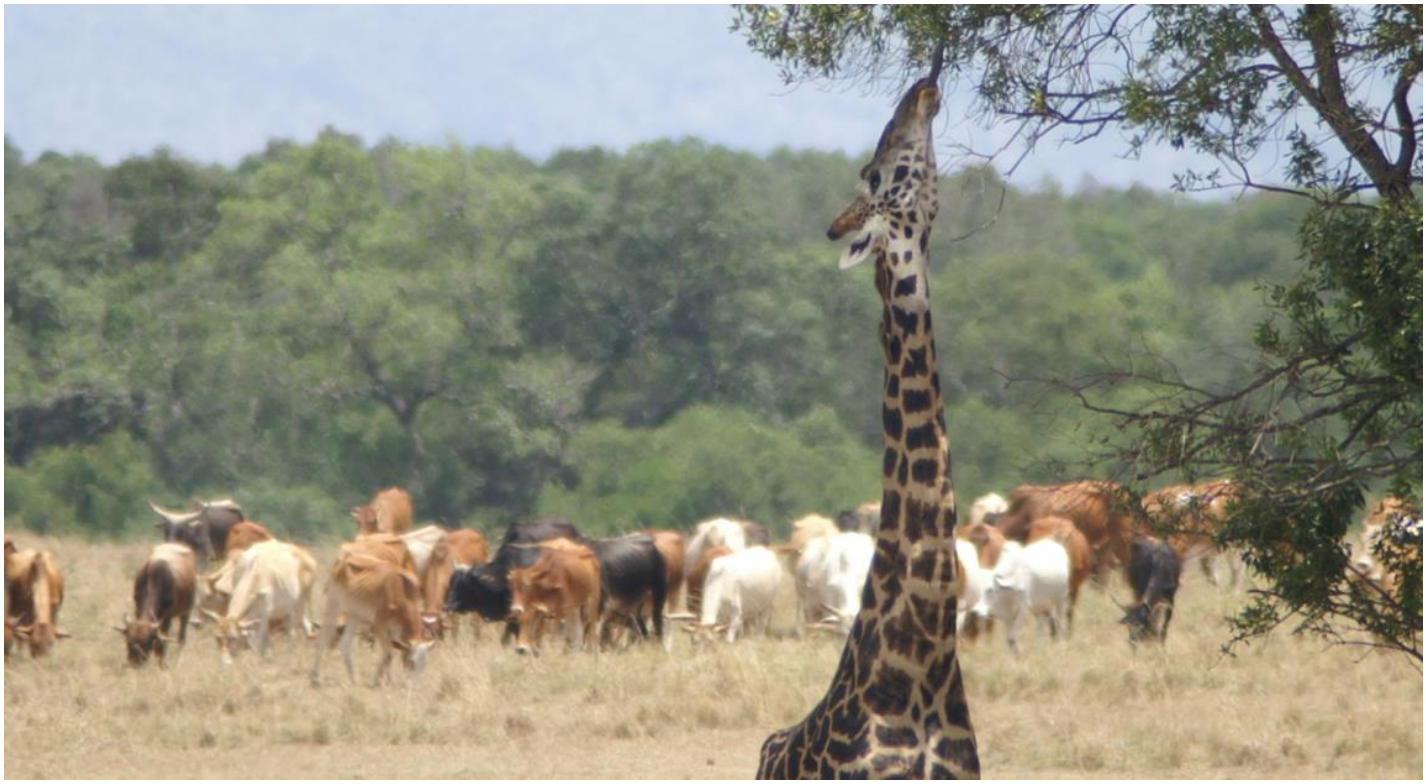
Symposium

ZOOLOGICAL SOCIETY OF LONDON
REGENTS PARK, LONDON, NW1 4RY

22 and 23 November 2018



Linking behaviour to populations and communities: how can behavioural ecology inform conservation?

An international symposium to discuss how human-influences changes in animal behaviour can support future conservation research

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Bernt-Erik Sæther, Norwegian University of Science and Technology

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George Wittemyer, Colorado State University

11.15 TEA/COFFEE

11.45 Space, time and seasonal interactions in migratory species
Jennifer Gill, University of East Anglia

12.15 Navigating changing risks and resources in heavily human-dominated landscapes: behavioural strategies and population consequences in a threatened endemic antelope
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Friday 23nd November

09.00 Registration opens

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Matthew Silk, Exeter University

10.00 Behavioural ecology and infectious disease: implications for conservation of vertebrate biodiversity
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10.30 Troubled communication in polluted environments: conservation implications
Ulrika Candolin, Helsinki University

11.00 TEA/COFFEE

11.30 Pace-of-life syndromes and the success of biological invasions
Daniel Sol, (Centre for Ecological Research and Forestry Applications)

12.00 Metapopulation modelling as a conceptual tool for the management of marine invasions: a case study with lionfish on Caribbean coral reefs
Isabelle M Côté, Simon Fraser University

12.30 Discussion

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SESSION 4 Reintroduction

13.45 Reintroduction: a founder event with no evolutionary precedent
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14.45 Incorporating behavioural metrics into predictions and decisions for reintroductions
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15.30 TEA/COFFEE

SESSION 5 Forging links between the behavioural ecological and conservation community

16.00 Integrating behaviour and ecology into global biodiversity conservation strategies
Joseph Tobias, Imperial College London

16.30 Bridging the divide between conservation decision makers and scientists: how can ecologists make their research relevant?
Sarah M Durant, Institute of Zoology, ZSL

17.00 Can a behavioural ecologist set up a protected area?
Tim Caro, University of California - Davis

17.30 Discussion and final comments

17.45 END OF SYMPOSIUM

ABSTRACTS

Thursday 22nd November

10:00 **Welcome by Jakob Bro-Jørgensen, University of Liverpool**

10.10 **Towards a predictive conservation biology: the devil is in the behavior**
Bernt-Erik Sæther, Centre for Biodiversity Dynamics, Norwegian University of Science and Technology, N-7491 Trondheim

A predictive conservation biology requires that we can quantify the influence of processes strongly influencing future population sizes, often dealing with declining populations. In this talk I will give examples for how behavioral variation will affect long-term persistence of small populations in a fluctuating environment. I will focus on the effect of demographic stochasticity, which is caused by random variation among individuals in reproductive success and survival. Demographic variances reduce the long-run population growth rate of small populations and is also directly related to the magnitude of genetic drift. Consequently, demographic stochasticty will strongly affect the viability of small populations. Behavior strongly influence the magnitude of the demographic variance because it affects individual differences in fitness. I will illustrate the importance of understanding mechanisms generating behavioural variation in a small moose population by showing how demographic variance is strongly influenced by individual differences among males in mating success. Similarly, variation in male mating success was the major determinant of demographic contribution by translocated individuals to the growth of small house sparrow populations. These examples strongly emphasis how important knowledge about individual variation in behavior is for management of small populations, in particular through the effects on the demographic stochasticity.

SESSION 1 Habitat loss and fragmentation

10.45 **Guiding landscape conservation planning with animal movement behaviour**
George Wittemyer, Colorado State University

Wildlife tracking is one of the most frequently employed approaches to monitor and study wildlife populations. To date, the application of tracking data for conservation and management objectives has focused largely on the intensity of use by an animal in a specific location or type of habitat. While this has provided valuable insight and advanced spatial wildlife management, such interpretation of tracking data does not capture the complexity of spatiotemporal processes in animal behavior and simplifies the rich behavior represented in the movement path. Here, we present movement-based approaches to estimate the behavioral value of spatial locations, focusing on emerging areas at the nexus of conservation behavior and movement ecology that can amplify the application of animal tracking research to contemporary conservation challenges. We highlight the importance of applying behavioral ecological approaches to the analysis of tracking data, and discuss the utility of comparative approaches, optimization theory, and economic valuation to gain understanding of movement strategies and gauge population level processes. First, we discuss innovations on the most fundamental movement-based valuation of landscapes, how frequently a location is used (i.e., intensity of use), namely dissecting temporal dynamics in and means by which to weight intensity of use. We then expand our discussion to three less common approaches for behavioral valuation of landscapes, namely the assessment of the functional (i.e., what an individual is doing at a location), structural (i.e., how a location relates to use of the broader landscape), and fitness (i.e., the return from using a location) value of a location. Strengthening the behavioral theoretical underpinnings of movement ecology research promises to provide deeper, mechanistic understanding of animal movement that can provide unprecedented insight to the interaction between landscapes and animal behavior and advance application of movement research to conservation challenges.

11.15 TEA/COFFEE

11.45 Space, time and seasonal interactions in migratory species

Jennifer Gill, University of East Anglia

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Many migratory systems are changing rapidly in space and time at present, and these changes present challenges for species conservation. Ongoing changes in species' ranges, through colonisation, local extirpation and changes in relative abundance, have raised concerns over the efficacy of existing protected area networks, while changes in phenology have raised concerns over mismatches in the timing of key annual events with the availability of key resources. Identifying the mechanisms driving these changes in space and time is a critical step in understanding their likely rates and directions, and thus in devising appropriate conservation actions. Using a long-term study of a migratory shorebird system in which (a) range expansion across breeding and non-breeding areas has occurred over the last century, (b) timing of spring migration has advanced substantially in recent decades, and (c) life-long and population-wide tracking of individual migratory routes takes place through a citizen science network, we explore the evidence for these changes being driven by either individuals shifting in space and time or by generational shifts in spatial and phenological distributions across the population. We also explore the processes that can drive such individual and generational shifts in phenology and distribution, and the studies that will be needed to distinguish among these mechanisms of change, and to inform the development of future conservation strategies.

12.15 Navigating changing risks and resources in heavily human-dominated landscapes: behavioural strategies and population consequences in a threatened endemic antelope

Kavita Isvaran, Indian Institute of Science, Bangalore

In the developing world, many wild animal species live in heavily human-dominated landscapes. How do they respond, if at all, to variable risks and resources in such landscapes? Are these populations likely to persist or are they on their way to local extinction? We have been studying the behavioural and population ecology of a threatened endemic antelope (blackbuck, *Antilope cervicapra*) in a typical human-dominated, fragmented, semi-arid grassland landscape. We describe a suite of behavioural responses that blackbuck appear to show in response to small- and large-scale variation in human-related risk factors. We also examine the population consequences of these responses. We use a modelling approach, together with long-term population data, to relate these behavioural responses to long-term population persistence.

