*, which have been maintained in the lab under two different sex ratios (male-biased versus female-biased) for over 130 generations. Specifically, we will test whether male preference for females in high condition differs between individuals from male-biased or female-biased populations. This study will therefore examine the evolvability of mate choice, and the importance of the population sex ratio in driving the evolution of choice.

## Consequences of early life social environment on scent marking behaviour of male house mice.

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Early life environments have many important consequences for later life behaviours and physiology. In this study we investigated whether the social environment experienced during development would affect later life competitive strategies, using male wild house mice (*Mus musculus domesticus*) reared in enclosures under different social conditions. House mice live in flexible social groups with mainly related but also unrelated group members. Reproductive competition between females for nest sites is intense and influences whether females rear offspring in single or communal nests. To create naturalistic social environments, we manipulated relatedness within groups of four adult resident females (high or low relatedness) and competition for favoured nest sites (high or low competition). Male offspring reared within these environments were housed individually at weaning, and quantified competitive responses to artificial scent marks from unfamiliar rival males (related or unrelated). Scent marking plays a major part in mediating male-male competition, with dominant males marking more than subordinates and countermarking scent marks from territory intruders. We predicted that scent marking in males is influenced by social conditions experienced during rearing, preparing them for low social conflict (related, low competition) or high social conflict (unrelated, high competition). Contrary to our prediction, early life social environment did not influence scent marking behaviour. Instead, scent marking varied with body mass of subjects and type of scent mark stimulus. Results highlight the greater importance of current social conditions in determining scent marking behaviour in male house mice, underlying the flexibility and adaptability of this highly social mammal.

### **I'm not going back there! Calves avoid the pen where they were disbudded.**

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Dairy calves are routinely disbudded by cauterization with a hot iron. To mitigate pain associated with this procedure some dairy farmers provide calves general and local anaesthetics. It is unknown if disbudding is still unpleasant for the calves even when pain mitigation is provided. The aim of this study was to use place conditioning to test if disbudding (combined with sedation and local anaesthetic) would be more aversive to calves than a control procedure. Nine Holstein calves (35±16d) were enrolled. A 2.4x7.3m test area was divided into equally sized pens: two "Treatment" pens with distinct visual cues connected by a "Neutral" pen. Each calf went through the disbudding procedure (Rompun, 0.1mg/kg; Lidocaine, 10mL; hot iron disbudding) in one Treatment pen and the control procedure (Rompun, 0.1mg/kg) in the other Treatment pen, allowing each calf to act as its own control. In three subsequent tests (48h, 72h and 96h after the last treatment) calves freely roamed between the pens until they lay down. In the first test session calves spent less time in the pen associated with disbudding (Mean±S.E.: -282±56s,  $t_8=-5.0$ ,  $P=0.001$ ), but this difference was reduced in the second (-152±108s,  $t_8=-1.4$ ,  $P=0.2$ ) and third (59±154s,  $t_8=0.4$ ,  $P=0.7$ ) sessions. Calves were also less likely to lie down in the pen associated with the disbudding procedure (twice out of 27 tests,  $\chi^2=9.6$ ,  $P=0.008$ ). We conclude that disbudding with a sedative and local anaesthetic is more aversive than the sedation procedure and suggest that disbudding should be avoided or further refined.

### **Update on host manipulation by acanthocephalan parasites : a meta-analysis**

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Host manipulation by parasites (HMP) refers to the ability of parasites to alter their host's phenotype in ways that favour their own transmission. Yet, robust evidence for HMP as an adaptation is weak in regard to the reported cases of HMP. Meta-analysis is a powerful method to gather, weight and analyze evidence from literature survey. Here, we run a meta-analysis based on more than 40 years of studies to review host manipulation by acanthocephalans (trophically-transmitted parasites) We addressed global intensity of phenotypic changes independently and related to parasite transmission with absolute and standardized effect sizes, respectively. Then, we conducted a meta-regression to detect possible abiotic and / or biotic factors that could explain variations in the intensity of manipulation. We first found that independently from and related to parasite transmission, the intensity of phenotypic changes was medium. Interestingly, the intensity of HMP was independent from the phylogeny of acanthocephalan species suggesting that HMP is likely to be an ancestral trait in acanthocephalans. The category of traits (behaviour, life-history, morphology, physiology and predation vulnerability) and parasite maturity (non-infective versus infective stages) were the most important factors that could explain variation in the intensity of HMP when changes were related to parasite transmission. Independently from parasite transmission, behavioural traits were not more affected than physiological ones, confirming the multidimensionality of HMP, and leaving open the possibility of HMP having evolved as a by-product of infection. We ended by suggesting some perspectives about points of interest and methodologies to apply.

**A volatile situation: attraction of male house mice to female urine**

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Odour signals are important in the social communication of mammals, and a key role of chemical signalling by females is to advertise sexual receptivity and fertility. In this study we investigated the attraction of male house mice (*Mus musculus domesticus*) to female urinary odour signals. Urine is particularly important in house mouse communication, and contains both volatile and non-volatile signalling components. In this study we tested male attraction to the urine of oestrus versus juvenile females when 1) they had access to the full urine scent cue and 2) when their investigation was restricted to volatile components only. Our results confirm that male house mice spend significantly more time interacting with the urine from oestrus females compared to juveniles, and provide evidence of increased attraction to the urinary volatiles of oestrus females when investigation of the full urine cue is restricted. Our results thus provide evidence for a signal of sexual receptivity in female house mice that is at least partly communicated in the volatile components of urine.

**Prenatal allocation decisions in a cooperatively breeding species: assessing the effects of helpers, climate and nest predation risk**R. Fortuna<sup>1</sup>, C. Doutrelant<sup>2</sup>, M. Paquet<sup>3</sup>, R. Covas<sup>14</sup>

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In egg laying species, mothers' investment decisions include allocating resources to egg size, number and contents. Breeding females have been found to adjust egg investment in relation to factors ranging from temperature to mate attractiveness or sociality. Such maternal effects are expected when mothers can predict postnatal conditions based on the current environment, thereby modulating offspring's phenotype in a way that optimises her own and/or her offspring fitness. In cooperatively breeding species, mothers have been found to use the presence of helpers as a cue of enhanced conditions. Females were previously shown to lay smaller eggs when assisted by helpers, but long-term investigations suggest a large plasticity on females' response to helpers' presence. This variation is likely to arise from variation in the several environmental factors that may modulate the effects of the social group. Nest predation probability is predicted to be another key factor influencing maternal allocation. Previous empirical studies have found that females laid bigger eggs when predation risk was reduced or smaller clutches when nest predation probability increased. We monitored the egg mass and number of over 3000 clutches together with temperature and rainfall for 10 years in a colonial cooperative bird, the sociable weaver *Philetairus socius*. Throughout this period, we manipulated nestling survival probability by protecting some colonies against snake predation. Intra-female comparisons as they lost or gained helpers allowed us to assess the ecological and social drivers of maternal investment strategies in this cooperative breeding system.



**Is group familiarity important in conservation translocations?****V. Franks<sup>12</sup>, C. Andrews<sup>12</sup>, J. Ewen<sup>2</sup>, M. McCready<sup>2</sup>, K. Parker<sup>3</sup>, R. Thorogood<sup>14</sup>**

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Translocations create an abrupt transition to an unknown environment. Learning by observing others (social learning) may be an important way for naïve animals to adapt their behaviour quickly and survive the post-release period, particularly if peers are familiar. However, there are few detailed studies of how social bonds are maintained or disrupted during translocations, or if altered social dynamics have consequences for population stability and the success of our conservation actions. Establishing new populations (or supplementing pre-existing ones) by moving groups of juveniles is a main focus of conservation for hihi (*Notiomystis cincta*), a threatened New Zealand passerine. Juvenile hihi are social and form groups once independent from parents, and they learn socially in these groups about food resources in situ. We used a recent translocation to test how movement changes social bonds. We collected data on associations (i) pre-translocation, (ii) in temporary captivity during translocation, and (iii) following release. Additionally, during temporary captivity we established aviaries of familiar and unfamiliar hihi from within the source population to assess if translocating coherent groups maintained social bonds. We discuss the consequences of maintaining and disrupting social bonds for social learning (food finding) and survival post-release. Despite a growing awareness that the characteristics of social networks has consequences for the rapid spread of behavioural change, social associations are rarely accounted for in conservation translocation events. However, this could be an important consideration when animals change behaviour as a first-response mechanism to survive in new environments.

## **Social conformity in solitary crabs (*Carcinus maenas*) is driven by individual differences in behavioural plasticity**

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Group-living is widespread in the animal kingdom and recent studies into the mechanisms underlying group cohesion have highlighted the importance of between-individual behavioural differences ('personality'). Social conformity occurs when animals compromise their own behaviour to the level of a certain behaviour displayed by another individual or a group, and the degree to which individuals conform can depend upon personality differences. Social conformity can enhance group cohesion and ultimately predator avoidance and/or resource acquisition for group-living individuals. However, it remains unclear whether similar conformity effects exist in solitary species, which can form temporary aggregations and, if so, whether changes in behaviour in the presence of conspecifics are dependent on individuals' personalities in solitary contexts. We studied the effects of social context on behaviour in solitary shore crabs (*Carcinus maenas*). Individuals differed consistently in their activity levels within and across contexts and were significantly more active in solitary compared to dyadic contexts. Crabs' activity levels were more similar when tested together compared to when tested alone, indicating a social conformity effect. Furthermore, more active behavioural types decreased their activity to a greater extent when paired with a conspecific. Overall, our findings suggest that social conformity is moderated by individual behavioural differences in a solitary organism. It is often presumed that, over evolutionary time, the social structure of animal populations has important consequences for the evolution of personalities and vice versa. We suggest that studying solitary or facultatively social organisms may allow researchers to tease out causality between personality differences and socio-ecological dynamics.

## **Sheep wool cortisol: Intra-individual repeatability and plasticity in response to grazing-related changes in body mass**

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In recent years, hair cortisol analysis has been established as a powerful retrospective measure of chronic physiological stress in numerous mammal species. However, careful validation is necessary in order to assess whether hair cortisol analysis can be used as a reliable marker of long-term hypothalamus-pituitary axis activity. Here we evaluate the use of wool cortisol measures in  $n=33$  Welsh mountain barren ewes (*Ovis aries*). Specifically, we assess repeatability and differences in cortisol concentrations across (i) the wool shaft ( $n=3$  segments) and (ii) time ( $n=4$  samples per individual across a six-month period). In addition, we (iii) investigate effects of grazing-related changes in body mass on wool cortisol, controlling for age of subjects. For the latter, samples were collected (and sheep weighed) before and after two one-month grazing periods in a semi-improved enclosed 11.5 ha upland pasture in North Wales. Cortisol concentrations were repeatable but differed significantly across the wool shaft. The increase in body mass during grazing corresponded with a decrease in wool cortisol which was significantly negatively correlated with body weight and positively with age. Overall, our segmental analysis demonstrates consistent individual differences in wool cortisol and that a single sample per individual can be used to retrospectively assess physiological stress during different time periods. Furthermore, wool cortisol can be used to assess effects of gradually (as opposed to suddenly) changing variables (e.g. body condition) on individuals' stress physiology.

**“Don’t push, I come first!”. Selection of roost position in Spix’s disk-winged (*Thyroptera tricolor*) bat.**

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The costs and benefits associated with relative position within the group during commuting and foraging have been widely correlated with animal fitness, yet the selection of specific positions while roosting, and its costs and benefits, are unknown. Spix’s disk-winged bats (*Thyroptera tricolor*) roost in columns (one on the top of each other) inside tubular leaves of tropical plants (*Zingiberales* order) which are suitable as roosting sites for 8-16 hours, forcing individuals to change shelters each night. Despite the refuge’s ephemerality, the species is a suitable model for position fidelity studies: it displays high territoriality and forms stable and cohesive family groups (2-11 individuals). We recorded the positions of individuals with transponders injected subcutaneously to bats belonging to 9 different groups in Hacienda Barú Refuge (Puntarenas, Costa Rica) over a 2-month period with an average encounter of 8.4 days (min=5, max=15). The individual position was recorded scanning the leaf wall with a transponder reader and custom-made antenna. In 8 of the 9 groups, each individual showed a strong preference for a specific position within the leaf, with all positions being equally consistent among the groups. This suggests each position has intrinsic advantages and disadvantages (e.g. protection from rain or predators) which can be related to social roles or hierarchies. *T. tricolor* shows a complex communication system during roost searching, with some individuals potentially spending more energy than others for the task. A specific position in the leaf can provide benefits which may balance the search costs.

