Welcome!

We are very excited to have so many of you here in Edinburgh for the 2022 ASAB Winter Conference! This edition of ASAB Winter has an extraordinary numerous and diverse participation of scientists, both in terms of geographic origin, study system, and career stage. These are the premises for two days of fantastic fruitful scientific exchange in the context of a very exciting and top-quality programme focused around animal movement!

Animal movement is a component of animal behaviour that brings together many different research approaches, from navigation and motion in different contexts, to individual and group responses to environmental changes, to physiological and genetic regulatory feedback. We received an incredibly rich number of applications for talks and posters, each one of them interesting and innovative, and had to face the very difficult task to choose among all these contributions, which were all of high quality. We decided to aim at the broadest diversity of study systems and topics of research on movement and include an exciting new talk format - flash talks. We hope you will have a fantastic time at this year's winter conference supported by ASAB!

Sincerely,

The 2022 ASAB Winter Organizing Committee

Christine Beardsworth, Ginny Chan, Francesca Cagnacci, Jolle Jolles, Myles Menz

PROGRAMME

Day 1: Tuesday December 6th, 2022

08:30 – 09:15 **Registration & poster setup**

09:15 – 09:30 **Welcome**

09:30 – 10:30 **Plenary lecture**

Lucy Hawkes – *Adventures (and the future!) of animal tracking*

10:30 – 11:00 **Coffee break & outreach poster session**

11:00 – 12:25 **Talks session 1**

Andrew King – *Collective motion: why do many terrestrial animal groups travel in lines?*

Edward Hurme – *Bats flexibly wait for better weather at stopover sites*

Mina Ogino – *Between-group differences in space uses within a multilevel society of vulturine guineafowl (Acryllium vulturinum)*

Samuel R. Matchette – *'Shadowing' behaviour by trumpetfish serves as a form of motion-camouflage*

Sergio Rossoni – *How the raptorial forelimb of praying mantids achieves behavioural flexibility*

12:25 – 13:50 **Lunch break & networking event**

13:50 – 13:55 **ASAB AGM Pt2 - confirming the accounts**

13:55 – 14:55 **Plenary lecture**

Rosie Woodroffe – *Putting animal behaviour to work*

14:55 – 16:05 **Talks session 2**

Sarah Skeels – *Exploring the role of egocentric movement for shape discrimination during active electrolocation in the weakly electric fish, Gnathonemus petersii*

Francesca Santostefano - *Social interactions generate complex selection patterns in virtual ecosystems*

Melinda Boyers – *How resilient are African herbivores to climate induced changes? A comparison of the movement responses to variation in resources across ecosystems*

Marilia Freire – *Desert ants avoid homing errors by self-manipulation of their nest hill height in the absence of environmental landmarks*

16:05 – 16:35 **Coffee break**

16:35 – 17:20 **Talks session 3**

Charlie Russell – *Impacts of war on the behaviour of an endangered long-distance migratory bird*

Deyatima Ghosh – *Exploring predator cognition to understand ecosystem service provisioning: a new approach to bioregulation of crop pests*

Ines Fürtbauer – *Advancing behavioural endocrinology with high-resolution movement data: insights from baboon studies*

17:20 – 17:40 **Flash talks session 1**

Andréa Thiebault – *Acoustic foraging network in African penguins*

Christian Rutz – *Unlocking the full research and conservation potential of animal-tracking data through a global tag registry (TRACK)*

Hella Péter – *The impact of water as a resource on the space use of female East African chimpanzees (Pan troglodytes schweinfurthii)*

Lindsay A. Carroll – *Using telemetry to deepen knowledge of frostfish (Microgadus tomcod, punamu) movement ecology in Bay of Fundy, Nova Scotia tidal rivers*

Michele A. Johnson – *Shake, wiggle, and curl: how and why lizards move their tails, before and after tail autotomy*

17:40 – 18:20 **Wine and poster session 1 (odd numbers)**

18:20 – 19:00 **Wine and poster session 2 (even numbers)**

Day 2: Wednesday December 7th, 2022

08:30 – 9:00 **Coffee**

09:00 – 10:00 **Plenary lecture**

Ran Nathan – *The high-throughput revolution in movement ecology*

10:00 – 10:35 **Talks session 4**

Lily Johnson-Ulrich – *Collective movement decisions & 'move' calls in meerkats*

Vito Lionetti – *Conflict between aversive and appetitive learning of panoramic views: how foragers shift to a new route during navigation*