12.45 Invisible barriers: anthropogenic impacts on inter- and intra-specific interactions as drivers of landscape-independent fragmentation

Oded Berger-Tal, Ben-Gurion University of the Negev

Authors: Oded Berger-Tal and David Saltz

Anthropogenically-induced fragmentation constitutes a major threat to biodiversity. Presently, conservation research and actions focus predominantly on fragmentation caused by physical transformation of the landscape (e.g. deforestation, agriculture, urbanization, roads etc.). While there is no doubt that landscape features play a key role in fragmenting populations or enhancing connectivity, fragmentation may also come about by processes other than the transformation of the landscape and

which may not be readily visible. Such landscape-independent fragmentation (LIF) usually comes about when anthropogenic disturbance alters the inter- and intra-specific interactions among and within species. LIF and its drivers have received little attention in the scientific literature and in the management of wildlife populations. In this talk we will present three major classes of LIF processes and their relevance for the conservation and management of species and habitats: (1) Interspecific Dispersal Dependency, in which populations of species that rely on other species for transport and propagation become fragmented as the transporting species declines. (2) Interspecific Avoidance Induction, where species are excluded from habitats and corridors due to interspecific interactions resulting from anthropogenically-induced changes in community structure (e.g. exclusions by increased predation pressure). (3) Intraspecific Behavioral Divergence, where populations become segregated due to anthropogenically-induced behavioral differentiation among them.

13.15 LUNCH

14.15 Learning opportunities contribute to both problems and solutions for wildlife-train collisions

Colleen Cassady St. Clair, University of Alberta

Authors: Colleen Cassady St. Clair, Jonathan Backs, Alyssa Friesen, Aditya Gangadharan, Patrick Gilhooly, Maureen Murray, and Sonya Pollock, Department of Biological Sciences, University of Alberta

Transportation infrastructure creates both opportunities and hazards for wildlife with potential for net negative effects that can threaten vulnerable populations as ecological traps. Such traps may often occur on railways that attract wildlife for forage or movement advantages, but generate high rates of collisions with trains. This situation has arisen recently for grizzly bears (*Ursus arctos*), a provincially-threatened species, in Banff, Canada's first National Park, where train strikes have become the leading cause of bear mortality. To identify potential targets for mitigation, we measured forage opportunities associated with the rail, monitored habitat use of bears fitted with GPS collars, and examined spatial and temporal correlates of past mortality. Rail use by bears provided access to forage that included grain spilled from hopper cars, enhanced growth of adjacent vegetation, and train-killed ungulates, but rail use also appeared to support travel through rugged topography and avoidance of people. Despite these potential benefits, bear use of the rail was surprisingly variable among individuals, while locations with higher grain deposits and use by bears did not predict sites of historic mortality. Our results support current mitigation efforts to minimize rail-side attractants and enhance alternative travel routes, but they also emphasize the variation in net effects of rail use among individuals and contexts. We posit that railways create an ecological trap mainly via limits to the behavioural processes of perception and learning necessary for adaptation to many novel or rapidly-changing environments. We show how wildlife managers might increase rates of relevant learning for wildlife on railways by installing affordable warning devices that signal approaching trains. This approach could vastly increase the speed and reduce the costs of mitigation, relative to conventional forms used for roads based on exclusion fencing and crossing structures.

14.45 Discussion

SESSION 2 Human-wildlife conflict and overexploitation

15.00 Using social network analysis to predict the community-wide repercussions of severing the Great Migration in the Mara Ecosystem

Kristine Meise, University of Liverpool

Increasing habitat fragmentation is a threat to savannah ecosystems throughout Africa, in particular the persistence of large-scale migrations. Community structure and function often is shaped by the influx of migrant at certain times of the year, which can have poorly understood consequences for social affinities between the resident species and hence their ecological interactions. We here use social network analysis to analyse how the presence of the key migratory species in the Serengeti-Mara

system influence the community structure of resident species. While the overall network structure of the resident species showed only limited variation across seasons, we found significant changes in association patterns at the species level, which could be partly attributed to the presence/absence of wildebeest and partly to differences in rainfall. The findings suggest that if the migration is lost, eco-evolutionary ties between several species pairs will change, with unknown consequences for predator-prey relations and the stability of the system.

15.30 **Resource availability, sociality and survival in resident killer whales**
Sam Ellis, University of Exeter

Conflict between the resources needs of wild populations and humans is a defining feature of many modern ecosystems. Understanding how wild populations react to changes in resource availability is a key aim of many conservation studies. To be able to predict how populations will react to changes in resource availability we need to understand how animals are gathering resources from the environment. For many species, access to resources does not depend only on their ecological environment but also on their social environment. Sociality can have a profound influence on an individual's ability to acquire resources. This in turn can affect how we expect a population to react to changes in resource availability. Using killer whales as an example, we show how social behaviours and social structures can have a profound effect on an individual's ability to acquire resources and to survive in an extremely vulnerable apex predator population.

16.00 **TEA/COFFEE**

16.30 **Can hyena behavior predict abundances of sympatric carnivores?**
Kay Holekamp, Michigan State University
Authors: Kay E. Holekamp, David S. Green, Matthew T. Farr, Eli D. Strauss and Elise F. Zipkin
Department of Integrative Biology, Program in Ecology, Evolutionary Biology and Behavior, Michigan State University, East Lansing, MI, USA

Mammalian carnivores are declining worldwide due to human activity, but simple behavioral indicators may help to identify population trends such that these declines can be mitigated. We documented striking increases in anthropogenic disturbance in parts of the Masai Mara National Reserve, Kenya between 1988 and 2018. Hyena behavior changed markedly during this period, mainly in response to increasing incursions by livestock and herders into the Reserve. Here we inquired whether specific hyena behaviors predicted subsequent changes in populations of hyenas themselves, or in densities of lions and other sympatric carnivores. Group sizes of hyenas found at kills correlated with clan size in only one of four study clans, the clan most disturbed by humans. Rates at which we observed interactions between hyenas and lions varied over time, suggesting decreased abundance of lions in heavily disturbed areas. Whereas lion abundance appeared to decrease in disturbed regions, hyena numbers increased. Hyena movement speeds correlated with densities of sympatric carnivores up to five months in the future. Finally, we used a novel hierarchical multi-species distance sampling model to estimate differences in densities of multiple carnivore species between disturbed and undisturbed areas. Our results suggest that tracking certain hyena behaviors might be useful to those charged with conserving Africa's carnivores.

17.00 **Integrating models of human behaviour between the individual and population levels to inform conservation interventions**

EJ Milner-Gulland, University of Oxford

Authors: Andrew Dobson, Emiel de Lange, Aidan Keane, Harriet Ibbett and EJ Milner-Gulland

Conservation takes place within a social-ecological system, and many conservation interventions aim to influence human behaviour in order to push that system towards sustainability. Predictive models of human behaviour are potentially powerful tools to support these interventions. This is particularly true if the models can link the attributes and behaviour of individuals with the dynamics of the social systems within which they operate. Here we explore this potential by showing how combining two modelling approaches (social network analysis, SNA, and agent-based modelling, ABM) could lead to more robust insights into a particular type of conservation intervention; the spread of information regarding sanctions for rule-breaking. We highlight the complex, context-dependent nature of outcomes of this intervention, depending both on the configuration of the network and the attributes of the agents, even for our simple model. This suggests that, although combining ABMs and SNA could lead to new insights, these are likely to be case-study specific. We conclude by reflecting that both these methods, and many other decision science tools, are still too compartmentalised in application, either in ecology or social science, despite the strong methodological and conceptual parallels between their uses in different disciplines. We need more than cross-fertilisation of methods between disciplines, however. Given the impact of conservation on both social and ecological and social aspects of systems, an integrated approach is needed, which both combines modelling approaches and draws on different disciplinary insights.

17.30 **Discussion**

17.45 **DRINKS RECEPTION AND POSTER SESSION**

19:00 **SYMPOSIUM DINNER**

SESSION 3 Disease, pollution and invasive species

09.30 **Integrating network modelling and demography to better understand wildlife disease**

Matthew Silk, Exeter University

The emergence and spread of disease can play a critical role in the decline and extinction of populations, and this impact is forecast to increase in response to anthropogenic environmental change. The importance of heterogeneity in processes of transmission, resistance and tolerance is increasingly well understood, but empirical studies that consider both the demographic and behavioural implications of infection are scarce. The social and spatial behaviour of individuals can provide an important indirect link between population and disease dynamics by impacting the demographic thresholds that determine the amplification or attenuation of disease prevalence. I discuss how integrating the most recent developments in epidemiological research from a demographic and social network perspective can reveal feedbacks among demographic change, behavioural dynamics and infection that are fundamental to better understanding the conservation implications of new disease threats to wildlife populations. For example, social interactions, and how they change in response to the presence of infection, can both mitigate against and exacerbate epidemic spread of infections. Similarly, the impact of demographic changes such as reductions in population density on social behaviour can be critical in determining whether infectious disease can drive a host population to extinction. The risk assessment and management of disease in threatened wildlife populations must therefore consider not just host density, but also how this influences the structure and dynamics of the social contact network of hosts. I will illustrate key points throughout using a combination of

epidemiological simulations and empirical work on the dynamics of bovine tuberculosis in wild European badgers. Overall, this highlights the importance of considering the combined impacts of demographic processes and social dynamics on the spread of infection to successfully manage infectious disease in a conservation context.

10.00 **Behavioral ecology and infectious disease: implications for conservation of vertebrate biodiversity**

James P. Herrera and Charles L. Nunn
Department of Evolutionary Anthropology, Duke University, Durham NC USA

Behavioral responses to stimuli are an animal's first line of defense in agonistic interactions with conspecifics, predators, and parasites. Important feedbacks occur between host behaviors and parasite transmission; many animal behaviors are influenced by parasite avoidance, and animal behavior can also drive parasite transmission. Here, we explore how parasite transmission and avoidance relate to social behavior, and we consider how these linkages are important for conservation measures. Many threatened species are also susceptible to infectious diseases that put them at the brink of extinction. Intervention measures such as culling and vaccination can integrate knowledge of how behavior affects population and community dynamics to improve results. In addition, some animal responses to infection – such as sickness behaviors – can alter disease transmission. While infectious diseases would appear to operate at the individual and population level, behavioral responses have effects that scale up to higher levels of community assembly.