**Choice of high-quality mates vs. avoidance of low-quality**

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Research in sexual selection assumes that individuals attempt to choose high-quality mates, and that sexual signals evolve to indicate high quality. But it may often be more important to instead discriminate and avoid low-quality mates, thus reducing the likelihood of large penalties in fitness. We show, using simulations, that avoidance of low-quality mates (i.e., rejecting low-quality and accepting either high- or medium-quality mates) evolves in socio-ecological circumstances such as monogamy with moderate opportunities for choice, costly choice, or abundant low-quality mates. We also show that this strategy is qualitatively different from choosing high-quality mates (i.e., preferring high-quality over medium- and low-quality mates). Rather than selecting signals that distinguish high- from low- and medium-quality mates, avoiding low-quality mates selects for signals or cues attuned at discriminating low-quality mates from the remaining (e.g., low-cost signals, signaling mistakes). This helps explain the high diversity of sexual signals in nature, and their high evolutionary turnover with frequent losses and replacements (rather than reductions/increases of the same signal) over evolutionary time.

## Effects of dietary and environmental enrichment on growth and behaviour in zebrafish

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Many species across a range of taxa are experiencing sustained and increasingly rapid environmental change, and the ability of animals to adapt to rapid change is of concern. There are three main mechanisms by which a population can adapt to cope with environmental stress; dispersal to preferred environmental conditions, phenotypic plasticity and, in the long term, genetic evolution and fixation of alleles which match phenotype to local conditions. While early life experience is a key modulator of adult phenotype, we were interested in the phenotypic change in response to environmental variation experienced in adulthood. We gave 9 month-old zebrafish four-week treatments of either dietary or environmental enrichment and carried out individual and group tests of behaviour before and after treatment. We used a combination of motion tracking, trajectory analysis and image analysis to measure growth, individual behaviour and social behaviour. We found that increased dietary protein resulted in significant increases in body length but also affected social behaviour, increasing shoaling time. Increased environmental enrichment had more pronounced behavioural effects and resulted in increased shoaling time, reduced shoaling distance, increased swimming speed and reduced anxiety-like behaviour. Our results suggest that zebrafish behaviour is sensitive to both dietary and environmental enrichment in adulthood, that effects are seen across different behaviours, but that zebrafish behaviour in adulthood is more sensitive to environmental change than to dietary change.

## Predatory behavior in the Broadclub Cuttlefish (*Sepia latimanus*)

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Predators, such as most cephalopods, actively seek out and hunt their food. The challenges of hunting live prey are approaching undetected, catching and overpowering the prey. However, even after a successful hunt, the predator can remain vulnerable, either to conspecifics who want the same food, or to other predators. *Sepia latimanus* display a unique sequence of behaviors, from detection of prey to capture and eating. In this study we observed the hunting behavior of 13 subadult Broadclub Cuttlefish (*Sepia latimanus*). In total 133 instances of hunting 3 different types of food (shrimp, fish, and crabs) were video recorded and analyzed. Behaviors recorded were the posture of the arms (round, triangular, laterally extended and lure, Fig. 3, Fig. 5), the success of the attack, and which pattern (standard hunting, pale, yellow and passing cloud) was exhibited before tentacle extension. Hunting prey in cuttlefish consists of a sequence of behaviors: detecting prey, approaching the prey, catching the prey and then securing and eating the prey. During the approach phase cuttlefish showed a clear preference to use specific body postures (Fig 1) and patterns (Fig 4) for certain prey items. An interesting observation that warrants further investigation is the fact that in 133 cases of cuttlefish hunting only 1 case of cuttlefish attacking the same prey item occurred. Even then the cuttlefish parted without a further fight. This number is much lower than other cephalopod species that are found in groups, for example in Big fin Reef squid approximately 1 in 8 attacks results in a fight between animals.

## Peace, Love, and AVP

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To live in social groups, animals need to be motivated to interact with conspecifics and be able to distinguish between group members and strangers. Arginine vasopressin (AVP) is a known modulator of several social interactions, including social recognition, affiliative behaviour, and social memory. We investigated the role of AVP in mediating the motivation to be social (sociability) and social recognition in two socially different species of African striped mouse, *Rhabdomys*, utilising the established three-chamber apparatus for testing sociability and social recognition, using the social discrimination paradigm. Ten females each of the naturally group-living *R. pumilio* and naturally solitary-living *R. dilectus* were used as the focal animals in the tests. Focal mice were sequentially injected subcutaneously with 20  $\mu$ L of saline, 1  $\mu$ g/g AVP (low AVP) or 1.5  $\mu$ g/g AVP (high AVP) on separate days. Both species displayed a propensity to be social in the sociability test, with high AVP significantly increasing the frequency of approach toward a conspecific in both species. Neither species displayed a preference for social novelty or familiarity in all three treatments, but AVP affected affiliative behaviour toward known and novel individuals in the two species differently: AVP enhanced amicability for the familiar mouse in *R. dilectus*, and increased amicability toward the novel mouse in *R. pumilio*. Our findings suggest that AVP facilitates social approach in *Rhabdomys* but does not affect the preference for familiar or novel conspecifics. The differing effect on affiliative behaviour could indicate a mechanism behind the differences in sociality in these species.

## The role of affective state in the evolution of deimatic displays

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Many prey species deter predators by performing deimatic displays composed of characteristic movements and postures often in combination with visual, auditory, and olfactory stimuli. These displays have been suggested to work by startling predators. If deimatic displays do startle predators, we would expect manipulations of predator affective state to alter the responses of predators towards deimatic prey: startle responses are typically enhanced in anxious individuals and reduced in depressed individuals. Here, we present new research investigating the influence of affective state on the predatory responses of naïve avian predators towards artificial lepidopteran deimatic prey. Using an innovative playback protocol, we were able to manipulate the affective state of our experimental predators (domestic chicks, *Gallus gallus domesticus*), creating individuals in a neutral state, an anxiety-like state and a depressive-like state. We then presented these individuals with deimatic or control prey and monitored their responses. Our findings shed light on why predators are deterred by deimatic displays. They also provide important insight regarding how factors influencing predators' affective state (such as perceived predation risk, resource abundance, or intraspecific competition) could influence the efficacy of antipredator defences and, in turn, their evolution.

### **Are between- and within-individual behavioural variability linked? Results of a phylogenetic meta-analysis.**

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Mainstream animal personality research put the emphasis on consistent between-individual variation over time, often studying individuals from the same population under standardized environmental settings. While this approach undoubtedly helps us in understanding within-population behavioural polymorphism, or the evolution of behaviour in general, it also neglects variation in the next level: within-individual. Recently, behavioural plasticity (potentially adaptive individual change in behaviour induced by environmental change) and behavioural predictability (precision of expressing the behavioural type at the given prevailing conditions) were recognized as biologically relevant components of within-individual behavioural variation, with growing number of empirical results indicating non-random variation in both components. Yet, evolutionary ecology of within-individual behavioural variation is much less understood. It is especially important to reveal, whether behavioural plasticity and predictability are independent components of behavioural strategy or constrained by behavioural type (individual behavioural mean). We concluded a phylogenetic meta-analysis using data of both vertebrate and invertebrate taxa to test general correlations between behavioural type, behavioural plasticity and behavioural predictability. Our meta-analysis reveals variation in the presence/absence/direction of correlations between behavioural type and behavioural predictability with no general correlation. Further, the results indicate that the correlations between behavioural type and behavioural plasticity typically do not differ significantly from zero and there is no general correlation either. These findings indirectly suggest that the link between behavioural type, behavioural plasticity and predictability is rather shaped by selection than physiological, developmental or environmental constraints.

### **Can you think outside the box? How habit propensity and mental fixation could influence innovativeness and problem solving skills in humans**

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When we encounter a new problem, finding an innovative solution can be crucial. Divergent thinking (the process of generating creative ideas by exploring many possible solutions) and convergent thinking (the process of finding a single, correct solution to a problem) are mechanisms that help us to do that. But several factors, such as habitual actions (driven by stimulus-response associations only) and mental fixation (the negative effect of previous experience when solving new problems; in other words, being unable to “think outside the box”) could affect these aspects of human innovation and problem solving skills.

### **Preliminary observations of the ‘sleep-like’ resting state in the broadclub cuttlefish, *Sepia latimanus***

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We describe rhythmic activity expressed during the resting state in young broadclub cuttlefish (< 2 months post hatch). Preliminary observations reveal that cuttlefish demonstrate behavioural patterns of activity during rest. The animals show short episodes of rapid body color and pattern changes coupled with eye movement and arm twitching while in the resting state. These episodes are phasic in nature lasting ~1 minute separated by ~10-15 minutes of a rest state without this activity. This phenomenon was observed in-ovo (as early as ~24 hours before hatch). *S. latimanus* therefore presents an opportunity to study complex sleep-like behavior in an invertebrate using an ontogenetic framework.

### **Human attitudes towards reptiles: the relationship between fear, disgust and aesthetic preferences**

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Snakes represent evolutionarily prioritized stimuli to humans. Based on our previous studies, snakes may evoke several emotions; besides fear, disgust or positive emotion of joy accompanying aesthetic judgements are also involved. A following question is whether these reactions might originate from emotions evoked by other reptiles. Thus, we designed a study of human perception of all reptiles (snakes, lizards, turtles, and crocodiles) focusing on the relationship between perceived fear, disgust, and aesthetic preferences and differences between snakes and other reptiles. We developed 2 sets containing 127 standardized photos of reptile species, one from each subfamily. Respondents were asked to rate the animals according to elicited fear, disgust, and perceived beauty on a 7-point scale. The results revealed a high agreement among respondents. In the whole set, there was a strong positive correlation between fear and disgust and a strong negative correlation between disgust and beauty and between fear and beauty. The results were similar in a subset of lizards, however, the relationship between beauty, fear, and disgust evoked by snakes was different. A significant positive correlation between fear and beauty in snakes was revealed, i.e. the most feared species of snakes also tend to be perceived as beautiful. When morphological traits behind this evaluation were analysed, the presence of legs and overall body form was essential for lizards/snakes differences in fear perception, dark and less saturated colours increased disgust evaluation, green and blue colour increased beauty perception of lizards, while a bright contrast pattern increased beauty of snakes.

### Exploring speed accuracy trade-offs in archerfish shooting decisions

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The trade-off between speed and accuracy is an important underlying constraint in decision making: where speed is favoured there is often a cost to accuracy, or vice versa. Archerfish (*Toxotes* spp.), famous for their ability to shoot down prey with controlled jets of water, are able to maintain high accuracy while making rapid decisions and sensorimotor responses. To ensure they reach their prey faster than competing foragers after a successful shot, archerfish must solve complex problems at an impressive speed, assessing multiple variables to determine the point of impact of their falling prey. Previous studies have shown they are able to do this rapidly, within the critical period after making a successful shot and before their prey hits the water surface. However, before taking a shot archerfish must also make decisions about what to shoot. Using a longitudinal study we explored the effects of speed and latency to shoot on accuracy in a foraging experiment with differentially rewarded targets. Our results indicate that in visual discrimination of high and low reward targets, archerfish are bound by speed accuracy trade-offs, and fish are more likely to shoot a target with a greater reward if they take more time before shooting. Our results also suggest that individual archerfish may employ different strategies – some archerfish consistently shoot more rapidly with a commensurate cost to a success while others take longer to shoot and have higher success rates.

### Does a co-actor matter? The feeding behaviour of long-tailed macaques (*Macaca fascicularis*) in competitive and non-competitive setups

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Social comparisons are a fundamental characteristic of humans, yet little is known about their evolutionary foundations. When doing a task, humans have been reported to assimilate their performance to a moderately better performing social partner. We assessed if long-tailed macaques compare themselves to others in similar ways, assuming it to be an adaptive behaviour in complex social groups. Here we explored whether the monkeys would be sensitive to a partner's performance when it has direct consequences for their own reward outcome. The setup consisted of a feeding board with 20 compartments, each baited with a food item. We assessed whether n=18 subjects adapted their feeding rate to the feeding behaviour of a partner in 4 conditions: feeding alone; a social control condition with a passive human experimenter present; a co-action condition, with the experimenter feeding at a higher-than-baseline speed from a second board; and a competition condition with both human and monkey feeding from the same board. If the monkeys would be affected by partner performance irrespective of own reward outcome, they should increase their feeding speed both in the co-action and the competition condition. However, subjects increased their feeding rate only in the competition condition, suggesting that own reward outcome was more important than partner performance.



## **Activation of the Social Behaviour Network in Zebrafish in Response to Different Social Cues**

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The 'social behaviour network' (SBN) is a proposed network of highly conserved and interconnected brain areas that are thought to regulate social behaviour across vertebrate taxa. To investigate the involvement of the SBN in social behaviour in zebrafish, we measured the expression of phosphorylated ribosome S6 (PS6), a marker of neuronal activation, in four major nodes of the SBN in response to different social cues. In teleosts, these major nodes are found in the dorsal telencephalon and the hypothalamic/preoptic area and are homologous to key brain areas involved in mammalian social behaviour. The regions observed were the preoptic area (POA), the dorsal portion of the ventral telencephalon (Vd), the ventral pallidum (Vs), and the ventral portion of the ventral telencephalon (Vv). These four regions are mediators of social behaviour and reward, making them crucial nodes to investigate cellular activation in order to understand the mechanisms underlying simple social behaviours. We investigated how these brain areas were activated after differing kinds of exposure to a shoal of conspecifics. Adult zebrafish were given one of four different social treatments: swimming with a shoal, visual and olfactory exposure to a shoal, visual exposure to a shoal, or a no-shoal control. After exposure, subjects' brains were immediately dissected and processed for immunohistochemistry and staining for PS6. Our results provide insight into how different social cues elicit activity across the SBN and indicate that different SBN areas respond differentially to different levels of social stimuli.