10:35 – 10:55 **Flash talks session 2**

Anna M. Bracken – *Inter-individual variation in the urban space-use by Cape chacma baboons (Papio ursinus)*

Fumihiro Kano – *What are birds looking at? A motion-capture system reveals the selective use of visual fields in freely-behaving pigeons*

Jena E. Edwards – *Fish without borders: international tracking reveals seasonal distributions and connectivity pathways of European fishes*

Luke Rendell – *Ocean nomads or island specialists? Culturally driven habitat partitioning contrasts in scale between geographically isolated sperm whale populations*

Rachael Brown – *Investigating a body shake behaviour in Lasius niger and its potential role as a pathogen alarm behaviour*

10:55 – 11:25 **Coffee break**

11:25 – 12:15 **Talks session 5**

Iris D. Bontekoe – *The consequences of an increased time constraint during migration*

Matthew J. Hansen – *Group-Hunting in Striped Marlin: from Chase to Capture*

Michael Chimento – *How immigration can shape animal culture*

12:15 – 12:30 **Flash talks session 3**

Francesca Occhiuto – *Using precision technology to investigate personality and plasticity of movement in farmed calves*

Alex H. H. Chan – *3D posture tracking of bird flocks by automated annotations using machine learning and computer vision tools: towards markerless tracking in the wild*

Katrina R. Davies – *Do Procellariform seabirds adapt their migratory behaviour in response to climatic changes?*

Stefano Masier – *Space retention, memory capabilities and habitat fragmentation: a study on Belgian butterflies*

12:30 – 14:00 **Lunch break & LGBTQ+ event**

14:00 – 15:00 **Tinbergen lecture**

Nicola Clayton – *Fingers, thumbs and wings. What magic effects reveal about cognitive constraints and embodied knowledge of movement*

15:00 – 15:35 **Talks session 6**

Florian Orgeret –*Shift in habitat selection during natal dispersal of a long-lived raptor species*

Joe Wynn – *There and back again: the mechanisms of avian natal homing*

15:35 – 15:55 **Flash talks session 4**

James A. Klarevas-Irby – *Group living limits the energetic efficiency of movement*

Katalin Ozogány – *Fine-scale aerial video tracking of collective movements reveals group dynamics in Przewalski's horses*

Katherine R. S. Snell – *Motion Capture Energetic Performance of Avian Movements*

Mackenzie Meier – *Information content in bottlenose dolphin whistles during a cooperative task*

Máté Nagy – *Multimodal, high-throughput measurement of behaviour and interactions in animal collectives*

15:55 – 16:25 **Coffee break**

16:25 – 17:35 **Talks session 7**

Mathilde Le Levier – *Host plant spatial memory in butterflies: does habitat fragmentation matter?*

Hui Yu – *Continuous on-board behavior classification using accelerometry, a case study & ecological insights*

Jasmeen Kanwal – *Population viscosity promotes altruism under density-dependent dispersal*

Jessica Rudd – *Fine-scale post-release behaviour and recovery of Atlantic bluefin tuna to catch and release in the UK*

17:35 – 17:50 **Closing remarks**

TALK ABSTRACTS

Talk session 1

Collective motion: why do many terrestrial animal groups travel in lines?

Andrew King[1]

[1]*Swansea University, UK*

New technologies are providing animal behaviour researchers with data on collective motion in a variety of different species. Here, we present data from swimming, flying, and walking animal groups: stickleback fish (*Gasterosteus aculeatus*), flocks of homing pigeons (*Columba livia*), herd of goats (*Capra aegagrus hircus*), and troop of chacma baboons (*Papio ursinus*). We describe how local patterns (inter-neighbour distances and positions) and group patterns (group shape, speed, and polarization) during collective motion differ across each system and highlight a striking difference between the terrestrial and flying/swimming species: goats and baboons show a strong front-back formation – especially with the first two nearest neighbours, whilst pigeons and fish have their nearest neighbours more often to the left or the right than in front or behind. We develop a new metric "frontness" to quantify this aspect of collective motion and propose different hypotheses to explain why many terrestrial animal groups travel in lines (if they indeed do, as our pilot data and Google image searches suggest).