10.30 **Troubled communication in polluted environments: conservation implications**

Ulrika Candolin, Helsinki University

Pollution (e.g. by chemicals, noise, light, heat) is an insidious consequence of anthropogenic activity that affects environments worldwide. Exposure of wildlife to pollutants has the capacity to adversely affect animal communication and behaviour across a wide range of sensory modalities – by not only impacting the signalling environment, but also the way in which animals produce, perceive and interpret signals and cues. Such disturbances, particularly when it comes to sex, can drastically alter fitness. I will discuss how pollutants can disrupt communication and behaviour during mate choice, and the ecological and evolutionary changes that such disturbances can engender. I will first explain how the different stages of mate choice can be affected by pollution, from encountering mates to the final choice, and then consider how changes to these stages can influence individual fitness and thereby population dynamics, and eventually even community structure. I will use examples from the literature to illustrate these changes, the mechanisms behind them, as well as our current knowledge of their ecological and evolutionary consequences. I will end with discussing how an understanding of these disturbances to mate choice can help inform better conservation and management practices. In this respect, I will stress how studies of wildlife behavioural responses to human-altered conditions, including altered reproductive responses, such as mate choice, are crucial in understanding the harmful effects of pollution.

11.00 **TEA/COFFEE**

11.30 **Pace-of-life syndromes and the success of biological invasions**

Daniel Sol, (Centre for Ecological Research and Forestry Applications)
Authors: Joan Maspons[1] & Daniel Sol[1,2]
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Life history theory has long been deemed essential to understanding the success of invaders, yet surprisingly the theory has achieved little predictive success. Here, we will combine theoretical and empirical evidence to show that to fully understand how life history affects animal invasions we need to

explicitly consider the role of behaviour as part of a pace-of-life syndrome (POLS). By mediating habitat choice and problem-solving, behaviour allows animals to reduce environmental uncertainties and adaptive mismatches, two of the major challenges that pose novel environments. However, the benefits of these behavioural mechanisms are contingent on the position of the species in the fast-slow continuum of life history variation. Developing the neural architecture and cognitive skills needed is energetically costly and takes time. Consequently, only long-lived animals may pay the costs. Moreover, behaviour mediates some of the mechanisms by which life history influences the response to novel environments. For example, a reproductive failure is costly but the cost may be reduced in long-lived species if the experience improves future reproductive decisions. When we examine how life history affects invasion success we are thus inevitably considering behavioural mechanisms as well. By clearly delineating the mechanisms and contexts where POLS are most relevant, we can better understand what makes a successful invader.

12.00 **Metapopulation modelling as a conceptual tool for the management of marine invasions: a case study with lionfish on Caribbean coral reefs**

Isabelle Côté, Simon Fraser University

Authors: Natascia Tamburello[1,2*], Brian O[1]. Ma, and Isabelle M. Côté[2],

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Metapopulation modelling can pinpoint habitat patches that are critical for population persistence in fragmented landscapes. Although developed for conservation, this approach also lends itself to planning invasive species management in naturally patchy habitats. We show how this approach can be used as a conceptual tool to help optimize the distribution of limited management resources among populations of invasive Indo-Pacific lionfish (*Pterois volitans*) in the Western Atlantic. We use field data on lionfish occupancy and movement from a network of coral reef patches in The Bahamas to parameterize an incidence function model (IFM) and examine the effects of network properties on the probability of long-term patch occupancy. Through simulation, we derive three insights that can inform management. First, removing lionfish from target patches also reduces the probability of occupancy at surrounding patches, but occasionally increases occupancy elsewhere in the patch network. Second, these effects depend on patch size and connectivity, but are strongest at the local scale and decay with distance. Finally, size-selective culling can change a population's size distribution and this dispersal potential with cascading effects on network connectivity, population dynamics, and management outcomes. By explicitly considering seascape structure and movement behaviour when allocating effort to the management of invasive species, managers can optimize resource use and improve management outcomes.

12.30 Discussion

12.45 LUNCH

SESSION 4 Reintroduction

13.45 Reintroduction: a founder event with no evolutionary precedent

Kevin Parker, Parker Conservation and Massey University

Parker Conservation and Massey University, PO Box 130, Warkworth 0941, New Zealand.

The translocation process is essentially a forced dispersal event with no evolutionary precedent. The translocated founders usually represent just a small proportion of the larger source population and this, along with post-release mortality following release, represents a hard and abrupt selection event. But how does this selection event manifest itself and how will it affect the evolutionary trajectory of the new population, and the likelihood of persistence, in the short, medium and long-term? Here, I use two

model systems to illustrate the potential evolutionary impacts of translocations. In the first, I show how translocation has directed the cultural evolution of bird song in the tīeke or North Island saddleback (*Philesturnus rufusater*). Serial translocations have changed this fundamental behavioural signal through cultural bottlenecks that generate drift and reduce song variability within islands. Critically, the birds themselves can detect these changes. In the second system, I am using toutouwai, or North Island robins (*Petroica longipes*), to investigate whether the individual behaviour of birds during the translocation process predicts who recruits into the breeding population following translocation. I will discuss what these founder events might, or might not, mean for the conservation management of translocated populations.

14.15 ***In situ* predator conditioning naïve prey prior to reintroduction**

Daniel T Blumstein, UCLA

Authors: Daniel T. Blumstein[1], Mike Letnic[2], Katherine Moseby[2,3]

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Many translocations and introductions to recover threatened populations fail because predators kill prey soon after release; a problem exacerbated for predator-naïve prey. While pre-release training has been shown to work in some situations, it is time consuming and relies on using inferred predator cues and treating small groups. We review a relatively new and very promising management tool: in situ, pre-release predator conditioning. Here, the goal is to allow prey in large enclosures to live with low densities of predators to accelerate selection for anti-predator traits (in an evolutionary sense) or provide prey essential experience with predators that they will later encounter. We review the published results of a large-scale, controlled experiment where we have permitted burrowing bettongs (*Bettongia lesueur*) and greater bilblies (*Macrotis lagotis*) to live with low densities of feral cats (*Felis catus*), a species implicated in their widespread decline and localised extinction. Compared to control populations, predator-naïve prey exposed to cats have a suite of morphological and behavioral responses that seemingly have increased their antipredator abilities. Results suggest that predator-conditioned bilbies survive better when released into a large enclosure with an established cat population; future work will determine whether this increased survival extends to the wild.

14.45 **Incorporating behavioural metrics into predictions and decisions for reintroductions**

Elizabeth Parlato, Massey University

Reintroduction is a frequently used conservation tool that attempts to re-establish species within their historical ranges. As such, a fundamental objective is the establishment of a viable population. However, decision-making for achieving this objective is challenging, primarily due to the multiple management alternatives frequently available and the high uncertainty associated with how a new population will fare under each of these. Population modelling can help inform reintroduction decisions by predicting how alternative management actions will perform. Most demographic models of reintroduced populations have been developed using detailed demographic data to estimate vital rates (e.g. survival and reproduction). However, even with such detailed data the population projections are often highly uncertain in the initial years after reintroduction. Behavioural metrics may correlate with vital rates, and therefore be useful in reducing uncertainty in population projections. Incorporating behavioural metrics in population models also enables quantitative evaluation of the influence of behavioural management actions on population trajectories. Here we investigated one aspect of behaviour, personality, for predicting survival, post-release dispersal and natal dispersal in reintroduced hihi *(Notiomystis cincta)* populations. Our results suggest that bolder individuals had higher survival probabilities in the first three years of life, and behaviour during handling predicted both post-release and natal dispersal distances. We then expand on these promising findings to explain an approach we are developing to investigate the importance of individual variation (including behavioural

variation) for predicting population dynamics, and discuss how to best embed behaviour into reintroduction management.

15.15 **Discussion**

15.30 **TEA/COFFEE**

SESSION 5 Forging links between the behavioural ecological and conservation community

16.00 **Integrating behaviour and ecology into global biodiversity conservation strategies**
Joseph Tobias, Imperial College London

Global and macroecological approaches to conservation prioritisation have been highly influential, but rarely consider the role of behaviour, at least partly because comprehensive, standardised data on relevant behavioural traits are not currently available. This talk will describe examples of behavioural traits potentially affecting population dynamics and sensitivity to threats, and discuss how new datasets for a range of such traits – including mating, social, territorial and foraging behaviour – might be harnessed to improve conservation status assessments at the species level. I will explore methods for identifying current and future threats to species using their ecology and behaviour, highlighting the potential application of behavioural traits to global conservation prioritisation exercises.

16.30 **Bridging the divide between conservation decision makers and scientists: how can ecologists make their research relevant?**
Sarah M Durant, Institute of Zoology, Zoological Society of London

Effective conservation management is underpinned by science. Yet there are often barriers against the incorporation of up-to-date scientific research into decision-making and policy. Here we draw on the experience from a multi-nation approach to conserve cheetah and African wild dogs across Africa, using relationships between scientists and managers established over more than a decade, to better understand the scientific information needs of managers. Managers view science as critical to their decision-making processes and support scientific research within their protected areas, particularly when research directly addresses their information needs. However, managers reported problems in accessing final results and also identified a need for access to ecological data from research undertaken within their protected areas. In the African countries that are the subject of this analysis, scientists undertaking research within protected areas are often not citizens, leaving protected area managers with limited leverage to secure copies of publications and data once the scientist has left. Fundamental to improving the relationships between managers and scientists is the need to build trust through open and clear communication; agreed processes for access to biodiversity data; the management of data; and the submission of final results. In order to foster future scientific endeavours and collaborations, systems should be established to better facilitate information exchange, while also safeguarding the rights of scientists to publish their data and protect their academic freedom. Our analysis touches on broader issues over who 'owns' data and improving systems of participation and coauthorship in scientific endeavours in order to recognise, and give credit to, a wider diversity of scientific contributions and expertise.