## **Animal personality: testing for trait repeatability and a behavioural syndrome in female Trinidadian guppies.**

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Animal personality has become a highly interesting field of research, with the main basic questions being whether personality traits are repeatable and whether they are intercorrelated, so as to form a behavioural syndrome. Here, we investigated these questions using laboratory-reared descendants of the guppy from a high-predation risk population (Quaré River) in Trinidad. We repeatedly assayed individual adult females for three behavioural traits on three consecutive days. We quantified their exploration tendency in a novel environment on Day 1, sociability on Day 2, and boldness (risk taking) on Day 3. These tests were repeated in the same sequence 1 week later. We measured exploration tendency as the proportion of the novel environment visited or 'explored', shoaling tendency as time spent associating with a conspecific stimulus shoal, and boldness as latency time to exit a refuge in a potentially risky environment. We estimated the repeatability of each of these behavioural variables using either a linear or a generalized linear mixed-effects model, depending on data distribution. All behavioural traits were found to be significantly repeatable and can therefore be considered consistent personality traits. To test for a behavioural syndrome, we used a multivariate mixed-model to estimate correlations between the three repeatable personality traits. None of the correlations between all possible pairings of these traits were significantly different from zero. In conclusion, although adult female guppies originating from a high-predation Trinidadian population exhibited repeatable personality traits, these traits did not form a behavioural syndrome and were thus independent of each other.

**A new approach to non-invasive monitoring of cryptic mammals.****N. Koch<sup>1</sup>**, R.J. Beynon<sup>1</sup>, J.L. Hurst<sup>2</sup>, M. Morris<sup>3</sup><sup>1</sup>Centre For Proteome Research, University of Liverpool, Liverpool, UK. <sup>2</sup>Mammalian Behaviour and Evolution Group, University of Liverpool, Liverpool, UK. <sup>3</sup>Waters, Wilmslow, UK.

Rapid Evaporative Ionisation Mass Spectrometry (REIMS) is a new way of analysing biological material by a very simple treatment. A diathermy electrode is used to burn biological material and generates an aerosol that is highly information rich. REIMS is fast, non-invasive and requires no sample preparation. We have investigated the potential of REIMS to be used as a non-invasive method for monitoring mammals, using faeces as the biological source. We have shown that discrimination between different species is readily achievable, but the aim of this study is to explore the extent to which REIMS can be used to discriminate donor sex, maturity or genotype. Preliminary analyses have been completed using laboratory strains (BALB/c, BALB.k, ICR(CD-1) and C57BL/6) of house mice (*Mus musculus domesticus*) under uniform conditions. Five faecal pellets were burned for 170 individuals and the spectra were analysed by Random Forests using Rstudio within R. The accuracies of assigning faecal pellets to the correct sex and age class were > 80%, suggesting that REIMS has the potential to identify sex and age from faecal material. REIMS could provide a new approach to analysis of material, including scat, collected from the field.

**Cellular scaling rules for brains of galliform (Galliformes) and anseriform birds (Anseriformes)****M. Kocourek<sup>1</sup>**, Y. Zhang<sup>1</sup>, C. Osadnik<sup>2</sup>, Y. Kersten<sup>2</sup>, S. Olkowicz<sup>1</sup>, P. Němec<sup>1</sup><sup>1</sup>Department of Zoology, Charles University, Prague, Czech Republic. <sup>2</sup>Department of General Zoology, University of Duisburg-Essen, Essen, Germany.

Galliform birds (landfowl) and anseriform birds (waterfowl) together make up the *Galloanserae*, the sister group of *Neoaves* and the most basal clade of *Neognathae*. The galliform birds feature low encephalization, a proportionally small telencephalon and generally lower neuronal densities. Therefore, their brains harbour much smaller absolute numbers of neurons than equivalently sized brains of other birds. Galliform birds resemble mammals in having small telencephalic (24–37 % of brain neurons) and dominant cerebellar (49–74 % of brain neurons) neuronal fractions. Despite their close phylogenetic affinity to the galliform birds, anseriform birds have large brains characterized by expanded telencephalon, resembling landbirds, such as parrots and songbirds, in this respect. However, their neuronal densities resemble those of galliform birds, being much lower than in the landbirds. Therefore, despite being significantly enlarged, the telencephalon typically contains slightly less than 50% of brain neurons. The total number of neurons for a given brain size is significantly lower in anseriform birds than in songbirds and parrots. This suggests that different developmental mechanisms leading to the expansion of the telencephalon differ markedly in their potential to generate large neuronal populations. Anseriform birds are precocial and their telencephalon grows in size early in embryonic development, whereas in altricial parrots and songbirds, telencephalic expansion is associated with protracted neurogenesis and delayed neuronal maturation. Extensive post-hatching neurogenesis is thus evidently much more efficient in generating large neuronal populations.

### Personality dependent corridor use in a grassland species

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The effectivity of corridors connecting isolated patches has been investigated for more than three decades with animals of different species. It is already known that the presence and the properties of corridors are crucial for the species' dispersal and mobility in a landscape. But corridor use may also depend on the behavioural traits of its users. Animal personality, i.e. consistent among-individual differences in behaviour, might affect the space use in general, but also the usage of corridors. We investigated whether the width of grass stripes and the personality of the individual are important for the corridor use of common voles (*Microtus arvalis*). If so, corridors may allow passage only for a proportion of individuals in a population and may thus affect individual mobility and population gene flow. We studied movement behaviour of male common voles in experimental grassland corridors of different width (1m and 3m). Voles were tested with established behavioural tests to parametrise boldness and activity. Automated and hand VHF telemetry was used to observe the individual movement of the tested animals (N=34) and to determine whether the animal perceives the structure as a corridor. Results on movement will be discussed in relation to animal personality and corridor width to allow predictions of dispersal abilities of personality types in habitats with different degrees of fragmentation.

### Would *Salmonella Enteritidis* modify social behaviour in contaminated chickens?

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*Salmonella Enteritidis* (S.E) is a bacterium that is involved in foodborne toxi-infection in human, particularly via the intake of contaminated chicken meat or eggs. It is difficult to identify the contaminated chickens since this pathogen induces no illness cue in this species (asymptomatic carrier state). In order to detect the contamination in chickens, we then looked for changes in general activity and in social behaviour. Four flocks containing eight non-inoculated chicks reared in cages were progressively contaminated (aerial contamination) by two other flocks close to these cages and that were orally inoculated with S.E (5x10<sup>4</sup> bacteria /chick). Individual faecal samples were collected to establish the contamination by S.E. and they confirmed that aerial contamination by S.E. can be reproduced under experimental conditions. Scan sampling analysis showed that the mean distances between birds were reduced in the target flocks between 3 and 8 days after inoculation of the neighbour flocks and they rose up to the initial value thereafter. The analysis of focal birds showed that the mean duration of quick walk bouts was lower in contaminated birds than in birds that were not contaminated yet. This experimental design made us able to detect differences in behaviour according to the level of contamination within the week following S.E infection. The changes observed in inter-individual distances suggest that S.E. may modify social behaviour during the week following contamination. The changes in behaviour suggest automated analysis of behaviour in commercial flocks would enable the detection of contamination by S.E.

**Individuals in larger groups are more successful on spatial discrimination tasks.****E.J.G. Langley, J.O. van Horik, M.A. Whiteside, J.R. Madden**

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To understand how natural selection may act on cognitive processes, it is necessary to reliably determine interindividual variation in cognitive abilities. However, an individual's performance in a cognitive test may be influenced by the social environment. The social environment explains variation between species in cognition, with species that live in larger groups purportedly demonstrating more advanced cognitive abilities. It also explains variation in cognitive performances within species, with larger groups more likely to solve novel problems than smaller groups. Surprisingly, an effect of group size on individual variation in cognitive performance has rarely been investigated and much of our knowledge stems from impaired performance of individuals reared in isolation. Using a within-subjects design we assayed individual learning performance of adult female pheasants while housed in groups of three and five. Individuals experienced the group sizes in a different order, but were presented with two spatial discrimination tasks, each with a distinct cue set, in a fixed order. Across both tasks individuals housed in the large groups had higher levels of success than individuals housed in the small groups. Individuals had higher levels of success on their second than their first task, irrespective of group size. We suggest that the expression of individual learning performance is responsive to the current social environment but the mechanisms underpinning this relationship require further investigation. Our findings demonstrate the importance of accounting for an individual's social environment when characterizing cognitive capacities and demonstrates the flexibility of an individual's cognitive performance depending on the social context.

### **Why do dogs look back at the human in an impossible task? Looking back behaviour may be over-interpreted.**

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A famous task used to investigate dogs' exceptional abilities to communicate with humans is the 'Impossible task'. It consists in presenting 3 consecutive possible trials that allow the animal to get food and a 4th, impossible, one. After attempting the impossible, dogs look back at the human, which has been considered a communicative act to seek human assistance. Alternatively, subjects may look back because expecting food or because, once they stopped interacting with the apparatus, the person represents a salient stimulus. We tested 20 pet dogs and 14 free-ranging dogs in an impossible task. We simultaneously presented 3 possible and 1 impossible bowl. The subjects were tested with the experimenter present (social condition) and absent (asocial condition), and 2 control conditions with a 'human-like' and a 'non human-like' dummy object. The subjects looked longer at the human than the dummy objects. However, animals that looked back after attempting the impossible did so with the same latency in the social and control conditions. Similarly, no differences between groups were observed in the frequency to look back after attempting the impossible. No differences were observed in the frequency to look back after attempting the possible compared to the impossible. Importantly, persistence in interacting with the impossible bowl also did not vary with the presence or absence of the human. These results suggest that looking back is not an alternative social problem solving strategy, but rather linked to the dogs giving up the manipulation and humans being an attractive stimulus to look at.

### **Ten-year spatial variation of Indo-Pacific humpback dolphins (*Sousa chinensis*) off Yunlin, Taiwan**

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A small population of Indo-Pacific humpback dolphins (*Sousa chinensis*) occurs near shore off western Taiwan. This very likely isolated population is very small (only less than 80 individuals left), and has been claimed as Critically Endangered by International Union for Conservation of Nature (IUCN) since 2008. In order to understand their spatial variation, we analyzed the association between dolphin activities and PCA factors of five environmental variables (water temperature, depth, salinity, pH, and turbidity) on 19 latitude-grids of coastal waters off Yunlin county. During the period of year 2008-2017 (separated into three time phases), we executed 233 near-shore boat surveys and sighted 266 dolphin groups, among which 147 groups were focal tracked for over 30 minutes. We found that spatial variations among three time phases were different significantly in dolphin-sighting rate and in foraging activity index on/at various latitude grids, but not in traveling activity. In addition, correlation analyses between dolphin-sighting rates and PCA factors reveal associations of low dolphin activity/occurrence with low pH and high turbidity. We suggest that the variation in dolphin sighting as well as foraging intensity might be influenced by the water quality of run-off from the power plant company, as well as the river mouth.

### **How do rearing background noise levels affect spatial preferences for quiet versus noisy conditions in subadult birds?**

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Anthropogenic noise is rising worldwide and spreading far beyond urban areas. There is increasing concern that such noise negatively impacts avian acoustic communication and population structure. However, it is unclear whether currently observed declines in density and diversity are due to an active avoidance of noise or urbanization-related habitat deterioration. To investigate at what levels of background noise birds showed active avoidance, the spatial distribution of laboratory-raised zebra finches was assessed in interconnected aviaries with playbacks of ambient sounds recorded at different distances from highways. Birds could move freely between aviaries during the test. The tested birds were then paired and allowed to breed with highway sound playbacks of either avoided or neutral noise level. As subadults, all offspring were tested with the same protocol as the parental generation to test whether rearing noise conditions would lead to different noise avoidance behaviour. I will present the test results of both generations and discuss what previous observational data and the outcome of the active avoidance can tell us about how increased road noise may impact spatial behaviour in birds.

### **Influence of kinship and sex on association patterns of non-breeding ravens**

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Most animal social groups show some form of fission-fusion dynamics, which is a temporal variation in group size and composition, driven by different social and ecological processes. In Common ravens monogamous breeders defend a territory year round, but non-breeders spend their first 3 to 10 years (or even longer) in such highly dynamic fission-fusion systems. They show large individual variation in movement distances (few to hundreds of kilometres) and different durations of temporary settlements close to rich food sources (from days to years). This system leads to repeated associations of many individuals at the same and different locations, where socio-positive behaviour and alliance formation in agonistic interactions can frequently be observed. We investigated whether kinship and sex influence the composition of these groups. Although, a previous study based on a small sample size did not find any kin effect, we now examined this question on a much larger sample size. We marked individually more than 250 ravens over the last 10 years, estimated their age, collected blood samples and recorded their associations at a rich food source almost daily during this time. We hypothesized that kinship favours repeated associations, particularly in the early life stages. Additionally, the genetic structure of these groups is expected to be influenced by female biased dispersal following the resource competition hypothesis (Greenwood 1980). We will discuss the results in relation to ravens' social system and outline further mechanisms which might affect ravens' fission-fusion dynamics.