Bats flexibly wait for better weather at stopover sites

Edward Hurme[1,2], Timm Wild[1], Martin Wikelski[1], Dina Dechmann[1,2]

[1]*Max Planck Institute of Animal Behavior, Germany;* [2]*Centre for the Advanced Study of Collective Behaviour, University of Konstanz, UK*

Stopovers during migration usually provide areas where animals can shelter from bad weather and refuel. Challenges with long-term tracking of small nocturnal species have limited insight into the strategies of bat migration. For example, bats, may be better at reducing energy loss during stopovers when compared with migratory birds through the use of torpor. We hypothesized that heterothermic bats flexibly use a combination of resting in torpor and foraging to wait for ideal weather conditions for migration. Piloting the novel 1.2g TinyFoxBatt Sigfox tag we remotely downloaded the daily location and VeDBA (vector of dynamic body acceleration) of female common noctules (*Nyctalus noctula*) during spring migration across Central Europe. We tracked 23 individuals for up to 28 days, migrating between 200 and 800 km. A Gaussian mixture model of daily VeDBA identified three likely behaviors: migration, foraging, and resting in torpor. We found that bats often entered torpor the day after arriving at a stopover site and then engaged in foraging flights on nights leading up to the next departure, although bats used torpor before departure as well. Common noctules timed their departures and arrivals with reduced precipitation. Additionally, reduced VeDBA compared to distance traveled suggested that bats benefitted from wind support. By following each migration step of small free-ranging bats we show how heterothermic animals migrate flexibly depending on environmental conditions.

Between-group differences in space uses within a multilevel society of vulturine guineafowl (*Acryllium vulturinum*)

Mina Ogino[1,2], Damien Farine[1,2,3]

[1]*Department of Evolutionary Biology and Environmental Science, University of Zurich, Switzerland;* [2]*Department of Collective Behaviour, Max Planck Institute of Animal Behavior, Germany;* [3]*Division of Ecology and Evolution, Research School of Biology, Australian National University, Australia*

Social groups can exhibit striking differences in behaviour. These differences can arise from several social and asocial factors, such as the differences in within-group social environment,

the behaviour of other groups, and seasonality. For example, territoriality limits where groups can move. But, how do groups navigate space when they are not limited by social boundaries? Here, we integrate long-term census data with fine-scale GPS tracking from a population of vulturine guineafowl (*Acryllium vulturinum*) in Kenya to study the partitioning of space among groups. Vulturine guineafowls live in a multilevel society, where groups interact regularly with other groups, and are not territorial. Our data allow us to capture changes in group membership over time and group history shaping space use. We show that group home ranges are consistent across years under similar ecological conditions, despite groups ranging in different areas under different conditions. However, group-level fidelity in space use varies between groups, and we relate these changes to changes in group dynamics, such as group splits and joins. Our study therefore provides insights into how group-level behavioural traits are maintained in wild populations, and the factors that affect their stability.

'Shadowing' behaviour by trumpetfish serves as a form of motion-camouflage

Samuel R. Matchette[1]**,** Christian Drerup[2], Isla Keesje Davison[3], Stephen D. Simpson[3,4], Andrew N. Radford[3], James E. Herbert-Read[1,2]

[1]Department of Zoology, University of Cambridge, UK; [2]Department of Biology, Lund University, Sweden; [3]School of Biological Sciences, University of Bristol, UK. [4]Biosciences, University of Exeter, UK

Many animals use camouflage to reduce their detectability by others, however even the most inconspicuous objects become detectable against the background when moving. One way to avoid detection while moving would be to 'hide' behind the movements of objects or other animals. Here, we test whether trumpetfish (*Aulostomus maculatus*), a piscivorous fish that is common on Caribbean coral reefs, utilise a behavioural motion-camouflage strategy to avoid being detected by their prey. Trumpetfish are often observed 'shadowing' another species, whereby an individual trumpetfish swims closely behind another species of 'host' fish. While it is widely assumed that shadowing enables a trumpetfish to remain concealed as it approaches its prey, this proposed function has never been directly tested. Using *in-situ* behavioural responses of a trumpetfish prey species, bicolor damselfish (*Stegastes partitus*), to three 3D-printed models of shadowing or non-shadowing trumpetfish, we test the functional role of shadowing behaviour. Fleeing and inspection behaviours elicited by damselfish towards the shadowing trumpetfish models more closely resembled the responses to non-predatory species (parrotfish) than those to a non-shadowing trumpetfish. The success of shadowing behaviour as a foraging strategy therefore appears to be governed by the misdetection of trumpetfish by their prey. This is the first study to demonstrate how predators can actively use another organism to conceal from their prey.