17.00 **Can a behavioural ecologist set up a protected area?**
Tim Caro, University of California, Davies
Authors: Tim Caro and Joel Berger

We assess how a scientist studying behavioural ecology could help establish a protected area. In situ conservation is the most important contribution anyone can currently make to conservation because the window is closing on opportunities to set up new reserves. We suggest that those studying

charismatic species and who are willing to engage with stakeholders have the best chance of getting decision-makers' attention although species' charisma is a fluid property that can be shaped by scientists themselves. We also suggest that the extent to which behavioral ecological knowledge itself is helpful in setting reserve boundaries is actually quite limited and centres on knowledge of animal movements and habitat preferences. Limited knowledge about certain aspects of animal behaviour (e.g., sexually selected infanticide, cultural traditions) may help maintain populations once the reserve is gazetted, and researcher presence may curb poaching. Overall, we believe that committed scientists working in the field may be more important than their scientific discoveries when it comes to promoting this conservation programme.

17.30 Discussion and final comments

17.45 END OF SYMPOSIUM

SPEAKER BIOGRAPHIES

Oded Berger-Tal is a senior lecturer at the Mitrani Department of Desert Ecology, Ben-Gurion University of the Negev, Israel. His research centres upon the integration of behavioural ecology into wildlife conservation and management in a variety of systems and species. Some of his latest projects include behavioural mitigation of human-hyena conflict in Israel, understanding the effects of wind-turbine noise of communication in migrating birds, and investigating the links between rate of human development and behavioural flexibility. In 2016, he co-edited the book *'Conservation Behavior: Applying Behavioral Ecology to Wildlife Conservation and Management'* published by Cambridge University Press.

Daniel T Blumstein is a professor in the Department of Ecology and Evolutionary Biology at UCLA and in UCLA's Institute of the Environment and Sustainability. He received his PhD at the University of California Davis, and conducted postdoctoral work at the University of Marburg, the University of Kansas and at Macquarie University before joining UCLA. He conducts interdisciplinary studies on social behaviour, communication and anti-predator behaviour and much of his work seeks to integrate primary findings with applied needs. As such, he has been a leader in the field of conservation behaviour where much of his work has focused on implications of anti-predator behaviour for conservation and management.

Tim Caro was trained in animal behaviour, teaches conservation biology and behavioural ecology, and works on the evolution of animal colouration. He is interested in links between observing the behaviour of individuals and conserving species.

Jakob Bro-Jørgensen is a senior lecturer at the University of Liverpool where he is a member of the Mammalian Behaviour and Evolution Group. His research focuses on social behaviour and conservation using ungulates as model systems, with key topics including reproductive and communicative strategies, interspecific interactions, and climate change impacts. Since 1998, he has been a research affiliate of Kenya Wildlife Service and Director of the Masai Mara Herbivore Research Project in Kenya. He is a member of the IUCN Antelope Specialist Group and former Programme manager for the ZSL Bushmeat & Forest Conservation programme.

Ulrika Candolin is lecturer in ecology and evolutionary biology at the University of Helsinki. Her research concentrates on behavioural responses of animals to human-induced environmental changes, and how the responses influence the fitness of individuals and the viability of populations. Much of her research has

focussed on aquatic ecosystems, and particularly on the effects of cultural eutrophication on fishes. Candolin has edited a book on 'Behavioural responses to a changing world', published by Oxford University Press, in addition to publishing highly cited research papers and book chapters on the topic. She currently serves as a member of the editorial board of *Behavioral Ecology.*

Isabelle Côté is a Professor of Marine Ecology at Simon Fraser University in Vancouver, BC. Her interests in marine ecology and conservation are broad, but she currently focusses on marine invasive species – measuring their impacts, predicting their spread and devising the best ways to control them. She is passionate about science communication, particularly relating to ocean discovery. She is the President of the Canadian Society for Ecology and Evolution, was awarded the ZSL's Marsh Award for Conservation Biology in 2009 and is a Leopold Leadership Fellow for her efforts at linking science, public engagement and policy.

Sarah Durant is a Senior Research Fellow at Zoological Society of London (ZSL) with more than 25 years of experience working in Sub-Saharan Africa. Her research focuses on carnivore conservation, biodiversity monitoring, human wildlife conflict, conservation management, landscape connectivity and conservation policy. She has headed the Serengeti Cheetah Project, the longest ongoing study of wild cheetah, since 1991. In 2007, with Rosie Woodroffe, she established the Range Wide Conservation Programme for Cheetah and African Wild Dog, with the ultimate aim of halting global decline in these species, a programme which she continues to lead. In her work Sarah engages with a wide international network of decision makers.

Sam Ellis completed his PhD at the University of York studying social behaviour in ants. He then moved to work at the University of Exeter as a postdoctoral researcher as part of a team studying the behavioural ecology of menopause in killer whales. Sam is studying the consequences of social behaviour in rhesus macaques.

Jennifer Gill is Professor of Applied Ecology at the University of East Anglia. She works on migratory systems, primarily wading birds, and especially on the role of individual behaviour in driving populations-scale processes and associated conservation implications

James Herrera is a postdoctoral associate with Dr. Charlie Nunn at Duke University. James is combining community ecology with infectious disease to explore how parasite species richness is related to behavioral and environmental factors across all primates and small mammals of Madagascar. He explores novel questions in the co-evolution of primates and parasites to understand the socio-ecological factors that place species at risk of diseases. In addition, he is investigating patterns of disease transmission in small mammals of Madagascar, with on-going data collection in northeastern Madagascar.

Kay Holekamp received her bachelor's degree at Smith College, her PhD at the University of California at Berkeley, then did postdoctoral work in behavioral endocrinology at the University of California at Santa Cruz. She then started her on-going study of spotted hyenas and other large carnivores in the Masai Mara National Reserve, Kenya, that has been continuously funded by the US National Science Foundation since 1987. Dr Holekamp joined the Michigan State University faculty in 1992, and she is now a University Distinguished Professor of Integrative Biology and Director of the University's interdisciplinary program in Ecology, Evolutionary Biology & Behavior.

Kavita Isvaran: Animals display a bewildering diversity of solutions to common problems, such as how to avoid predators, how to find and choose mates, how many offspring to have, and how much resources to allocate to each offspring. Kavita studies the ecology and evolution of such diversity in behaviour and life histories. She is also interested in the consequences of adaptive behaviour for populations, and in applying behavioural and ecological principles towards conservation questions. Her study systems are varied and include mosquitoes, butterflies, lizards and antelope. Kavita is also deeply committed to teaching research design and statistical inference in ecology. She is at the Centre for Ecological Sciences at the Indian Institute

of Science, Bangalore; joining CES after completing her PhD in Zoology at the University of Florida, Gainesville, USA and a post-doc at the University of Cambridge, Cambridge, UK.

Kristine Meise is a post-doctoral researcher at the University of York. Her research primarily focuses on interactions between individuals and species in order to understand the principles that govern the social structures in animal groups. In particular, she is interested in how variation in social behaviour in response to environmental change affects population and community level processes. Her PhD focused on the importance of intra-sexual relationships for male reproductive success; and currently she is investigating the drivers of mixed-species groups. Detailed knowledge about the long-lasting consequences of social changes can have important implications for conservation as it allows to predict, i.e. how populations respond to habitat fragmentation or invasive species.

EJ Milner-Gulland is Tasso Leventis Professor of Biodiversity at the University of Oxford. Previously she was Professor of Conservation Science at Imperial College London, and she has also held lectureships in Resource Economics and Mathematical Ecology. Her PhD, at Imperial College London, was on the wildlife trade, with a focus on ivory, rhino horn and saiga antelopes. Her research group is the Interdisciplinary Centre for Conservation Science, which has a wide range of research projects within conservation science. These include developing and applying methods for understanding, predicting, and influencing human behaviour in the context of local resource use in developing countries. Her team also works on the illegal trade in wildlife and on designing, monitoring and evaluating conservation interventions in order to improve their effectiveness. She aims to ensure that all the research in her group is addressing issues identified by practitioners, and is carried out collaboratively with end-users.

Kevin A. Parker is a conservation scientist with expertise in reintroduction biology, restoration ecology and small population management. His particular interest is in the theory and practice of reintroduction biology with published work ranging from evolutionary impacts through to the more practical aspects of carrying out translocations. Kevin has been directly involved in 65 translocations, and led 48, and he provides ongoing advice to local and international NGOs and governmental groups on translocations, restoration and threatened species management.

Elizabeth Parlato lives in New Zealand and currently holds a post-doctoral position at Massey University. After completing her master's degree, Elizabeth worked in conservation-related positions in Ireland, Canada and New Zealand. Elizabeth is passionate about wildlife reintroductions and she went on to do her PhD at Massey University, which focused on improving methods for predicting reintroduction outcomes. Elizabeth has recently started working on a 3-year research project that is investigating the importance of individual variation for population dynamics. This will involve evaluating whether incorporating individual variation, including behavioural variation, into population models will significantly improve their predictive capacity and our ability to manage populations.

Bernt-Erik Sæther is a professor in population ecology at the Norwegian University of Science and Technology in Trondheim, Norway. Since 2013 he has been the Director of the Centre for Biodiversity Dynamics, which is a Centre of Excellence funded by the Research Council of Norway for a period of 10 years. Bernt-Erik's research profile is located in the interface between ecology and evolution with a focus on application of stochastic models in analysis of dynamics at the genetic, population and community level. He has published more than 260 papers, 6 book-chapters and co-authored the book *Stochastic Population Dynamics in Ecology and Evolution*.

Colleen Cassady St. Clair is a Professor of Biological Sciences at the University of Alberta. She and her students study the way wildlife use and move through human-dominated landscapes, which frequently involve human-wildlife conflict. They seek novel solutions to those problems by combining ideas and methods from animal behaviour, wildlife management, and conservation biology. Current projects attempt

to reduce human-coyote conflict in urban areas, train strikes on grizzly bears, and bird mortality at industrial sites.