### **Do ultrasonic vocalizations of wild house mice contain individual signatures?**

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House mice (*Mus musculus*) emit complex ultrasonic vocalizations (USVs), especially during courtship and mating, and these vocalizations have been suggested to contain individual signatures. Our aim is to compare the variability in types of calls, as well as in quantity of USVs, emitted within and between individuals over time. Therefore, we recorded the USVs of wild-derived male house mice (n=22) emitted during presentation of a sexual stimulus (female urine) over three weeks (1 recording per week). We used a semi-automatic method to detect USVs (Automatic Mouse Ultrasound Detector or A-MUD), and unsupervised and supervised (manual classification) methods to classify USVs into different syllable types. We will present our methods in which we investigated different multivariate techniques, and our results comparing USVs of individuals. We find that some individuals do not vocalize or rarely vocalize, and we are also investigating the consistency of non-vocalizing, which may have fitness consequences. These results will allow us to determine whether individuals are consistent in their USV emission and usage of their vocal repertoire, and provide a crucial step towards testing for USV-mediated individual recognition.

### **Artificial selection on relative brain size affects neuronal numbers and densities in the guppy**

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Brain size, both absolute and relative (i.e., derived from brain–body allometry), is widely used as a proxy for cognitive capacity in evolutionary and cognitive neuroscience. This simplistic approach is fuelled by the notion that larger brains harbour higher total numbers of neurons and their connections and therefore have a higher information processing capacity. Here, we test this assumption experimentally on the recently introduced model of the guppy (*Poecilia reticulata*) artificially selected for large and small relative brain size. In an earlier series of studies, we have shown that larger brains yield cognitive benefits at the intraspecific level. Guppies selected on larger relative brain size outperformed small-brained conspecifics in a number of tasks, including numeric learning, predator avoidance and reversal-learning. Using the isotropic fractionator to determine numbers of neurons in specific brain regions, we estimated that the brain of a female guppy consists of ~4.2 million neurons. The telencephalon houses on average 630 000 neurons, tectum opticum 1.1 million, cerebellum 1.7 million and the rest of brain (i.e., diencephalon and brainstem) 732 000 neurons. Pilot experiments strongly suggest that large-brained females possess greater absolute neuron counts but somewhat lower neuronal densities than small-brained females. These findings suggest that cognitive benefits associated with larger relative brain size are indeed attributable to an overall higher number of brain neurons per body size.

## **An Assessment of Individual Differences in Generalisation and Associative Learning Abilities in Wild Chacma Baboons**

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The ability to learn new associations is key to many aspects of animal behaviour, including fitness-related ones such as foraging and reproduction. Past research in captivity has focused on inter-species, rather than inter-individual assessments of learning, despite potential fitness differences amongst individuals. We presented individuals belonging to two troops of wild chacma baboons (*Papio ursinus*) with an operant conditioning task involving two piles of corn kernels differing in colour and taste. The baboons we tested rapidly learnt the association, and, although showing no preference for either bitter or non-bitter corn, individuals differed in which kernels were consumed first depending on their personality and social rank. Based on this task, we investigated two additional aspects of associative learning: (1) the ability to generalise a cue from a previously learnt association; and (2) the ability to learn associations using stimuli that differ in reward, while in a risky social environment. To do this, we presented the same individuals with two opaque paper bags that shared the same colour cues as the previous task, but that differed in reward value. We found that individuals vary in their success to generalise past cues to a novel task; while, vary in their choice between bags over repeated presentations based on a trade-off between exploratory behaviour and learning. We propose the latter reflects a foraging strategy employed by animals that currently experience environments with patchy resources, where more value is given to current information rather than past experience.

## **Cross-species comparison of personality structure in callitrichids based on everyday behaviours**

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Comparing the personality structure of closely and distantly related species can facilitate the understanding of evolutionary origins of personality in nonhuman primates as well as humans. Callitrichid primates, although sharing some basic features, represent a diverse group regarding their social and ecological adaptations. We examined the personality structure of captive cotton-top tamarins (N=20), red-handed tamarins (N=28), and common marmosets (N=17) through coding of common everyday behaviours. All 22 behavioural indices used were moderately to highly repeatable. The personality structures of the three species differed in dimension numbers as well as their interpretation but also overlapped in some respects. Principal components analysis identified three dimensions in red-handed tamarins (Assertivity, Sociability, Extraversion) and marmosets (Extraversion, Sociability, Neuroticism) and two dimensions in cotton-top tamarins (Extraversion, Confidence). The presence of an Extraversion dimension in all three species suggests Extraversion as an ancestral characteristic of callitrichids. Comparison between species revealed an overlap in Confidence and Assertivity in both tamarin species suggesting these behaviours as a common trait in tamarins, but not in marmosets. The separate Sociability dimensions in red-handed tamarins and common marmosets overlapped with Extraversion in cotton-top tamarins. We discuss the results with respect to phylogeny as well as social and ecological factors such as habitat differences, group size, and mating system, that can also play important roles in the shaping of the personality structure.



## **The mechanisms of animal personality in sea anemones faced with a changing climate.**

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Anthropogenic environmental change is an ever-increasing threat to global biodiversity. Within species, a key determinant of the ability to cope with environmental shifts is the magnitude and nature of phenotypic variation within a population. An important aspect of this is between-individual behavioural variation, or personality. How personality affects individuals' abilities to handle environmental perturbation is therefore a critical factor to investigate when predicting how populations might respond to climate change. In this study we used the beadlet sea anemone, *Actinia equina*, to investigate how individual differences in personality across a population may affect responses to temperature increases. *A. equina* exhibits personalities which are seemingly linked to at least three different morphotypes, occupying different heights on rocky shores. We investigated how individuals of these morphotypes alter their boldness when exposed to environmental stressors. Individuals were exposed to a graduated increase in temperature up to a thermal extreme, with levels of 10, 18 and 24°C. We also took proteomic samples at 24°C from the boldest and shyest individuals, to be used in a novel investigation of *A. equina's* molecular stress response. Preliminary results suggest there is clear variation between individuals in response to thermal stress. We furthermore predict differences in the magnitude of both behavioural and molecular stress responses between the morphotypes (i.e. individuals adapted to live in different environmental conditions) and between different behavioural types. We expect some groups will be better suited to dealing with environmental change than others.

## **Inequity Aversion in Dogs: Mechanisms, Function, and Future Directions.**

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Inequity aversion, the resistance to inequity, has been demonstrated in a wide variety of non-human animal species. Domestic dogs are particularly interesting in this context as they display a seemingly primitive form of the behaviour. To date, inequity aversion tests have been carried out with over 140 individual dogs, across 7 published studies, making them one of the best studied species in the field of inequity aversion. These studies have contributed considerably to our knowledge of inequity aversion in dogs. However, research in this field on dogs could also provide key insights into inequity aversion in other non-human animal species. Here, we critically review research on inequity aversion in dogs, highlighting recent developments, gaps in our knowledge, and emerging questions. In particular, we discuss two understudied areas in the field of inequity aversion, namely the proximate mechanisms and ultimate function. We place the canine research in the context of what is known in other animal species, while we also identify contributions from research on dogs that could shed light upon the mechanisms and function of inequity aversion in the variety of species studied to date.

## **Do black-headed Gouldian finches take greater risk at waterholes than red-headed conspecifics?**

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In dry habitats birds often assemble in large numbers around waterholes. This attracts predators resulting in higher predation risk. It is well known that individuals differ in their risk-taking due to differences in assets to loose, condition, experience and conspicuousness. Colour-polymorphic species are a good example of this with morphs not only of different conspicuousness but often differing in behavioural strategies. Gouldian finches are colour-polymorphic in both sexes and signal their personality with their head colour – at least in captivity. Black-headed birds take more risks and are more explorative but less aggressive than red-headed birds in the same population. We tested whether this is also the case in the wild. We observed Gouldian finches at seven waterholes in the Kimberleys and around Lake Argyle, Western Australia, and recorded which head colour descended first to the ground. For analyses we considered head colour ratios. Gouldian finches were rarely the first to land on the ground but usually waited until other closely-related species descended. Black-headed females were more likely than expected by chance to land on the ground first. Generally, females descended before males particularly earlier in the season possibly due to males attending to the young. Finally, adults were more often than expected the first ones on the ground as compared to juveniles. The results indicate that Gouldian finches are very careful at waterholes and generally follow others. Black-headed females take the lead which in part confirms findings from the lab though larger groups should be tested in the future.

## **Calcineurin inhibition in anxiety-related behaviours in animal models**

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Calcineurin (a calcium and calmodulin dependent phosphatase) is highly expressed in the amygdala, a brain area which plays an important role in mediating fear and anxiety. Hence, the aim of the study was to evaluate the importance of calcineurin inhibition in anxiety-related behaviours in 5 dpf larval zebrafish and adult mice. Zebrafish larval behaviour analysis was evaluated using the ZebraBox system manufactured by ViewPoint. Thigmotaxis was used as an index of anxiety. Zebrafish larvae displaying thigmotactic behaviour avoid the center of an arena (inner zone) and prefer to stay close to the boundaries of a well (outer zone). Moreover, larval locomotion was measured using simple locomotor assay as well as light on/off assay. To assess anxiety-related behaviours in mice we used the elevated plus maze test (EPM test) and the novelty suppressed feeding test (NSF test). Calcineurin inhibition was investigated using FK-506 (a potent calcineurin inhibitor) in a range of doses from 1 to 20  $\mu$ M in zebrafish model and from 1 to 10 mg/kg ip in mice. Our results indicate that calcineurin inhibition affects anxiety-related behaviours in larval zebrafish and adult mice. Therefore calcineurin may become an interesting pharmacological target for the treatment of anxiety and other mood disorders.

### **New Caledonian crows show flexible decision-making comparable with young children and Goffin cockatoos in an inhibitory control tool-use task.**

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Flexible decision-making requiring inhibitory control in a tool-use context may be more complex than in a simple choice between a delayed and immediate reward. Inhibitory control likely influences cognitive performance across all species, although few studies have investigated inhibition in humans and non-primate species. Here, we presented 3 to 5-year old children, adult humans and tool-using New Caledonian crows with the same two problem-solving apparatuses involving the use of two different types of tools and rewards of varying quality. We found that adults selected the correct choice across all conditions. Performance in children improved with age, though children of all ages struggled with two conditions: the ‘tool functionality’ condition, where the correct choice was the least preferred reward over the non-functional tool, and the ‘motivation’ condition, where the correct choice was the most preferred reward over the functional tool. New Caledonian crows performed well in the motivation and other conditions. Therefore, children, though not adults or crows, preferred to use the tool, even when the same reward was available immediately. Like children, the crows struggled with the tool functionality condition, while Goffin cockatoos – a species tested previously that does not use tools in the wild – performed well in this condition. Humans outperformed both bird species when all task components were present. Taken together, these findings indicate that tool use ability in crows and children may potentially increase difficulty in inhibiting the selection of a tool. We discuss our findings in relation to the role of inhibitory control on cognitive performance.

### **Predator personality and its impact on prey behaviour.**

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Behavioural decision-making plays a crucial role in determining the outcome of predator-prey interactions. Even though an extensive body of research has explored how prey adjust their behaviour in response to changes in predation risk, individual predators are often viewed as posing the same, unchanging level of threat. Consistent individual differences in behaviour are a widespread feature of natural populations, raising the possibility that predators with contrasting personalities differ in their effects on prey. We aim to investigate the consequences of this variation by quantifying inter-individual differences in the predatory response of pike cichlids (*Crenicichla frenata*) towards groups of their Trinidadian guppy (*Poecilia reticulata*) prey. Our approach includes both observations of free-swimming predatory fish in natural river pools and staged encounters between predators and prey in semi-controlled conditions. While field observations can provide an insight into how predatory behaviours are expressed in their natural context, more controlled experiments allow predator behaviour to be quantified at a finer scale and the prey response to be observed. This enables us to address questions such as whether individual differences in predatory behaviour are correlated with other well-documented personality traits, and how groups of prey adjust their anti-predator behaviour when exposed to predators with different personalities.

### **Waiting for better or more: a comparison of inhibitory control in New Caledonian crows and young children.**

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Inhibitory control, i.e. forgoing an immediate, less preferred reward for a delayed, more preferred one, may underlie many aspects of cognitive performance and has been suggested to contribute to the difficulties of some non-human species in cognitive tasks when compared to children. For example, New Caledonian crows struggled to inhibit selection of a non-functional tool when it had previously been rewarded, while 5 to 10-year old children performed well. Children show more inhibitory control than great apes; however, this topic has received little comparative investigation in humans and other species, particularly birds. Here, we adapted a paradigm used previously with capuchin monkeys to test for inhibitory control, with rewards differing in either quality or quantity. We tested New Caledonian crows and 3 to 5-year old children – the age range at which inhibition develops according to child development studies. Rewards were presented on a rotating tray, moving sequentially towards the subject, thus eliminating the need for more complex tasks such as exchange of tokens, which potentially place additional mental stress on the non-human subjects. We found that New Caledonian crows performed comparably to young children and capuchin monkeys, in that they were able to inhibit taking the immediate reward and waited for the better, delayed one. Furthermore, when we manipulated the visibility of the rewards, crows and children continued to perform well, similar to the capuchins. We discuss these findings in relation to the potential impact of inhibitory control on cognitive performance across different species.