How the raptorial forelimb of praying mantids achieves behavioural flexibility

Sergio Rossoni[1], Jeremy Niven[1]

[1]University of Sussex, UK

Praying mantids possess a morphologically specialised raptorial forelimb that they employ in their role as sit- and-wait predators. But how do mantids achieve the flexibility required to capture different prey, and the multifunctionality needed to perform other behaviours such as walking, reaching, or searching? In this talk, I will show how the limb is used during a predatory strike, focussing on the aspects of the strike that are stereotypical and those that are not. I will then compare the strike to reaches, such as those performed whilst crossing gaps or climbing towards new perching spots. I will examine the control and flexibility needed in both behaviours, focussing particularly upon flexion of the femoro-tibial joint, a key behavioural phase of both striking prey and reaching. I will explore the role of passive forces in flexing the tibia to a small resting angle, and how this biomechanical feature saves energy and assists control when striking prey. Although tibial flexion during a reach is much slower than in the strike, the strong passive forces acting to flex the tibia are countered by active braking, a novel form of control in lightweight limbs. Overall, the talk will show how

biomechanical forces can work in concert with muscular activity to execute behaviours that are both specialised and flexible.

Talk session 2

Exploring the role of egocentric movement for shape discrimination during active electrolocation in the weakly electric fish, *Gnathonemus petersii*

Sarah Skeels[1], Gerhard von Emde[2], Theresa Burt de Perera[1]

[1]University of Oxford, UK; [2]University of Bonn, Germany

Body movements play an active role in sensing, however, it is not entirely understood what information is provided by these movements The weakly electric fish *Gnathonemus petersii* senses their environment through active electrolocation during which they perceive object-induced distortions of a self-produced electric field with epidermal electroreceptors. The analysis of electric images projected onto their skin enables them to recognise objects. While we know the electric image parameters used to encode numerous object properties, we don't fully understand the parameters for shape perception. We hypothesise that 'movement-induced modulations' (MIMs) of the electroreceptive input evoked by body movements might be involved in shape discrimination. MIMs represent the changes to the electric images that occur as a fish swims alongside an object. Our study investigated whether body movements were important for shape discrimination during active electrolocation. We trained fish to complete a shape discrimination task in a two-alternative forced-choice setup, and manipulated the space available for scanning movements to test whether this affected their discrimination performance. We found that if enough space was available, fish were very good at discriminating the objects. However, performance decreased strongly when the space was reduced and scanning movements were impaired. This shows that the ability to discriminate between shapes is underpinned by egocentric movement.

Social interactions generate complex selection patterns in virtual ecosystems

Francesca Santostefano[1,2], Maxime Fraser Franco[2], Pierre Olivier Montiglio[2]

[1]University of Exeter, UK; [2]Universitè du Québec a Montréal, Canada

Organisms interact when they compete for food, court, mate, and communicate. Through these interactions, phenotypes of conspecifics affect an individual's fitness and behaviour. A key challenge in ecology and evolution is to establish a predictive understanding of the effects of social interactions on selection and evolution of traits. This requires extensive datasets monitoring the behavior and fitness of many individuals across interactions, which are difficult to collect in natural populations. We capitalize on a novel data source, virtual ecosystems of online multiplayer videogames, which provide large and complete datasets in environments recreating realistic ecological settings. In the videogame "*Dead by Daylight*", a group of prey interact and cooperate to achieve the goal of escaping a predator. We estimate non-social and social selection and their contribution to selection differentials in four traits expressed explicitly in a social context and mediating competition, cooperation, and predator-prey interactions. We find that behaviours of groupmates have a large impact on survival. Depending on whether behaviours are synergic or conflicting, social interactions enhance or counter the strength of natural selection. Interactions are thus an important ecological element shaping selection, which is the result of several factors: a prey's own behaviour, its conspecifics' behaviour, and traits correlations. Our study emphasizes the complex selective consequences of predator- prey dynamics and interactions among individuals.