Matthew Silk is an early career ecologist working at the interface of social behaviour, disease ecology and demography. Matthew's PhD, based at the University of Exeter Cornwall campus, used social network analysis to investigate the cause and consequences of social relationships in migratory geese. Subsequently he remained at the University of Exeter, using social network approaches to better understand disease epidemiology, with his main project focussed on understanding how social behaviour influences bovine tuberculosis epidemiology in badgers. Matthew's research interests have now expanded to include a range of projects using demographic modelling approaches, as well as continuing work using network analysis.

Daniel Sol is a Senior Research Scientist at CREAF-CSIC (Centre for Ecological Research and Applied Forestries). After finishing his PhD at the University of Barcelona in 2000, he moved to McGill University where he worked for three-years on the ecological and evolutionary implications of behavioural plasticity. In 2004, Daniel returned to Catalonia to create his own evolutionary ecology lab at CREAF. Daniel's research seeks to understand how animals respond to environmental changes, combining theoretical models, experiments and comparatives approaches. This research has contributed to develop the "cognitive buffer hypothesis" for the evolution of animal intelligence, a more general life history theory for biological invasions, and improved global estimations of the current loss of biodiversity driven by habitat alterations.

Joe Tobias studied the behaviour of the European robin for his PhD at Cambridge University, then worked for 10 years in environmental NGOs including BirdLife International, focusing on bird research and conservation projects, with an emphasis on tropical rainforests. Returning to academia, he developed a research programme in evolutionary ecology and conservation biology as a Lecturer at Oxford University, before moving to Imperial College London where he is Senior Lecturer in Biodiversity. His current research focuses on the evolution and conservation of avian diversity.

George Wittemyer is an associate professor at Colorado State University's Department of Fish, Wildlife and Conservation Biology, where he teaches undergraduate and graduate courses in conservation ecology. George's research interests include investigation of the impacts of human pressures on natural systems. Human activities are causing major ecological changes from the alteration of species life history strategies to, in the worst case, population collapse. The long-term impacts of these changes on species survival and ecosystem functioning are largely unknown. His research strives to provide greater understanding of the factors influencing ecosystems and the manner in which species respond to these influences, with the ultimate aim of providing empirical based information and strategies to address the many conservation challenges we face today. George works to actively translate these research outputs into policy and conservation actions.

POSTER PRESENTATIONS

1. Foraging for a foothold in a novel environment: using translocations to test the causes and consequences of behavioural variation

Caitlin E. Andrews[1,2*], John G. Ewen[2], Mhairi McCready[3], Kevin A. Parker[4], Jessica E. M. van der Wal[5] and Rose Thorogood[1,5]

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One of the challenges of conservation translocations is predicting how an individual will behave after release. The few studies that have addressed this typically link pre-existing behavioural variation (e.g. boldness) to post-release mortality but rarely to other measures of success (e.g. foraging success) or longer-term translocation goals (e.g. ecosystem recovery). At the same time, there is a growing recognition among behavioural ecologists that individuals within species exhibit consistent differences in their responses to novel environments; opportunities to test the causes and consequences of this variation in the wild are rare, however. Here, we demonstrate how translocations could enable conservation biologists and behavioural ecologists to unite in their efforts to answer common questions regarding: (1) how individuals vary in their behaviour; (2) what factors shape this variation; and (3) whether variation has consequences for the ecosystem. We tracked individual dietary changes during a translocation of hihi (*Notiomystis cincta*), a threatened New Zealand passerine. One group remained on their natal island, while another was translocated to a more mature forest with reduced competition. As a whole, the translocated group's diet broadened, while the untranslocated group became more specialised. Individual dietary changes were more complex, depending on age, pre-translocation diet, and end site. These results demonstrate how individual-level analyses can enrich our understanding of behavioural responses to environmental change by revealing trends masked at higher population levels. We discuss the value of this approach as a tool for shaping translocation outcomes and testing ecological hypotheses requiring the movement of individuals between disparate habitats.

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2. Behavioural ecology for conservation and management of aquatic biodiversity

Chiara Benvenuto

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Successful conservation and management of biodiversity require a multidimensional approach. In this interdisciplinary framework, the importance of behavioural ecology has been widely accepted and the term "conservation behaviour" has been introduced to legitimate this new field. Yet, some researchers still debate on the actual contribution of behavioural studies to the conservation and management of biodiversity. Moreover, the role of these studies is not often explicitly recognized or employed in concrete actions. This is particular evident in marine and freshwater projects, which are often completed neglected from the discussion: examples of the role of behavioural ecology in aquatic conservation and management are scarcely reported. However, animal behaviours can affect demography and effective population size, can act as early indicator of pollution and endocrine disruption, can reveal conservation threats, can explain movements and migrations, can predict risks and effects of biological invasions, and more. Reproductive strategies in particular affect abundance of stocks and populations and should be included in fisheries management, designation of protected areas and conservation efforts, as well as in sustainable aquaculture plans. Here, I present examples on the influential implications of behavioural responses, mating systems and strategies, and life history traits in populations of fish and crustaceans, in the face of over-exploitation, pollution and climate change.

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3. Behavioural thermoregulation, climatic range restriction and conservation of the globally threatened Ethiopian Bush-crow

Andrew J. Bladon[1,2] (attending), Paul F. Donald[1,2,3], Samuel E.I. Jones[4,5], Nigel J. Collar[3], Jarso Deng[6], Galgalo Dadacha[6], Yilma D. Abebe[7], Rhys E. Green[1,2]

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Climate may influence a species' distribution and abundance through many demographic and ecological processes, but the proximate drivers are only recently being identified. The Ethiopian Bush-crow *Zavattariornis stresemanni* is an Endangered corvid restricted to a small region of Ethiopia. Previous work suggested this range restriction is defined by a cooler climate envelope, but the proximate mechanism remained unexplained. The habitats the Bush-crow inhabits are widespread across Africa, and the species is behaviourally adaptable. We assessed whether its distribution can be explained by behavioural responses to the higher temperatures surrounding its current range. Using environmental niche models and observations of thermally-mediated behaviour, we compared the range restriction and behavioural thermoregulation of the Bush-crow with those of two sympatric species similar in size and ecology, but with larger ranges including hotter environments, the White-crowned Starling *Lamprotornis albicapillus* and Superb Starling *L. superbus*. We projected the Bush-crow's climatic range to future scenarios to predict the impact of climate change on its distribution. We found that the Bush-crow's range is limited primarily by temperature, whereas the ranges of both starling species are better predicted by rainfall. Bush-crows exhibited panting behaviour and moved into the shade of trees at lower ambient temperatures than did the starlings, and their food intake declined more steeply with increasing temperature. The area of climatic suitability for the Bush-crow is projected to decrease sharply in the coming decades. The Bush-crow's restricted range reflects an inability to cope with higher temperatures, and drastic conservation action is required to save the species.

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4. An individual-based model to identify key threats facing the elephants of Amboseli

Boult, V.L.[1]*, Quaife, T.[2], Hawkins, E.[3], Fishlock, V.[4,5], Moss, C.J.[4], Lee, P.C.[4,5] and Sibly, R.M.[1]
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[5] Psychology, Faculty of Natural Sciences, University of Stirling, UK
* V.L. Boult (lead author of this project) will be attending the symposium and will present the poster.
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Global change presents a major challenge to biodiversity conservation which must identify and prioritise the most critical threats to species persistence given the limited resources available. A mechanistic approach is required so that predictions remain robust under novel future conditions and multiple stressors may be considered in combination. We have developed an individual-based model (IBM) to predict elephant population size under a range of environmental scenarios incorporating habitat loss and climate change. The IBM uses food availability as a key mechanistic driver of elephant population dynamics and relates variation in food availability to changes in vital demographic rates. Possible scenarios of habitat loss were identified using empirical data (including occurrences of high-risk human-elephant interactions and human population growth) and stakeholder opinions. We incorporate climate projections from a range of models under two CO2 emissions scenarios to establish the impacts of climate change. Simulations suggest that habitat loss, rather than climate change, represents the most significant threat to the persistence of the Amboseli elephants and highlights the need to address causes of habitat loss in order to preserve sufficient space for elephants and ensure the population's resilience to environmental stochasticity. The IBM employed here uses a general energy budget framework, calibrated to the Amboseli elephants, and could easily be adapted for implementation for other elephant populations or other mammalian herbivores. This mechanistic approach shows how key drivers and animal populations respond to possible environmental change scenarios and will help identify conservation priorities and target efforts.

5. Planning conservation actions by investigating nest preferences and biotic and abiotic factors within lesser kestrel (*Falco naumanni*) colonies

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The lesser kestrel (*Falco naumanni*) was until recently classified as a Vulnerable species. It is a cavity nester species finding proper nest sites in natural cliff holes or, as more frequently today, cavities found within rural buildings. These are often abandoned and therefore, with no maintenance, the main structures of kestrel colonies have been collapsing across years. To counterbalance the reduced availability of nesting sites for kestrels, and because of their unfavorable conservation status, artificial nest boxes have been placed in several areas of their breeding range. On our study site, the Gela Plain in Sicily, as on other Mediterranean breeding areas, high temperatures may reach lethal values for the nest content. Since 2004, we collected biotic and abiotic data at macro- and micro-scales to integrate an analysis aiming to predict nest temperatures in different nest types. Paradoxically, early breeders preferentially occupied the coolest nest types, the roof tiles, whereas late breeders, starting their nesting attempts with hotter temperatures, occupied the overheated nest boxes. We discuss our findings in the light of planning proper and efficient conservation actions, such as providing different nest types, by pondering whether kestrel nest preferences might either sort into ecological traps or be the result of ecological limitations.