### **The effects of social enhancement on the spread of innovation in wild Goffin's cockatoos (*Cacatua goffiniana*)**

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Recent experimental work on captive Goffin's cockatoos (*Cacatua goffiniana*) has highlighted their advanced problem-solving abilities as well as their capacity to innovate the manufacture and use of tools. Despite this substantial body of data, little is known about the cognitive abilities of wild Goffins, endemic to Tanimbar Islands in Indonesia. Here we present pilot data of potential social influences on the spread of innovation in wild Goffins using a large arena consisting of 20 novel foraging tasks. In a previous study, 11 wild-caught individuals were presented with the arena in order to measure their individual innovation rate. However, despite being fully familiarized with and habituated to the setup only 3 subjects were repeatedly solving, 4 subjects solved a single task once, 1 subject did not solve, and 3 subjects stopped participating. We paired 3 one-time solvers and the single no-solver with a knowledgeable conspecific for one social test session to investigate social influences on the success likelihood in follow-up tests. Two out of the 3 one-time solvers immediately started solving 50% of all tasks and continued to increase their success ratio, whereas the no-solver did not. Our results suggest that wild Goffins are highly susceptible to social influences already after a single exposure. Thus, such experiences might constitute the basis for rapid social spread of novel behaviours throughout the population. This is the first test of social learning capacities of wild Goffin's cockatoos and opens future avenues for additional fieldwork research on the social transmission of skills in this species.

### **The evolution of animal colour patterns**

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Understanding the diversity and functional significance of animal colouration has fascinated scientists for well over a century. As a result, colour-based signals have become one of the most widely used models in behavioural ecology and have been core to our understanding of topics such as sexual selection and anti-predator adaptations. However, despite their importance, most studies of animal colouration tend to focus on a single exemplar colour patch on the species or individuals under study, and ignore the fact that those animals typically comprise a wide range of different colours (alongside which the exemplar colour is viewed) arranged in a particular pattern on the body. As a result, we have a comparatively poor understanding of fundamental questions such as why animals display the particular colours they do (e.g. why red, green and yellow, and not blue, purple and grey?), and why they are spatially arranged in the way they are (e.g. why is the head red and the body green?). Here we take a comparative approach to quantifying the evolution of whole-body colour patterns, using parrots (which exhibit enormous interspecific diversity in colour) as a model system. By reconstructing ancestral colour patterns, calculating rates of evolutionary change and quantifying colour pattern diversity across the entire *Psittaciformes* order, we explore the evolution of colour patterns and colour combinations, and link these to extant species' ecology and social behaviour. The functional significance of the considerable colour pattern diversity that is evident within this group will be discussed.

### **Effects of peatland restoration on foraging movements and resource selection of European nightjars**

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Collecting data on animal movements can help us to understand the importance of various resources and - in order to improve the management of locations important to them – how they respond to change. Foraging sites may be visited repeatedly or used less-frequently but more intensely, which may vary according to resource type and its relative importance. This study focuses on a population of an understudied species of conservation concern in the UK, the European Nightjar *Caprimulgus europaeus* on one of the few peatland sites in the country to hold a stable breeding population. Nightjars are a cryptic, ground-nesting migrant to the UK, so collecting data is challenging. Using the latest GPS tags we aim to understand nightjar foraging behaviour in relation to the environmental change occurring on their breeding site. Fine-scale data was used to examine movement patterns, and to create movement based kernel density estimations to assess habitat selection, producing a dynamic view of their breeding habitat use. Preliminary analysis of data from 30 tracked birds from 2015 – 2017 shows there is large variation among individuals within the population in both home range size and resource selection, with varying responses to habitat change depending on habitat type. Future management should aim to provide a mosaic of different habitats to cater for the whole population. Tracking will be carried out until 2018, to explore responses to further site management through behavioural changes in their foraging movements.

### **Study of the ring dove multicomponent courtship signal by integrated audio-video analysis**

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During courtship, single signals occurring in different sensory modalities can be combined into complex multimodal signals. Most research on sexual selection has focused on the effects of certain types of male courtship on female preferences and very few on the structure of the courtship signal itself. The effects of variation in courtship signal component parameters (velocity, duration or frequency for example) on female response is not well researched. Additionally, recent studies have shown that the response to a complex signal is typically not additive, stressing the fact that information might be contained in the interaction between different components. In the ring dove (*Streptopelia risoria*), males court females with a simple stereotyped multi-sensory display, composed of a visual part: the bow (male bends towards the ground facing the female) and an acoustic part: the coo-call. This makes the ring dove an interesting model species to assess the function of different components of a multimodal signal, as well as the possible information contained in the interaction between those components. We developed an experimental setup to video and audio record male courtship and female associated response. We then used software to semi-automatically track body movement and vocalisations of both males and females. We found that males differ regarding specific components of their multimodal courtship, and that those inter-individual variations trigger differential behavioural response in females. Further experiments using this approach will help us to understand the prevalence of multimodal signals and the complex interaction between signal components in the context of courtship communication.

### **Cache protection and pilfering strategies in rooks (*Corvus frugilegus*)**

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Competition over food plays a major role in the survival of individuals. Some animals use cognitive strategies to overcome it. For example, some corvid species hide their food for later consumption. In territorial corvid species, it has been shown that cachers use cache protection strategies to prevent pilferage by conspecifics. The risk of pilferage may be even higher in social species, as caches are exposed to a higher number of potential pilferers than in territorial species. But cache protection and pilfering strategies have never been investigated in social corvid species. Therefore, this study aimed to determine if rooks (*Corvus frugilegus*), a social corvid species, engage in cache protection and pilfering strategies. We followed a group of 14 adult rooks. We gave them valuable food items and recorded all cache-related behaviours and spying, approaching and pilfering behaviours. The results show that rooks cache predominantly behind and under structures, limiting the risk of being seen by potential pilferers. They also recover the food and recache it in new sites or eat the food. They also aggressively defend their caches on some occasions but accept the proximity of their mate. Some individuals spy on cachers, move to get a better point of view of the cache location and sometimes attack the cacher or wait until the cacher leaves the cache to pilfer it. Thus, our results suggest that social group living also influenced the evolution of caching and pilfering decision-making in corvids. The mechanisms involved in these decision-making processes will be discussed.

## The effect of variation in the availability of close kin on social bonds in wild female Assamese macaques

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Strong social bonds can enhance survival and reproductive success in group-living animals. Kin selection theory predicts that related individuals should be preferred bonding partners, as cooperation with close kin increases inclusive fitness. While Hamilton's rule is blind as to the origin of shared genes, maternal kin is often preferred over paternal kin with the same relatedness coefficient, suggesting that partner preferences are also affected by familiarity. Indeed, many studies have reported kin biases in social behaviour, with the strongest bonds being formed with close maternal kin. This is also in line with the time constraint model, which states that kin preference is limited to kin with relatedness above a nepotism boundary. Because the majority of studies on kin biases were performed in breeding colonies with large matrilineal groups where close kin are available for most individuals, the effect of variation in the availability of close maternal kin on the strength of a female's closest bonds is not well understood. It is also not clear with whom females form bonds when they have no close kin available. Here we assess both maternal and paternal kin biases in the social behaviour of adult female Assamese macaques (*Macaca assamensis*) living in their natural habitat with fluctuating resource availability and predation pressure. We use pedigrees based on microsatellites combined with longitudinal behavioural data to test whether females bond with less-related or paternally related individuals when they have no close maternal kin available, and whether these bonds vary in strength from bonds between close maternal kin.

## Social behaviour in big fin reef squid

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While some work has documented the ontogeny of schooling behavior in big fin reef squid (*Sepiotheutis lessoniana*), there has been no research on the individual behavior and preference for social rather than solitary setting and the effect of familiarity on social choice. In order to test individual preference for groups in squid we adapted the 3-chamber social approach test routinely used in rodents. A glass aquarium was split into two equally sized compartments, separated by a transparent divider: Test and Presentation. The Presentation compartment was further split into two equally sized compartments separated by an opaque barrier, Group (containing 3 conspecifics) and Empty. During each trial an individual squid could freely swim in the test compartment. We then measured the amount of time spent in front of the Group vs. the Empty compartments. In order to test the effect of familiarity we tested squids (3-month-old) either reared with the conspecific group (Familiar: tested n=11; group n=9) or reared with a same age different group (Non-familiar: n=18, group n=9). Both groups showed a significant preference for swimming in front of the group compartment. Additionally, we found a nonsignificant trend for longer times spent with the group when animals were familiar. These results show a clear social drive for gregarious behavior and schooling in sub adult squid and confirm the results of reported field observations. The method can now be applied to further investigate quantitatively the ontogeny of social behaviors in these and other species.

## The Goffin Lab Tanimbar

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Goffin's cockatoos (*Cacatua goffiniana*), a species endemic to the Tanimbar Islands in Indonesia, have exhibited remarkable capacities in controlled studies conducted in captivity. These include - but are not limited to - the ability to flexibly manufacture and use tools for accessing food items. However, little is known about the ecological circumstances which might have promoted the evolution of these skills. The newly established Goffin Lab Tanimbar aims at integrating controlled experiments and observational data to investigate how these environmental factors may be interlinked with the evolution of advanced cognitive abilities. Here, we provide an overview of recent work conducted in Indonesia, with focus on Goffin's cockatoos foraging ecology. Preliminary results indicate that Goffin's cockatoos are highly social, opportunistic generalists, relying on a variety of (partially seasonal) food sources and qualify as extractive foragers. All these characteristics follow the current hypotheses on the evolution of tool use. Nevertheless, tool use has so far not been observed in the Goffin's cockatoo's natural habitat on Tanimbar and we will discuss possible reasons for this. Finally, we will give an outlook on future planned activities, which will include a more detailed analysis of the dietary composition of this species, along with population and home range estimations. Further capture-release studies will aim at investigating the precursors of functional behaviour in comparison to the captive population at the Goffin Lab in Austria.

## Behaviour of brood thieves in an Indian ant.

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Thievery is ubiquitous in the animal kingdom and several methods are employed by thieves in different taxa. Theft of brood is common in ants, and in this study we have explored the phenomena in *Diacamma indicum*, a primitively eusocial ant found in the tropics. Comparison of the manner in which these ants handle brood items and the speed at which they carry them in three different contexts – stealing brood from a guarded nest (theft, n = 42), procuring brood from an unguarded nest (rescue, n = 99) and transporting brood of own colony during relocation to a new nest (transport, n = 56) showed that thieves significantly reduced handling duration and increased their exit speed up to 3 folds in contrast to rescue or transport. Further experiments were performed to understand the cause behind this modification in behaviour. While the presence of foreign colony odour or foreign adults blocked from showing aggression did not account for the extent of modification, we concluded that the potential risk of aggressive interactions with foreign adults was causing the modification in behaviour. Though thieves (n = 37) repeatedly visited the victim colony, their latency to revisit increased significantly upon facing immobilization in their previous visit, which further corroborated our previous observation. The latency reduced significantly only when thieves were successful in their previous visit, suggesting regulation through a cost-benefit trade-off. We conclude by examining thieving behaviour in other non-human societies and the interplay between the thieves and the victim.



### **Potential self-medication using millipede secretions in red-fronted lemurs**

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Self-anointing, referring to the behaviour of rubbing a material object or foreign substance over different parts of the body, is observed in several vertebrates, including primates and can be elicited by a wide variety of anointing materials, such as plants, arthropods or human-made products. In particular, anointment with millipedes, which secrete a variety of chemicals shown to have sedative, repellent, irritant and toxic effects, have been regularly reported. Several functions as detoxification of a rich food source, social communication or protection against ectoparasites have been proposed to explain this behaviour. In November 2016, we observed 6 wild red-fronted lemurs (*Eulemur rufifrons*) ingesting and anointing their perianal-genital areas and tail with chewed millipedes. We discuss the features of these observations, the nature and potential metabolic pathways of the released chemicals in regards of the literature and we suggest that combining anointment and ingestion of millipedes' secretions by red-fronted lemurs may have a self-medicative function. More specifically, we argue that these behaviours may act in a complementary fashion against *Oxyuridae* nematodes infections, providing both prophylactic and therapeutic effects.