6. Climatic impacts on hibernation behaviour in wild hazel dormice *Muscardinus avellenarius*

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Hibernation is a state of prolonged behavioural dormancy and metabolic depression, and is employed by many species to avoid periods of food scarcity. The timing of hibernation is often climate-linked, occurring in the winter in temperate regions in tandem with dormancy of food plants. During hibernation, animals experience 'arousals', where the metabolic rate and body temperature return to normal for a short time. These arousals, although apparently essential, use high amounts of energy that cannot always be replaced during the hibernation season. Hence, frequent arousals can be highly detrimental to an individual's chances of surviving the winter, and on their subsequent body condition. Warmer winters have been shown to increase the frequency of arousals in some species; with winter temperatures projected in continue increasing in temperate regions, understanding their effects on hibernators is essential. We will investigate the impacts of weather on hibernation patterns in wild hazel dormice. Dormice hibernate at, or just below, ground level, and so are relatively exposed to weather fluctuations during the hibernation period. We will record arousal frequency and subsequent activity levels during hibernation using dataloggers and camera traps, and measure habitat and microclimate variables to investigate if dormice can alleviate impacts of weather through hibernation site selection. These results will be integrated with UK Climate projections to model the potential effects of increasing winter temperatures on the hibernation success and overwinter survival of hazel dormice. These results will feed into future conservation strategies and habitat management protocols for dormice, and potentially other hibernating animals.

7. Are social groups important for reintroductions?

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Reintroductions are essential to many conservation programmes, and much research has focussed on understanding what determines the success of these translocation interventions. However, while reintroductions disrupt both the abiotic and social environments, there has been less focus on the consequences of social disruption. Therefore, we investigated if moving familiar social groups may help animals (particularly naïve juveniles) adjust to their new environment and increase the chances of population establishment. We used social network analysis to study changes in group composition and individual sociality across a reintroduction of 40 juvenile hihi (*Notiomystis cincta*), a threatened New Zealand passerine. We collected observations of groups before a translocation to explore whether social behaviour before the reintroduction predicted associations after, and whether reintroduction influenced individual sociality (degree). We also assessed whether grouping familiar birds temporarily in aviaries maintained group structure and individual sociality, compared to our normal translocation method (aviaries of random familiarity). Following release, we measured if survival depended on sociality changes. By comparing with birds that remained at the source site, we found that translocation lead to re-assortment of groups: non-translocated birds maintained their groups, but translocated juveniles formed groups with both familiar and unfamiliar birds. Aviary holding did not improve group cohesion; instead, juveniles were less likely to associate with aviary-mates. Finally, we found that translocated juveniles that lost the most associates experienced a small but significant tendency for higher mortality. This suggests sociality loss may have represented a disruption that affected their ability to adapt to a new site.

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8. Friends with benefits: the importance of chick sociality for survivorship in a precocial seabird

Lucy Garrett[1] (attending author), Julia Myatt[1], Jon Sadler[2], John Colbourne[1], Roger Dickey[3], Sam Webber[4], Damien Farine[5] and Jim Reynolds[1,3]
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In avian species with mobile (precocial) young, social aggregations of chicks often occur. Chicks are left alone for periods of time by both parents while they forage, and may or may not be guarded by other returning parents during feeding. The benefits of associating with other chicks have been surmised as including reduced predation, increased thermoregulation, and social information transfer. However, few studies have analysed the benefits of social group size on chick survivorship. Our study investigates chick sociality in a colonial seabird, the sooty tern. We examine chick social group size and the extent to which this changes over time, as well as the impacts of sociality on survivorship. Our initial findings suggest the number of chick associates or friends has important survival consequences during the pre-fledging stage. Interestingly social group size varied with chick age, becoming lower as chicks neared fledging. Our results indicate that social group size may be a response to predation pressures during the most vulnerable life stages. This has conservation implications in terms of introduced predator control. Our study also highlights the importance of including social life history traits in reproductive success estimates of species with precocial young.

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9. The impact of polygyny on effective population size: from theory to decision making

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Effective population size (N_e) is a fundamental evolutionary concept that is highly relevant to conservation biology. N_e is a measure of the strength of genetic drift a population is subject to. Understanding life history and behavioral traits that impact N_e can assist managers in designing strategies aimed at increasing N_e. We demonstrate this idea with a long-term study of a reintroduced Asiatic wild ass (*Equus hemionus*) population in Israel. We conducted genetic, demographic, and ecological surveys of the population and evaluated variance effective size (N_{ev}). By contrasting the genetic estimation of N_{ev} with theoretical predictions from demographic, life-history and mating-system data, we revealed that polygyny had the strongest impact on genetic drift: Only when strong polygyny (10-20% mating males per generation) was considered, were the predictions consistent with the genetically-estimated N_{ev}. Strong heritability of female reproductive success ($h_f^2 = 0.91$) was detected within the wild ass population and was also found to strongly affect drift in the system. The low N_{ev} in the wild ass population ($N_{ev} = 24.3$) is of concern. We therefore suggest management actions that will focus on the main factor identified as affecting N_{ev}, namely, increase the number of males contributing to the gene pool. Adding artificial water sources in the wild ass range of distribution will likely increase the number of available territories for dominant males, who are the breeding males, thus, increasing N_{ev}. This approach of evaluating life-history traits that impact N_e is a general, applicable strategy that can be used for species conservation and management.

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10. Conservation ecology and the theory of games

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Understanding the causes of the structure and dynamics of food webs is crucial for developing policies to halt the loss of biodiversity. Game theory could enable the prediction of links in webs as the outcomes of competitive games among species, and thereby help understand the consequences of environmental change. I focus on one example: the potential for loss of nest sites to cause great variation in the declines of closely-related species. Pollination of flowers is vital for the healthy functioning of ecosystems, so it is very important that we understand why the populations of pollinators, such as bumblebees, are declining. An obvious cause is the loss of flowers from farmland, but this does not explain why some bumblebee species have not declined. It is well known that bumblebee queens fight over nest sites. I used a mathematical model to predict how a reduction in nest sites would affect different species, and found that data on 43 bumblebee species worldwide agreed with the model's predictions. Very similar patterns were seen in data on 221 bird species, which also compete for nest sites. This means that behaviour that evolved when nest sites were not hard to find could result in some species may be driving others to extinction due to habitat loss. This phenomenon – anthropogenic competition – is likely to occur for any formerly abundant resources that suddenly, on an evolutionary timescale, are now limiting population sizes.

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11. Individual variation and consistency in inter-specific associations in mixed-species flocks

F. Hillemann[1], E. F. Cole[1], B. C. Sheldon[1], D. R. Farine[1,2,3]

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Biological communities comprise many species that compete for limited resources. Besides competition, commensal or mutualistic relationships may also occur between species, and can be fundamental to the resilience of communities. While there has been considerable attention given to the causes and consequences of social relationships among conspecifics, much less is known about inter-individual variation in contributions to and dependence on such relationships in mixed-species groups. Characterising the pattern of social interactions and exploring whether individuals adopt consistent social strategies (social phenotypes) is fundamental for understanding the evolutionary ecology of heterospecific sociality. We analysed mixed-species foraging associations in a large automatically monitored PIT-tagged population of three tit (Paridea) species, involving more than 500 000 observations of flock membership collected over four winters. Using social network analysis, we quantified individual variation in mixed-species flocking, and assessed flexibility and consistency in individuals' flocking behaviour within and between years using repeatability analyses. Having controlled for variation of population densities across the study area and throughout time, we found individuals are consistent in measures of gregariousness and differ consistently in their propensity to associate with other species. Our study shows that individual variation in behaviour is likely to translate to community-level processes, with individuals exhibiting marked and consistent differences in their propensity to engage in commensal or mutualistic interactions with heterospecifics. Thus, our results suggest that understanding how communities are formed and maintained may require gaining a greater understanding of their individual members.

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12. Water turbidity constrains male mating success in a marine fish

Marja Järvenpää, University of Helsinki, Finland (presenting the poster), Beatriz Diaz Pauli, University of Oslo, Norway, and Kai Lindström, Åbo Akademi, Finland
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Human-induced eutrophication, resulting in increased algal growth and water turbidity, is an alarming problem in aquatic systems. Many studies have focused on the effects of algal turbidity on mate choice and sexual selection in fish, but little emphasis has been given to the ways it can constrain mating success. Here we experimentally investigate the effects of algal turbidity on maximum male mating success and parental care in the sand goby, *Pomatoschistus minutus*, a fish with a resource-defence mating system and male parental care. For this purpose, we introduced 1 nest-holding male to 5 random-sized ripe females in either clear or in turbid water. After spawning, we observed how many mates and eggs the male received and followed his parental behaviour and egg survival for six days under turbid or clear water conditions. When spawning took place in clear water, the number of eggs the male received into his nest increased with the total weight of five females in his tank. However, when spawning took place in turbid water, there was no relationship between female size and the number of eggs laid, although the number of females that spawned was the same as in clear water. The results indicate that females adjust the number of eggs they lay according to water turbidity. This could explain previous findings that mating success is more evenly distributed among males in turbid than clear water conditions.

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13. Personality-dependent dispersal in the sand lizard, *Lacerta agilis*; implications for reintroduction success

Emily Jordan[1,2] (attending), Heidi Mitchell[1], Alex Kraaijeveld[2] and Martin Wilkie[1]

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Reintroductions can aid species recovery, with dispersal and personality key factors influencing outcomes and success. This study sought to determine personality-dependent dispersal in a locally rare lizard, the sand lizard *(Lacerta agilis),* which is subject to ongoing reintroductions in the UK. Dispersal behaviour was measured among a captive breeding and release group via a series of experimental releases into a novel environment. Social, exploratory and activity behaviors were measured in separate behavioural assays. Study subjects demonstrated repeatable behaviour indicative of exploration and activity personality types. Juvenile sand lizards demonstrated stronger dispersal tendencies and more flexible behaviour than mature individuals, indicating a possible ontogenetic component of behavioural variation; this holds implications for preferred age of release. Principal component analysis established an activity-exploration dispersal syndrome among captive sand lizards, and exploration and activity were found to be effective predictors of dispersal tendency. The outcomes from this study will directly inform release strategy in terms of demography of reintroduced groups, and design of a soft-release protocol. Ongoing research includes radio-tracking of released individuals, which will enable us to assess whether behaviours measured in captivity predict wild reintroduction responses and long-term dispersal patterns.