### **Expanding the social complexity hypothesis for communicative complexity**

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Animals exhibit stunning variation in both the nature and the number of signals they produce. Variation in communicative complexity has been conceptually and empirically attributed to social complexity, with animals living in more complex social environments exhibiting more signals and/or more complex signals. As compelling as studies supporting this hypothesis are, it remains challenged by operational problems, contrasting results and several weaknesses of the associated tests. First, how to best operationalize social and communicative complexity remains debated. Second, alternative hypotheses, such as the role of a species' ecology, morphology or phylogenetic position have been neglected. Finally, even if the complexity of social groups and their social environment can be considered as drivers of communicative complexity, in both an ultimate and proximate sense, the latest is rarely addressed. We aim to discuss these three issues and to propose an extended social-complexity hypothesis for communicative complexity. We specifically argue that integrating the multimodal nature of communication into a more comprehensive framework may uncover potential adaptive functions that are not necessarily apparent from studying communication in only one modality. Moreover, we argue that by acknowledging the social context of derived signals and the potential of audience effects, it will be better possible to generate more accurate predictions about which specific social parameters may be responsible for selection on new or more complex signals.

### **The influence of acute stress and cannabinoid receptor ligands on reinstatement of nicotine-induced place preference in rats**

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The rewarding activities of nicotine are assessed in many behavioral models using rodents, e.g., conditioned place preference (CPP) paradigm. Stress is a very important factor that precipitates and potentiates addictive effects of different drugs of abuse, including nicotine. From the point of view of the potential action of the endocannabinoid system on the symptoms of affective disorders, it seems important to establish mutual interactions between endocannabinoids, nicotine and stress. Methods: We used the CPP version of the reinstatement model to investigate the establishment, extinction and reinstatement of nicotine-induced place conditioning in rats. The CPP-reinstatement paradigm consisted of the following phases: pre-conditioning, 3 days of conditioning, post-conditioning, extinction and reinstatement provoked by a priming dose of nicotine or an acute stressor, i.e., swimming in cold water (10 C) for 10 min. The present study was also designed to investigate the influence of cannabinoid receptor ligands: CB1 (AM 251 0.5 mg/kg) and CB2 (AM 630 5.0 mg/kg) on the stress-induced reinstatement of nicotine CPP. Results: Our data showed that nicotine produced a place preference to the compartment paired with its injections during conditioning. After 3 days of extinction, both, injection of nicotine and exposition to stressor reinstated nicotine-induced CPP. Our results also demonstrated that AM 251 and AM 630 attenuated the stress-induced reinstatement of nicotine-conditioned response. The results revealed the mechanisms underlying the stress-induced reinstatement of the rewarding conditioned effects of nicotine and describe an influence of the endocannabinoid system through both CB1 and CB receptors on these processes.

### **Using virtual reality to explore interspecific variation in visual perception**

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Colour perception relies on the ability to compare two or more receptor types that are sensitive to different regions of the visual spectrum, and animals are known to exhibit considerable inter- (and sometimes intra-) specific variation in the number, retinal distribution, and wavelength sensitivity of these receptors. However, we have a poor understanding of why such diversity exists and of the particular selection pressures and physiological constraints that shape this variation. One of the reasons for this stems from the inherent difficulty of experimentally manipulating the way an animal perceives the world, and in designing manipulations that unambiguously test the same underlying processes in different species. In order to overcome some of these limitations, we tasked human subjects with searching for and locating cryptic moth-like stimuli within an immersive virtual reality environment, in which colours were manipulated to mimic those putatively perceived by either a human or an avian (specifically, a blue tit) visual system. We found clear differences in performance between the two scenarios, with participants being more likely to find the cryptic targets when perceiving colours in an avian-like way; moreover, this appears to be driven by differences in the relative use of low-level visual features (colour, brightness and edge orientation) to detect targets under each scenario. These findings provide insights into the visual mechanisms used to detect (cryptic) prey across species, and suggest that low-level aspects of vision are sufficient to drive some interspecific differences in search performance and behaviour.

### **On the trail of primate scent signals: scent-marking behaviour and semiochemistry in captive callitrichines (New World primates)**

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Olfactory communication is an important mediator of social interactions in mammals, providing information about an individual's identity and current social, reproductive, and health status. Callitrichines (marmosets and tamarins) constitute a good model for the study of olfactory communication, as they are known to rely a lot on odour signals. Callitrichines conspicuously deposit odorous secretions generated by three specialised scent-glands on branches in the environment (called scent-marking) or on the body of a conspecific (called allo-marking). Several functions have been attributed to tamarin scent-marking behaviour, including spatial orientation and signalling of food resource location, territorial advertisement and defence, and advertisement of reproductive and dominance status. This research project uniquely combines behavioural and chemical information to decipher some aspects of callitrichine olfactory communication. The study explores how species, social, and individual characteristics might influence patterns of callitrichine scent-marking behaviour, as well as the chemical composition of scent-mark secretions. Behavioural observations, along with swabs of scent-glands and naturally deposited scent-marks, were collected from captive groups of tamarins in several UK zoos. Chemical samples were analysed using headspace gas chromatography-mass spectrometry (GCMS). We investigate the existence of unique chemical signatures of species, group, sex, age, and reproductive status, in callitrichine scents. This study intends to provide baseline knowledge on primate olfactory communication systems, applicable to captive husbandry practices, including breeding of rare species.

### **Background noise precludes the perception of the fine structure of bird song.**

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Birds' songs can have a complex acoustic structure, details of which may convey a variety of information, including pertinent information about the signaller's quality. Perception of these details may affect decisions made by receivers in the context of territorial defence and mate choice. The fine structure of songs makes birds particularly susceptible to masking the potential disruption in communication caused by noise. Whether the message conveyed in bird songs is perceived or not may have major consequences for their reproductive success. We tested whether song consistency, a performance trait conveyed in the fine structure of song and important in sexual selection, is perceived under noisy conditions. We found that song consistency is not perceived when masked by low-amplitude white noise. In fact, blue tits (*Cyanistes caeruleus*) respond indiscriminately to consistent and inconsistent songs under noisy conditions, but only discriminate between the two signals under quiet conditions. This study shows that one of the mechanisms through which noise affects birds might be the masking of the acoustic fine structure of songs. The consequent loss of information that they carry can lead to decreased fitness of the individual.

### **Paternal stress in successful Northern bald ibis males: Behavioural, physiological and parasite load evidence.**

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Energy allocation is a key factor in determining reproductive success. Therefore, parental individuals face a general trade-off between investing into offspring or survival/future fitness. Hormones play a major role in allocation mechanisms. Northern bald ibises (*Geronticus eremita*) form seasonally monogamous pair bonds and engage in biparental care. Here, we investigated correlations between faecal corticosterone metabolites (CM), parasitological parameters (i.e. nematode eggs and coccidian oocysts), parental provisioning behaviour and nest site visitation frequency with reproductive success. Individual factors, such as sex and breeding experience, environmental variables, such as developmental day and reproductive phase (i.e. incubation, rearing, fledged) were also considered in the analyses. In males CM concentrations scaled positively with hatching success, while no relationship was found in females. Generally, elevated CM levels were found during incubation and rearing as compared to the phase when offspring were already fledged. Furthermore, males with a high breeding success also showed comparatively high nest visiting rates. No influence was found for females. Our results indicate that male parental investment as indicated by nest visit frequency also comes with metabolic investment, as indicated by high CM with the payoff being high hatching success. The decreasing investment over the breeding season is also manifest in decreasing endoparasite excretion. This may indicate an allocation shift back from parental care to the immune system and hence, to individual maintenance.

### **Black-headed gulls synchronise their activity with their nearest neighbours**

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Animals in groups can benefit from synchronising their behaviour, where multiple individuals conduct similar activities at the same moment in time. Previous studies have demonstrated that some species show synchronisation of vigilance behaviour, but have not explored the mechanism driving this behaviour. Synchronisation could be driven by animals copying their closest neighbours, which would mean that close proximity should lead to increased synchronisation. We simultaneously observed the behaviour of multiple individual black-headed gulls (*Chroicocephalus ridibundus*) within resting groups, and compared the activity of a focal individual with its two closest neighbours and a randomly selected control individual. Focal individuals were more likely to be synchronised with their closest neighbour. Synchronisation became less likely if individuals were not the closest neighbour. This suggests that synchronisation seen within groups is dependent upon the spatial positions of its members, and black-headed gulls pay more attention to their closest neighbours.

### **Wild and laboratory exposure to cues of predation risk increase relative brain mass in male guppies**

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There is considerable diversity in brain size within and among species, and substantial dispute over the causes, consequences and importance of this variation. Comparative and developmental studies are essential in addressing this controversy. Predation pressure has been proposed as a major force shaping brain, behaviour and life history. The Trinidadian guppy, *Poecilia reticulata*, shows dramatic variation in predation pressure across populations. We compared the brain mass of guppies from high and low predation populations collected in the wild. Male but not female guppies exposed to high predation possessed heavier brains for their body size compared to fish from low predation populations. The brain is a plastic organ, so it is possible that the population differences we observed were partly due to developmental responses rather than evolved differences. In a follow-up study, we raised guppies under cues of predation risk or in a control condition. Male guppies exposed to predator cues early in life had heavier brains relative to their body size than control males, while females showed no significant effect of treatment. Collectively our results suggest that male guppies exposed to predation invest more in neural tissue, and that these differences are at least partly driven by plastic responses.

### **From nipple to hand: Lateral biases in mother-infant interactions in barbary macaques (*Macaca sylvanus*).**

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Recent studies reported a lateralization of mother-infant interactions in several non-primate mammals, indicating right-hemisphere dominance for social processing in various mammals. In primates, early life asymmetries in mother-infant behaviour have been related with the development of the hand preference of the offspring. This study investigated asymmetries in different behaviours of mother-infant dyads in zoo Barbary macaques (*Macacasylvanus*). Fourteen subjects (seven mothers with their own infant) were observed. For the mothers, data of hand preference for maternal cradling, infant retrieval and feeding were collected. For the infants, we recorded preference for the mother's nipple and the hand preference for clinging on mother's belly and for feeding. Non-parametric tests were used to investigate the presence of lateral biases and to evaluate the relationship between different behavioural categories. First, we found that at the individual level, all infants had a significant nipple preference (six toward the right nipple, one toward the left one). Similarly, six out of seven mothers showed a cradling bias, three toward the right hand, three toward the left hand. At the group level, no significant bias was reported in any of the behavioural categories. In infants, nipple preference was positively correlated with the hand preference for feeding, suggesting that maternal environment might affect the development of hand preference in macaques. The infant preference toward the mother's right nipple resembles the overall tendency to keep the mother on the left side reported in non-primate species, supporting the hypothesis of a right-hemisphere involvement in social processing.

### **Do ultrasonic vocalizations during courtship predict reproductive success in house mice?**

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House mice (*Mus musculus*) emit ultrasonic vocalizations (USVs) consisting of a variable repertoire of different syllable types. Males emit USVs during courtship and mating, and it is assumed that their function is to enhance mating success. Our aim was to test whether the amount or features of male USVs predict their subsequent mating and reproductive success. Here we recorded 26 breeding pairs (16 unrelated, 10 related pairs) of wild-derived house mice during two phases of their first encounter. We recorded male USVs during presentation of a novel female through a perforated divider, and during direct interactions after removing the divider. Subsequently, the pairs were allowed to breed, and we measured their reproductive success (RS) using latency to the first birth and the number of offspring. USVs were automatically detected using the Automatic Mouse Ultrasound Detector (A-MUD), and manually classified into different syllable types. Our results will compare the number and structure of USVs emitted during these two phases of sexual encounters, and correlate vocalizations and their features with the subsequent RS of the breeding pairs. We expected that a higher number and complexity of USVs emitted during these interactions would facilitate mating and therefore would be correlated with RS. To our knowledge, this is the first study in house mice to test whether USVs predict mating and RS.

### **Behavioural and seasonal correlates of cortisol and testosterone metabolite levels in male Barbary macaques.**

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Testosterone (T) and glucocorticoids (GC) are steroid hormones that allow organisms to respond adaptively to social and environmental challenges. T is often implicated in promoting male reproductive competition through increased aggression or dominance rank acquisition and is traded-off against caring for infants and social bonding. GCs help to rapidly metabolise energy reserves and are often released in response to stressors. Therefore, during competitive social contexts (e.g. mating season, periods of high aggression rates) we may expect both hormones to be released simultaneously to achieve maximally adaptive responses. Furthermore, during bonding or non-competitive contexts (e.g. grooming), individuals would benefit from downregulating both hormones back to baseline. In this study we combine behavioural data on social interactions (4,000 hours of focal animal sampling) with measurements of T and GC levels measured in the urine (950 samples) of 14 adult male Barbary macaques (*Macaca sylvanus*) from a semi-free ranging population across a mating and non-mating season. From a competitive perspective, we first test for a rise in hormone levels from the non-mating to mating season, a period of increased male reproductive competition. We also test for a relationship between both hormones with aggression and dominance rank during the mating season. Next, from a bonding perspective, we will test for a relationship between both hormones with infant-carrying, grooming and triadic male-infant-male interactions. Our results will add to our understanding of how steroid hormones are related to social behaviours in different contexts. Funded by the German Research Foundation (RTG 2070).

### **The innovation arena: Comparing innovative capacities using a novel multi-task design.**

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Finding solutions to novel problems or dealing with familiar problems in a novel way describes an innovative process. Technical problem solving tasks have shown to be valuable tools to investigate innovation in experimental settings. Here we present a novel approach: the innovation arena. It features a battery of 20 novel tasks, each requiring a distinct motor action to access a reward, arranged in a semi-cycle. Subjects are repeatedly confronted with the setup with shuffled task positions and have a limited time-frame to obtain as many rewards as possible. The innovation arena targets questions such as: how fast is the innovation rate? Does its gradient rise or fall after an initial phase? Which innovations are consistently repeated and which are one-offs? And, importantly, who are the innovators? Here we pilot the design to test for a captivity effect in the Goffin's cockatoo (*Cacatua goffiniana*), who represents a prime model species for technical innovation in birds: they have proven to be skilful problem solvers and have even demonstrated innovative tool use and manufacture. Nevertheless, so far, studies on the Goffin's innovative abilities were limited to captive subjects. We applied the innovation arena to compare groups of long-term laboratory subjects in Vienna with temporarily wild-caught birds in Tanimbar, Indonesia. Our results show considerable individual variation in the subject's performances with individuals from both, the laboratory as well as wild-caught birds, reaching high innovation rates. We will present our findings and discuss how the innovation arena can be a valuable tool for further research.

### **Do animals see the Delboeuf illusion differently? A large-scale comparative assessment**

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Visual illusions are commonly used in animal cognition studies to compare visual perception among vertebrates. Few studies have investigated sensitivity to visual illusions in fishes and none in reptiles and prosimians. We investigated whether fishes (*Poecilia reticulata*, *Danio rerio*, *Pterophyllum scalare*), reptiles (*Pogona vitticeps*, *Geochelone carbonaria*) and a lemur species (*Lemur catta*), perceive the Delboeuf illusion, consisting in the misperception of the size of an object due to the surrounding context. We adopted the same spontaneous preference paradigm in all species, in particular their natural tendency to select the larger amount of food. In control trials, we presented two different amounts of food (the ratio between food portions was 0.66) in two identical plates. In test trials, we presented equal food portion sizes in two plates differing in size: if they were sensitive to the illusion, they were expected to select the food portion presented in the smaller plates. The different species had different performances with the illusory pattern suggest the intriguing possibility that the perceptual bias affecting size discrimination in vertebrates might be different.

### **Intentional gestural signalling amongst red-capped mangabeys (*Cercocebus torquatus*).**

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Apes, human's closest living relatives, are renowned for their intentional and highly flexible use of gestural signals. In stark contrast, evidence for intentional signalling in monkeys is scant, especially when considering signals produced amongst conspecifics. We present data on the naturally occurring gestural communication amongst captive red-capped mangabeys (*Cercocebus torquatus*), collected from a total of 17 individuals living in three different groups at the Station Biologique, Paimpont, France. When applying methods originally established in ape gesture research to assess whether these monkeys used 'markers of intentionality' during their gesture production, we found that 24 out of a total of 25 different signal types (including 4 facial expressions and 5 manual gestures) qualified as intentional. They were characterized by sensitivity to the attentional state of recipients, adjustment to audience effects, and goal persistence. Our results reveal that monkey communication is cognitively more complex than previously assumed, and show that the precursors to flexible and intentional communication were already present in the primate lineage around 30 My ago.

### **Experimental assessment of vocal imitation abilities in the kea (*Nestor notabilis*)**

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Vocal learning is thought to be a key component to the emergence of language in humans. Although numerous mammals seem to learn their calls or songs, examples of heterospecific mimicry are mostly confined to the oscine Passeriformes (songbirds) and *Psittaciformes* (parrots) birds. However, if the latter are famous for their imitations of sounds and human speech in captivity, examples of vocal imitators are only limited to species of the *Cacatuidae* and *Psittacidae* orders. And although some evidence suggests certain forms of vocal learning in more phylogenetically ancient parrots of the *Strigopoidae* branch (regional dialects), no experimental evidence of neural ability for vocal mimicry in this branch exists to date. Thus, the evolution of vocal imitation amongst parrots remains poorly understood. We aim to test whether a *Strigopoidae* parrot, the kea (*Nestor notabilis*), can imitate sounds in an operant setting and to further assess the extent of these imitation abilities. We hypothesized that kea possess the neural ability to imitate sounds but that this imitation is limited by overall imitation experience, vocal plasticity and familiarity level of the sound. We trained 8 kea of varying ages to produce and imitate sounds on command using methods first developed in human psychology and successfully adapted to other species. We then tested their abilities using calls or sounds of varying species and familiarity levels using a custom built playback program and apparatus.



### **Flexibility of foraging behaviours under reduced food availability**

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Optimal foraging theory suggests that the behaviours used by a forager to obtain food ([1] movement, [2] space use, [3] aggression and [4] diet choice) are adapted to the biotic and abiotic conditions that forager typically faces (e.g. food availability, competitors). If conditions change, then behaviours may become sub-optimal, leading to decreased health or survival. This is unless the animal shows significant flexibility in these behaviours and can adjust them to the changing conditions. For instance, there are many cases across taxa where foragers must respond to reduced food availability. While some generalized behavioural responses to decreased food availability have been proposed, such as a subsequent expansion in home range or diet, the strength and pervasiveness of these behavioural shifts across taxa have not been addressed in detail. We assessed these relationships in a meta-analysis of papers detailing the four above-mentioned foraging behaviours under varying food availability. We analysed effect sizes of changes in food availability, and how these compare with effect sizes for any resulting changes in behaviour. Consistent directions in effect sizes suggest some common responses among taxa. For example, a decrease in food availability consistently resulted in an increase in foraging distance. However, variability among studies indicates that phylogeny, social organization, food distribution, and seasonality each may have a role in the creation of context-dependent outcomes of food reduction. As anthropogenic disturbances continue to threaten food availability in many ecosystems, understanding behavioural responses to these disturbances will be critical in managing population survival.

### **Human-Wildlife Conflict: Characteristics of opportunistic carnivore depredators on subsistence and commercial farmland in north-eastern South Africa**

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Retaliatory killings or deliberate persecution of endangered wildlife by farmers due to crop and stock depredation by damage-causing animals intensify as farming practices expand into natural habitats. Our aims were to identify the most frequently depredated crops and livestock on subsistence and commercial farms as well as identify the common damage-causing animals associated with the greatest number of depredation incidences. Using semi-structured questionnaire interviews, we investigated the presence and control of damage-causing animals on subsistence and commercial farms in selected localities of north-eastern South Africa. Subsistence farmers lost a significantly higher number of crop species to depredation than commercial farmers, with Ndumo, a subsistence community in KwaZulu-Natal Province, experiencing the greatest numbers of crop species lost. Notably, maize *Zea mays* produced by both subsistence and commercial farmers was the most frequently raided crop, and primates were reportedly responsible for the greatest number of crop-raiding incidences, particularly on subsistence farmland. Poultry and young livestock were most frequently depredated throughout the study locations. Joint leading depredators were caracal *Caracal caracal*, endangered African wild dog *Lycaon pictus* and leopard *Panthera pardus*. Commercial farmers practised a significant number of retaliatory control compared with subsistence farmers, manifested as shooting and poisoning of wildlife, particularly carnivores, while subsistence farmers exclusively persecuted primates. In conclusion, wildlife depredation and persecution is the result of socioeconomic and ecological issues that are exceptionally contentious because the commodities depredated bear nutritional and financial implications for human livelihoods and the conservation of the wildlife species concerned, particularly for vulnerable and endangered species.

### **'Group personality' in common marmosets: importance of the social environment on individual variation in cognition**

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Animal personality, defined as consistent inter-individual differences in behaviours across time and contexts, has recently been found in common marmosets, using a set of personality tests and observations. Interestingly, consistent behavioural variation in exploration and boldness-shyness is smaller between individuals of the same group as compared to the variation among individuals of different groups. Marmosets are apt learners and they have also been reported to display substantial inter-individual variation in these tasks. However, consistency and direction of such variation has never been studied in terms of certain axes of marmoset personality, i.e. no study to date asked whether and how inter-individual variation in exploration and boldness-shyness affects marmosets' propensity for individual learning. Thus, we tested 28 common marmosets in standard personality tests (general activity, novel food, novel object, foraging under risk, predator) and a series of cognitive tasks, divided in simple motor tasks and discrimination learning tasks. Here, we will report i) which factors predict the degree of group-level similarity in personality and ii) whether the degree of such within-group similarity affects the likelihood of individually mediated learning (and subsequent social information transmission in the group). We will discuss the strengths and weaknesses of the concept of 'group personality' and evaluate the relative importance of the social environment on individual variation in information processing.

### **Development-related modification of intermediate host behavior and transmission in the acanthocephalan parasite *Acanthocephalus dirus*: field data**

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The acanthocephalan parasite *Acanthocephalus dirus* occurs in streams throughout the Midwestern United States (USA) where it infects crustacean isopods (*Caecidotea intermedium*) as intermediate hosts and fishes (e.g., centrarchids, cyprinids) as definitive hosts. Infection of juvenile *C. intermedium* occurs during the summer and the parasites develop from immature to mature stages as the isopods develop from juveniles to adults. Mature *A. dirus* (cystacanths) have been shown to modify several host traits (e.g., body color, refuge use, activity), which have the potential to influence transmission by increasing conspicuousness to predatory definitive hosts. However, little is known about the relationship between host modification and transmission especially in nature. Examining these relationships is critical for understanding the potential fitness consequences of host modification. We examined these relationships using a 12-month field survey in which host behaviour (refuge use), parasite development and prevalence in definitive hosts was recorded. The results showed that immature parasite stages (acanthellae) dominated isopod infections from June to September and mature stages (cystacanths) dominated infections from October to May. As the proportion of cystacanths increased, there was a correlated shift in behaviour (decreased refuge use), which is expected to increase exposure of infected isopods to predatory hosts. This shift in behaviour was also correlated with the pattern of prevalence of *A. dirus* cystacanths in the definitive hosts (the parasites reached a plateau in prevalence after the shift in behaviour occurred). We will discuss both adaptive (parasite manipulation) and non-adaptive hypotheses (pathology, host counter-adaptation) to explain these relationships.

### **New opportunities for citizen-led mammal monitoring in the UK.**

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Monitoring biodiversity is essential to underpin informed conservation and management. Some taxa are already rigorously monitored at large spatial scales but knowledge of UK mammal distributions and their temporal changes is limited. In part, that arises from their relative scarcity and low detectability. Passive infra-red camera traps offer a solution to those problems but are associated with other challenges. In particular, large-scale camera trapping projects require considerable investment of time to service field equipment and classify potentially large numbers of images. In response to these issues we developed MammalWeb, a crowdsourcing platform for mammal monitoring in the UK. Initially developed as a local-scale project in North East England we involved citizen scientists in both the capture and classification of sequences of camera trap images. A key attribute for crowd-sourced data is ensuring data reliability and we illustrate that our approach can be economical, yielding high consensus classification accuracy from relatively few classifications. The project is now expanding and a wide range of organisations can participate through engagement and more direct involvement, with significant potential for hosting research projects within the MammalWeb framework. We highlight why that participation would be of mutual benefit.

### **Cortisol in long-tailed macaques drops when they cooperate with affiliates**

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Cooperation occurs in a whole array of animal species and can be determined by different social factors. In many species social tolerance is a prerequisite for cooperation, and close social bonds were identified as a driving factor of maintained cooperation. The potentially underlying physiological mechanisms, however, have received comparatively little attention. Here, we investigated the link between cooperation, social bonds and cortisol levels in long-tailed macaques (*Macaca fascicularis*). We trained 14 macaques to provide saliva samples for cortisol analysis and conducted behavioural observations throughout the study period to determine their social bonds. In a dyadic cooperation experiment (loose-string task) we tested the individuals' cooperative performance with two partners of different social bonds. Moreover, we measured their salivary cortisol levels before and after the task, which allowed us to identify acute hormonal changes. There was no strong evidence that cortisol levels before the task influenced the subsequent cooperative performance, nor did the cooperative performance lead to changes in cortisol. However, irrespective of the performance, cortisol decreased after cooperation with closely bonded individuals. Other potential drivers of this effect – the mere presence of a closely bonded macaque and the pulling task itself – could be ruled out by means of two control conditions. Our findings suggest that the demonstrated anxiolytic effect of cooperation with closely bonded individuals may be the underlying proximate cause of the maintenance of cooperative interactions over time.