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14. Observations on the behavioural response of the white-clawed crayfish *Austropotamobius pallipes* to five standard marking techniques over a 14-day period

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The white-clawed crayfish, *Austropotamobius pallipes* has suffered a drastic decline in abundance across its natural range over the past century causing this species to be classified as endangered in the 2010 IUCN Red List and to be protected under Irish and European legislation. Mark-recapture methods play a vital role in the process of estimating population size, monitoring and aiding in the conservation of mobile protected and endangered species such as crayfish. A variety of marking techniques are routinely used across a range of crayfish species for ecological research. The majority of information on the effects of these marking techniques on the physiology of crayfish species revolves around survivability and growth, whereas there is little information available on the effects of marking technique on crayfish behaviour and how this may affect population estimates and monitoring projects. The marking techniques used within this study included internal and external passive integrated transponder tags, visible implant elastomer tags, cauterisation and ablation. The effects of each marking technique were evaluated before, immediately after and over a 14-day period on 78 crayfish (31-46mm CL). Results indicated that the internal PIT tag negatively affected crayfish behaviour by significantly decreasing activity levels and increasing resting levels, while ablation and cauterisation caused a significant increase in grooming levels. The remaining marking techniques did not significantly alter crayfish behaviour. These significant effects on crayfish behaviour may have a detrimental impact on the welfare and conservation of *A. pallipes* populations and may also lead to bias population estimates during mark-recapture projects.

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15. Habitat selection in a declining farmland bird, the whinchat (Saxicola rubetra) -- implications for physiology, reproduction, and conservation.

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To direct conservation money and effort, precise information about an animal's key habitat requirements and preferences are necessary. Moreover, we need to understand how different and differently managed habitats contribute to individual fitness, and affect population density and growth. We examined territory density, nest site selection, and reproductive behavior and success in a declining farmland bird, the whinchat (*Saxicola rubetra*), and it's currently more successful relative, the stonechat (*Saxicola torquata*). We monitored the faith of nests in 3 different areas of a protected wetland area, and collected data on nest orientation, surrounding vegetation, management, and disturbance. A second aim of the study was to detect physiological signs of potentially increased workload (such as hematocrit) due to differences in habitat quality. Habitat and nest site components varied widely among sites and between and within species. However, the choice of a certain nest site and -orientation contributed largely to the reproductive success of individuals. Our results underline the importance of species-rich, flood-proof, and wisely managed meadows for the effective conservation of a threatened farmland bird.

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16. Measuring Temperament in the Field: A broadly applicable method with implications for conservation

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Animal temperament or 'personality' is consistently related to fitness. Variation in personality within a species can be maintained via pay-offs that fluctuate depending on changing environmental and social conditions. Understanding the role of personality in the fitness outcomes of individuals within a species can be a powerful general tool for behavioural and conservation researchers. I outline a simple field method for measuring personality that can be adapted to different situations and species. I will demonstrate how a number of behavioural measures taken during live-trapping can be reduced into 'personality' factors, using data from live-capture of wild Eastern grey squirrels. I will also show how investigating repeatability of these factors over variable time-periods can be informative about which factors are valid indicators of personality traits. Finally, I will relate factor scores to individual 'trappability' scores to show how these measures can be used to predict likelihood of re-trapping individual wild grey squirrels. The general applicability of the methods as a tool to support conservation will be discussed. For example, measures of personality can be used to identify individuals most suited for reintroduction or relocation, as well as having potential implications for broad culling programmes.

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17. Multi-year tracking for detailed, dynamic habitat selection of European nightjars *(Caprimulgus europaeus)*

Mitchell, L.J.*, White, P.C.L. and Arnold, K.E.
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Understanding movement and estimating habitat selection of animals is important to assess the effects of landscape change and habitat management on populations. How animals use a changing landscape may impact upon their productivity and survival; for species of conservation concern developing suitable management strategies, knowledge of habitat use for foraging and breeding is vital. Technological development has allowed us to collect large amounts of fine-scale data that can provide us with accurate information on the importance of various resources to answer questions such as which foraging sites are visited, for how long and on how many occasions? Does this change between years, particularly where there has been habitat alteration? Here we have GPS- tracked a small, relatively stable

population of European nightjars *(Caprimulgus europaeus),* which have been subject to large-scale habitat change across their breeding site on the Humberhead Peatlands NNR, South Yorkshire. This habitat change is part of a LIFE+-funded peatland restoration project, which may both positively and negatively affect nightjar breeding. In order to monitor the behavioural response to this change, over multiple years, fine-scale movement data has been used to estimate home range size, overlap, and any changes between years, as well as resource selection metrics related to use of vegetation types and structure. Selection overall is focused on drier habitats and the birds are seen to strongly prefer newly created open areas, although high individual variation suggests the need for a mosaic of habitat-types and structural differences, encouraging habitats that support large numbers of their preferred prey of moths and beetles.

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18. Predicting disease transmission in gorillas through social network analysis

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Forest clearings represent important social hubs for the critically endangered Western Gorilla *(Gorilla gorilla).* Mineral-rich vegetation attracts groups and solitary males from considerable distances, which show preferential associations in their visit patterns. These clearings represent potential hotspots for disease transmission and potential targets for intervention strategies in this species for which infectious disease has been a major contributor to population decline. Using social network analysis on same-day visits, we investigated the potential for super-spreader structure at the Lokoué forest clearing, Republic of Congo. Group and solitary visit rate, eigenvector centrality and weighted degree distributions were consistent with both power law and exponential distributions; however exponential distributions provided a marginally better fit. These results demonstrated that a small number of individuals were responsible for a large proportion of connections in the social network (degree) and a large proportion of connections to other highly connected individuals (centrality). Solitary males had a higher average visit rate, degree, and centrality than groups, but not significantly so, exclusively representing the highest 4% of values across all three metrics. Visit rate, centrality, and degree all correlated negatively with distance from home range, such that individuals with home ranges close to the clearing were the most connected in the network. Our results suggest that whilst the extreme long-tailed distributions necessary for super-spreading may not best describe contact rates at forest clearings, there still appears to be considerable predictable variation, whereby gorillas with nearby home ranges, particularly solitary males, may represent important targets for disease intervention strategies.

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19. The first described behaviour related sounds from Brook Lamprey *(Lampetra planeri)* in the wild from a stream in Co. Mayo, Ireland.

Derek O'Driscoll (attending) [1], Martin Gammell[1] and Joanne O'Brien[1]

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Passive acoustic monitoring (PAM) is a technique used for listening to and recording the underwater sounds of aquatic life. Scientists have used PAM to gain information on distribution and habitat use of otherwise difficult to monitor aquatic organisms. This present study aimed to determine if brook lamprey produce sound during redd excavation and whether the sounds associated with this excavation could be used to locate them in the wild through PAM. A total of 25h and 27m of acoustic recordings and 46 minutes of video were analysed for this study. Two distinct behaviours were observed during redd excavation, rapid undulations (RU) and movement of stones (MS). In total MS was recorded on 110 occasions and RU on 24. Both behaviours were clearly visible on video recordings and associated acoustics were clearly described. MS mean peak frequency was 900.5Hz and RU mean peak frequency was 218.7Hz, mean duration was 2.9s (MS) and 4.2s (RU). It was found that both of the observed behaviours were visually and acoustically distinct and

that RU had less variation in the composition of its sound signature compared to MS. This study is the first to document the sound signature and characteristics of the spawning behaviour of brook lamprey and has shown that it is possible to detect their presence by means of PAM. This study demonstrates PAM as a successful method to determine the habitat use of lamprey and could prove to be useful tool for monitoring inaccessible sites or identifying new important lamprey spawning grounds.

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20. Assessment of anthropogenic disturbances due to ecotourism on a grey seal (*Halichoerus grypus*) colony in the Blasket Islands, SW Ireland

María Pérez Tadeo, Martin Gammell, Joanne O'Brien

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Wildlife-oriented tourism has experienced a rapid growth in the last decades. While ecotourism aims to promote conservation, its actual impacts on wildlife and populations must be assessed, especially during critical stages of the life cycle. The grey seal (*Halichoerus grypus*) is a protected species in Ireland and therefore, its population is subject to monitoring programs. Consequences of anthropogenic disturbances due to ecotourism will be assessed on a grey seal colony over the breeding and mating seasons in the Blasket Islands, SW Ireland. Here, the tourist season overlaps with part of the pupping period, and consequently the most sensitive time in terms of potential disturbances. Disturbance might adversely affect the fitness of this species by reducing resting and nursing times, forcing them into the sea and leading to abandonment of offspring. Impacts of ecotourism due to presence of tourists and ferries will be evaluated by investigating changes in the behaviour of grey seals between undisturbed and disturbed conditions due to the approaching ferries and walking tourists. Differences in behaviour, proportion of seals entering the water and time spent looking after and feeding the pups will be assessed using focal and scan sampling of seals hauled out on the beach. Response distance of seals to approaching ferries will also be taken into account. The results of this study identify whether conservation efforts need to be increased whereby restrictions or limitations should be enforced to reduce the effect of disturbance.

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21. Do rhino relationships persist over time? The use of social network analysis to improve the conservation management of white rhinoceros.

Sarah Scott, Manchester Metropolitan University (attending)
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Poaching for the illegal rhino horn trade is leading to the rapid decline of rhinoceros species worldwide. Consequently, wild populations of rhinoceros require intensive monitoring and management to remain viable. Further exacerbating the situation, captive southern white rhinoceros *(Ceratotherium simum simum)* have poor reproductive output, and the reasons behind this remain unclear. As white rhinoceros have the most developed social system of all the rhinoceros species, social conditions are likely to influence their reproduction. Social network analysis is a useful tool to investigate rhinoceros social bonds and their potential importance to reproduction. We used social network analysis to investigate the social structure of two white rhinoceros populations in Kenya. We used group composition data collected during two time-periods, over six months apart, to assess whether network structure and inter-individual relationships persist over time. Our preliminary results show that whilst network structure changes over time, re-association between pairs of individuals remains higher than expected if individuals were associating randomly, suggesting that relationships do indeed persist over time. Our results provide new insights into white rhinoceros grouping patterns that could be used to improve their conservation management. Individual rhinoceros are often moved between captive institutions, or

wild populations, subject to breeding management decisions. Such social upheaval may have a detrimental impact on individual well-being, as important social bonds are broken and existing group dynamics are altered. Applying knowledge of natural grouping patterns to the management of white rhinoceros may improve social conditions and translocation success, which could help to increase their reproduction.