### **Gut retention time of samango monkey (*Cercopithecus albogularis schwarzi*) in situ using artificial digestive markers.**

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The length of time food remains in the digestive tract can have consequences on digestive strategies, access to energy and nutrients from food, and seed dispersal patterns. As such, measuring the gut passage time of food through the gut can aid research from multiple disciplines. Here, we determined mean gut passage time in situ in a male and a female samango monkey (*Cercopithecus albogularis schwarzi*) using artificial digestive markers. We targeted provisioning of a male and a female at Lajuma, South Africa, four times over three and four days respectively. We impregnated a yellow banana with 50 wooden beads (2x3 mm) and left it in the path of the monkey for consumption. We followed the individual after each ingestion event over a 72 hr window from dawn to dusk, collecting all faecal samples deposited. We counted the number of beads in each sample and used the time from ingestion to calculate mean gut passage time. We found mean gut passage time to be 24.37 hours ( $\pm$ SE 1.88 hours) for male and 23.06 hours ( $\pm$ SE 0.69 hours). Our study is the first in the wild on samango monkeys utilising artificial digestive markers. When used together with data such as day journey length, our results can be used to estimate seed shadows and dispersal patterns, as well as interpreting digestive strategies in wild samango monkeys.

### **To eject or to abandon? Influence of mimicry on the type of the host rejection behaviour**

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Great Reed Warbler (*Acrocephalus arundinaceus*) is one the main hosts of the Common Cuckoo (*Cuculus canorus*) and it is capable to defend itself against parasitism. Recognition and rejection of the cuckoo egg is very important way of its defence. Great Reed Warbler is able to reject cuckoo egg in approximately half of cases (in 81 from 151 parasitized nests). This host is getting rid of the parasitic egg by two different ways; either it ejects the cuckoo egg and continues in the contemporary nesting trial, or it abandons the whole clutch and begins build new nest. The first way of rejection should be more advantageous for hosts because they do not have release other energy to the constructing of the new nest or laying new eggs. So why there is so many cases when warblers abandon their nests instead of ejecting cuckoo eggs? In this study we investigated 'mimicry hypothesis' that warblers tend to abandon their nests because they are not able to recognize the mimetic cuckoo egg among their own. Therefore, we expected that cuckoo eggs from abandoned nests will be better matching than cuckoo eggs that were ejected by hosts. We used reflectance spectrometry and digital image processing for evaluation of cuckoo egg mimicry in colour, spottiness, size and shape. Preliminary results showed that colour and size have no effect on the type of egg rejection behaviour in hosts.

### **Object permanence in horses (*Equus caballus*): how do they apprehend their physical world?**

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A key question in the field of animal cognition is how animals comprehend the physical world. One of the fundamental features of physical cognition, which is called object permanence, is the ability to reason about hidden object and to mentally reconstruct their invisible displacements. This cognitive skill, defined by six stages of increasing complexity, has been studied in a wide panel of species but never in horses (*Equus caballus*). In this presentation I will talk about a study assessing the understanding of visible (Stage 5) and invisible displacements (Stage 6) in adult female Welsh ponies. Stage 5 was investigated by hiding a food reward below one out of two or three plastic cups and by testing whether they committed the A-not-B errors (i.e. whether they persevere looking for an object at the location A, where it has previously been hidden repeatedly, rather than at its actual location B). Stage 6 was assessed by a single-transposition task. Horses succeeded in all of the visible displacement tasks and one horse significantly succeeded in the single-transposition task. However, her results suggest that she was using an associative rule rather than a real understanding of invisible displacements. Horses thus master visible displacements but seem unable to process invisible displacements, as do most non-human mammal species, except great apes. Hence, this study suggests that horses might use perceptual cues or associative rules rather than an understanding of invisible displacements to cope with concealed moving objects.

### **Long-term behavioural consistency and behavioural stability in Border collies**

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Temporal consistency and stability of behaviour are important aspects of personality, with high theoretical relevance and various practical applications. In the current study we aimed to investigate long-term consistency and stability of pet Border collies' behaviour, and analyse the effect of age on the behaviour. N=217 Border collies (mean age  $\pm$  SD = 4.0  $\pm$  3.5, range 0.5-15 years) were tested in a battery (Test1) which yielded five factors. N=37 dogs were retested after ~ 4 years with the same test battery (Test2). All factors proved to be consistent, that is, showed significant positive correlation between Test1 and Test2 (ICC=0.473-0.751;  $p < 0.029$ ). Activity-independence and Novelty-seeking decreased, Problem orientation increased from Test1 to Test2 ( $p < 0.001$ ,  $p = 0.022$ ,  $p < 0.001$  respectively). In the latter two factors, experience with the object and task contributed to the behaviour change, repeated exposure led to lower interest in a 'novel' object, but higher success in solving a familiar problem, which is surprising after 4 years. Effect of age was investigated on the subjects of Test1. Sociability-obedience and Frustration tolerance were not affected by age. Young and old dogs received higher Activity-impulsivity score ( $R = 0.379$ ;  $p < 0.001$ ), and received lower Problem-orientation score than middle aged dogs ( $R = 0.474$ ;  $p < 0.001$ ), while Novelty seeking generally decreased with age ( $R = 0.564$ ;  $p < 0.001$ ). This is one of the first studies that shows behavioural consistency over such a long time in dogs, moreover, we also showed that sociability- and frustration-related traits are not only consistent but also stable over time.

**Early-life Stress: Distinguishing Task- from Rule-Learning in Zebra finches (*Taeniopygia guttata*)****B.C. Turnbull, K.A. Spencer**

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Early-life stress, mediated by glucocorticoid hormones, can shape many phenotypic traits including hormonal profiles, behavioural responses, and learning abilities in later life. Tasks which measure variations in learning can be broken down into two components: an initial motor portion (task-learning) followed by rule-learning. Performance on task-learning may affect rule-learning however most studies focus on the latter without accounting for the former. To address this, we used the Zebra finches (*Taeniopygia guttata*) to test whether the two components can be distinguished and selectively affected by early-life stress. Birds were fed corticosterone (the primary avian stress hormone), mimicking the physiological effects of stress, for 10 days during either the nestling or adolescent phase of development. Birds were then tested in adulthood on their rate of learning a 6-stage motor task (task-learning) followed immediately by the location of a food reward (rule-learning). Learning was quantified as number of trials required to pass all 6 stages and then make 5 consecutive correct choices respectively. Elevated corticosterone exposure during the nestling and adolescence stages had opposing effects on task-learning, with nestling 'stress' reducing the number of trials required to learn the task whilst adolescent 'stress' increased them. Rule-learning was only affected by adolescent treatment: females required more trials to reach criterion if they experienced 'stress' during this phase. Overall, our data demonstrate that the two components of cognitive tests can indeed be distinguished, and that the timing of early-life stress can have selective impacts upon them.

**Development of personality: stable individual differences between littermates of the domestic cat****A. Urrutia, P. Szenczi, R. Hudson, O. Bánszegi**

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Interest in the phenomenon of animal personality has grown in the last decades, but until now most of these studies have been carried out on adult animals. However, marked behavioural differences among conspecifics may appear early during development and then change over time, since juvenile and adult individuals face different internal (perceptual, physiological) and external (ecological, social, foraging, etc.) environments from each other. The domestic cat (*Felis silvestris catus*) provides a good opportunity for personality studies in young and developing mammals as it is an easily accessible species with a rich behavioral repertoire, which is commonly agreed to display differences in personality to a greater extent than most other laboratory species. Here, we present the first findings of our study of personality in pre-weaning age kittens. We developed five novel, ecologically relevant behavioural tests and performed them repeatedly with 74 kittens from 16 litters between the ages of one and two months. Our first analyses indicate that in all five tests, stable individual differences in behaviour among pre-weaning age littermates are present; results will be presented at the conference. A subset of the kittens used in this study are currently taking part in a longitudinal study of personality across development, from pre-weaning age into adulthood, and the broader aims of which include the examination of long-term stability of behaviour and the predictive value of personality tests in early age.

### **Comparing mirror responses of crows and ravens**

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Inquiries of visual self-recognition involving mirrors date back to 1970 when Gordon G. Gallup designed the Mark Test and showed that chimpanzees can recognize themselves in mirrors. The Mark Test has since become the approved method to test for self-recognition in animals and its passing has been connected to ToM and some form of self-awareness. Implementing this test, it has been shown that only some species e.g. great apes, dolphins, Asian elephants and magpies possess the ability of mirror self-recognition (MSR) and share a similar pattern as to the evolution of their behaviours in front of the mirror: 1. Social behaviour, 2. Mirror Inspection, 3. Contingency Checking, and 4. Mirror Guided Self-directed behaviours. The latter being only performed by individuals considered able of MSR. Nevertheless, attempts to find MSR in other corvid species have so far failed, and with only few studies conducted it is difficult to explain these inter-species differences. The present study aimed to expand the number of corvid species tested in this assay and examines the response to mirrors of carrion crows and common ravens. We found that both species, as many bird species, exhibit a preference for viewing the mirror vs. the control and showed a common pattern concerning the evolution of their behaviours in front of the mirror over time. However, both species failed to show spontaneous self-exploration in front of the mirror nor mark-directed behaviours in the subsequent Mark Test, preventing claims about the ability of MSR in crows and at this stage.

### **Do visual cues play a role in zebra finch song learning?**

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Like many signals used in animal communication, birdsong is multimodal, which means that it can be perceived through more than one sensory modality. Song production is mainly an auditory signal, but it is accompanied by visual cues, such as beak and head movements. Zebra finches, the most commonly used songbird species in studies on vocal learning, show more song copying when raised with a live tutor than when passively exposed to taped song. This finding has usually been ascribed to a lack of social interaction with the tutor in the tape-tutor condition. Another possible explanation, however, is that a social tutor enables a pupil to see the visual correlates of song, such as beak and head movements, while a tape-tutor does not. A number of studies on human infants suggests that multi-modal cues play a role in language learning. We aim at finding out whether multi-modal cues are also important for song learning in zebra finches. Therefore, we conducted a song tutoring experiment in which young birds received either uni- or multimodal song exposure.

### **Spatial patterns of the song of the collared flycatcher (*Ficedula albicollis*)**

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Socially learned behaviors can be found in many animal species and it is also well known, that the cultural traits vary geographically within species. Bird song is one of the best-known behavioral trait that shows patterns of cultural evolution. Geographic song variation has been studied so far in numerous bird taxa, but most of these studies focused on species with relatively simple song. The collared flycatcher (*Ficedula albicollis*), has a moderately large repertoire size (20-90 syllables), and it is likely that individuals learn a large part of their song socially. When social learning occurs, the appearance of song elements (i.e. syllables), will not be randomly distributed, but structured in space. To test this hypothesis, we analyzed the song of the collared flycatcher males collected from different areas of Hungary. To examine whether the similarity of song content among individuals follows a spatial structure, we calculated similarity matrices based on the relative frequencies of syllables and tested the relationship with the geographical areas using Mantel-tests. We found that the composition of the population's song is spatially organized: the song of males from the same area shows greater similarity than from different areas. The detected compositional differences between the areas depended on the distance between them. Spatial pattern is effected by the rare and population specific, as well as the more frequent syllable types.

### **The impact of extreme developmental temperatures on the reproductive behaviour of insect species**

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Rises in global temperatures as a result of human-induced climate change will continue to threaten the future of biodiversity. Currently, studies that examine its impact on organisms use its physiological 'critical thermal limit'. This useful but crude measure ignores many important sub-lethal impacts of temperature, including effects on the behaviour of individuals. Ectotherms are particularly at risk to rises in global temperatures as they have limited capacity to cope with changes in ambient temperatures. Moreover, many invertebrate species have sessile early life-history stages, during which individuals cannot compensate for local high temperatures through behavioural thermoregulation to cooler microclimates. We examine how stressful temperatures experienced during the pupal stage affects the reproductive behaviour across *Drosophila* species. We examine how male and female mating is affected by pupal temperatures, and how these correlate with other vital fitness components such as fertility. We also address whether species can mitigate the impact of high temperatures during development through behavioural plasticity. We find that high temperatures have major impacts on the ability of individuals to mate successfully. These costs are seen both in physiology, in egg and sperm production, but also in ability to perform normal mating behaviours. These sub-lethal impacts of high temperatures have the potential to render areas uninhabitable by some species. We suggest that considering the impact of extreme conditions on physiology and behaviour is vital if we are to predict the effects of climate change.



**Sexual priming enhances emission of ultrasonic vocalizations of male mice****S.M. Zala**, D. Reitschmidt, M.A. Marconi, D. J. Penn

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Male house mice (*Mus musculus*) emit complex ultrasonic vocalizations (USVs) during courtship and mating, but neither the mechanisms nor functions of these calls are well understood. Here we tested whether and how long a brief interaction with a female (sexual priming) affects male USV emission in wild-derived male mice (n=50). We recorded the USVs of males following presentation of an unfamiliar female behind a perforated partition either 1, 10, 20 or 30 days after priming. We detected the number of USVs using an automatic algorithm (Automatic Mouse Ultrasound Detector or A-MUD), and we compared the calls of primed males with unprimed controls. We found that primed males emitted >2x as many calls compared to controls when they were recorded 1 day after priming, but not later. Thus, male USV emission is enhanced 1 day after sexual priming, but this effect is not long-lasting. Additionally, we will present our findings of the different syllables types that males emitted during our recordings. Our results provide a practical method to induce male USV emission, and they suggest that USVs potentially provide a reliable signal of male sexual motivation and recent sexual experience to potential mates.

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