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22. The impacts of human disturbances on the behaviour and population structure of impala *(Aepyceros melampus)* in the Serengeti ecosystem, Tanzania

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Human activities can lead to various changes in wildlife populations' behaviour and dynamics. Understanding specific responses to disturbances can help conservation management better protect wildlife populations to coexist with local communities. Here, we studied the response of impala *(Aepyceros melampus)* to different types of human activities in the Serengeti ecosystem. Impala were studied in the strictly protected central Serengeti National Park (CSNP), and in areas with higher human disturbances, including Grumeti Game Reserve and Loliondo Game Controlled Area, where pastoralism and/or hunting are the main disturbances. We hypothesized that in the more disturbed areas, 1) impala would spend more time on costly behaviours and would synchronize their behaviour more, 2) sex ratios would be more female skewed, and 3) group sizes, reproduction and recruitment ratios would be lower compared to CSNP. We found that impala spent less time resting in more disturbed areas, as well as a significantly lower proportion of males, and lower reproduction and recruitment ratios. Impala synchronized their behaviour, increasing their social cohesion potentially resulting in more efficient anti-predator strategies. Human activities induced a behavioural response in impala, indicating that in less regulated areas where pastoralism and hunting are allowed, these disturbances can potentially affect impala population persistence. These results highlight the importance of protected areas for wildlife populations, and the need for continuous monitoring of the impala and other ungulate populations in less regulated areas, as the underlying anthropogenic disturbances are likely impacting diverse species.

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23. Animal social network theory can help wildlife conservation

Lysanne Snijders[1,2], Daniel T. Blumstein[3], Christina R. Stanley[4] and Daniel W. Franks[5]
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All authors will be attending symposium, but C Stanley will be presenting the poster.
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Many animals preferentially associate with certain other individuals. This social structuring can influence how populations respond to changes to their environment, thus making network analysis a promising technique for understanding, predicting, and potentially manipulating population dynamics. Various network statistics can correlate with individual fitness components and key population-level processes, yet the logical role and formal application of animal social network theory for conservation and management have not been well articulated. We outline how understanding of direct and indirect relationships between animals can be profitably applied by wildlife managers and conservationists. By doing so, we aim to stimulate the development and implementation of practical tools for wildlife conservation and management and to inspire novel behavioural research in this field.

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24. Effectiveness of animal-conditioning in reducing Human-Wildlife-Conflict: a systematic map protocol

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Similar to the evidence-based revolution in medicine, the application of systematic maps and reviews has the potential to accelerate the uptake of behavioural evidence in policy and management. Systematic maps and reviews differ from traditional reviews and meta-analyses in that their methods are peer reviewed and pre-published, grey literature is included, and review findings are formally communicated with stakeholders. As a first step, **systematic maps** of the existing evidence can highlight knowledge gaps and clusters in the evidence base, thereby directing future research efforts and **systematic reviews**. As part of an international initiative of behavioural ecologists to systematically review the effectiveness of behavioural conservation interventions, we here present our plan to systematically map the evidence for the effectiveness of animal conditioning in reducing Human-Wildlife-Conflict (HWC). HWC is currently one of the most pressing conservation challenges. Conflicts often involve wild animals becoming habituated to consuming anthropogenic resources, either out of necessity or as a consequence of opportunistic behaviour. A variety of interventions are undertaken to reduce HWC, differing in practicability, costs and social acceptance. Animal conditioning is one such non-lethal intervention. With this technique, researchers aim to reduce conflict by changing the value animals have associated with certain resources or behaviours. However, studies testing conditioning interventions have reported seemingly contradictory outcomes. To facilitate reduction of HWC, we need to better understand if and when conditioning interventions are indeed effective. With this systematic map we therefore intend to make a global evidence base for conditioning of free-ranging vertebrates in HWC.

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25. Using genomics to inform behaviour and conservation - a case study of a reintroduced wild equid

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For highly dispersed, elusive species, direct observations are often not feasible. However, new genomic methods produce high resolution population data which allow to make inferences about behaviour. In Israel, individuals from two different subspecies of Asiatic wild ass *Equus hemionus* were reintroduced with the aim of establishing a viable population. However, the long-term success of this reintroduction could be compromised by physiological or behavioural barriers to reproduction and differences in habitat selection between the subspecies. Unsuccessful population admixture could result in reduced genetic diversity and reproductive success. Here we used genomic techniques to uncover the extant of interbreeding between the subspecies as an indication of the mating behaviour. We estimated genetic diversity and levels of admixture of the reintroduced population prior and post release using >5000 genomic markers. We further tested for spatial autocorrelation of hybrid indices to investigate potential differences in habitat selection. There was a small significant decrease in heterozygosity (HoFounding=0.249, HoWild=0.221; Wilcoxon test, Z=0.1930126, p<0.001) yet levels of admixture were high and did not differ between the founding and the wild population (MedianFounding=0.432, MedianWild=0.434; MWU test, U= 411, p=0.5514). Consistently, geographic analysis indicated no differences in habitat choice with respect to subspecies ancestry (Moran's I = 0.042, z=1.574, p=0.115). The analyses revealed successful admixture indicating no behavioural barriers between subspecies in neither the captive nor the wild populations. More broadly, this study is contributing to the maintenance of genetic diversity in the reintroduced population, crucial for population viability.

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26. Pair bond strength and vocal communication in the Bali myna (*Leucopsar rothschildi*)

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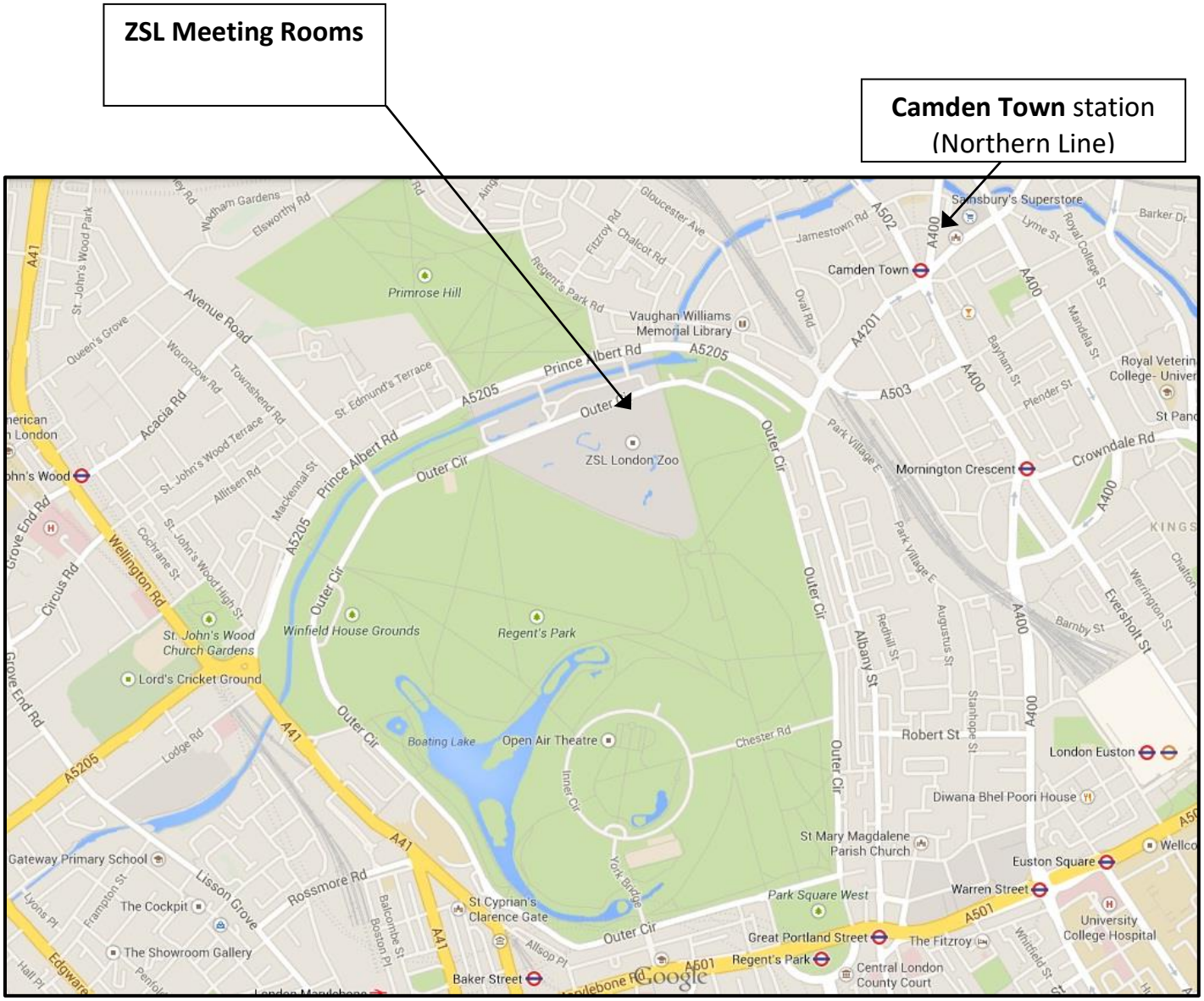
In socially monogamous animals, pair bond duration and quality are a significant determinant of reproductive success. To maintain a pair bond, mates usually improve their behavioural coordination during parental care, foraging trips, and territory defence. Here, we explored the variance of pair bond strength in Bali mynas, a socially monogamous bird that maintain a pair-bond all year long, by measuring the frequency of affiliative behaviour performed by each pair. Further we investigate whether strong social bonds are related to increased focal communication. We describe substantial differences in strength of pair bonds. Further, we found individuals to vocalize more frequently when in close proximity. We found no evidence for a correlation between frequency of vocalization and pair bond strength. Our results provide first insight into the social behaviour and vocal communication of captive Bali mynas, a critically endangered and understudied bird species. In future, this data has the potential to be used to increase success in captive breeding programs and reintroduction.

Linking behaviour to populations and communities: how can behavioural ecology inform conservation?

Location of lunch: Prince Albert Suite



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