How resilient are African herbivores to climate induced changes? A comparison of the movement responses to variation in resources across ecosystems

Melinda Boyers[1], Thomas Morrison[1], Juan Morales[1], Colin Torney[2], Grant Hopcraft[1]

[1]*School of Biodiversity, One Health and Veterinary Medicine; University of Glasgow, UK;* [2]*School of Mathematics and Statistics; University of Glasgow, UK*

Recent climate change scenarios suggest that most regions in Africa are expected to increase in temperature at a much faster rate than predicted globally. African temperatures have already increased gradually in recent decades, with each year being warmer than the last. However, the thermal threat projected for many areas of Africa is compounded, or even exceeded, by the threat of unpredictable rainfall. Animal movements are relatively sensitive to environmental change, and therefore provide a reliable early-warning system of perturbations to ecosystems, particularly if we can determine the mechanistic components driving movement decisions. For this study we will focus on using integrated Step-selection Functions (iSSF's) to discern how animals contend with different seasonal and spatial patterns of availability and paucity, and their ability to track these at different scales. GPS data from collared animals (wildebeest, zebra, eland and buffalo) collated by AfriMove from Serengeti, southern Kalahari, central Kalahari, Okavango Delta, and Kruger will be statistically linked to field weather stations and radar satellite imagery. We will therefore comparatively assess the movement patterns of the same species in different regions and different species within the same region across Africa. These findings will identify potentially beneficial changes to land-use management and protected area status illustrating where connecting corridors might be usefully established.

Desert ants avoid homing errors by self-manipulation of their nest hill height in the absence of environmental landmarks

Marilia Freire[1], Antonio Bollig[1], Markus Knaden[1]

[1]*Max-Planck-Institute for Chemical Ecology, Germany*

The desert ant, *Cataglyphis fortis*, inhabits the hot and dry saltpans of Tunisia, where the environmental conditions are extreme and food is scarce. These ants are individual foragers and homing ants rely mostly on path integration to quickly return to the coolness and safety of their nest. However, path integration is error- prone and it has been shown that the accuracy and reliability of the path integrator decrease with increasing foraging distance. To compensate, desert ants can use visual and olfactory cues to pinpoint their nest entrance. Here, we analyze the ants' homing accuracy after extremely long foraging runs and quantify the death rate during homing. In addition, we identify a strategy of the ants to cope with the high threat of getting lost in the desert during a foraging bout. After finding extraordinarily high nest hills in the center of the saltpan, where other visual landmarks are absent, we find that nests further away from environmental landmarks are indeed taller than those that are closer to the visually structured boarder of the saltpan. Furthermore, we show that ants homing to nests in the center of the saltpan rely on the presence of a nest hill, while environmental cues are sufficient to guide ants returning to a nest at the saltpan boarder. These findings suggest that desert ants self-manipulate their nest hill's height based on the surrounding landmarks, to facilitate homing and increase their chance of survival.

Talk session 3

Impacts of war on the behaviour of an endangered long-distance migratory bird

Charlie Russell[1]

[1]*University of East Anglia, UK*

Human conflicts affect wildlife through environmental damage, disturbance and socio-economic changes, however it is largely unfeasible to monitor the direct impacts of war on animal behaviour in conflict areas. Greater Spotted Eagles migrate between their breeding grounds in eastern-Europe and wintering grounds in southern-Europe/Africa each year and we present unique GPS tracking data from twenty-two eagles that migrated through the warzone in Ukraine during spring 2022. Migrating eagles adjusted their migration routes in response to disturbance from the conflict, making significant route deviations, stopping less

often and travelling further compared to previous migrations. This likely increased the energetic costs of migration, having potential sublethal fitness effects during the breeding season. Our results highlight the potential impacts on migratory birds, and other animals, exposed to areas of conflict, and other extreme anthropogenic disturbances, where hundreds of threatened species and millions of individuals may be affected.

Exploring predator cognition to understand ecosystem service provisioning- a new approach to bioregulation of crop pests

Deyatima Ghosh[1], Amarthya Chandar[1], Vikram Aditya[1], Aravind NA[1], Elizabeth A John[2], Anna Wilkinson[2]

[1]Ashoka Trust for Research in Ecology and the Environment, UK; [2]University of Lincoln, UK

Biological pest regulation traditionally considers the ecology of the pest and the natural pest predators to maintain the pest levels below a certain threshold. However, it does not generally consider the behavior and cognition of the pest predators; this can lead to failed attempts of introducing a potential pest predator. Here we examine the cognitive aspects of foraging in a generalist, insectivorous natural predator *Calotes versicolor*, as a model pest controller. Foraging decisions were monitored for lizards in a semi-natural crop patch, with two foraging areas that differed in pest densities. Results show evidence of learning, lizards spent more time in the high yield patch and chose this patch more often. However, the amount of patch switching influenced crop pest intake. Our results reveal that pest predators rapidly learn about areas where pests are most abundant. Suggesting that the cognition of pest predators vastly influences their pest regulation role which needs to be considered prior to selecting relevant species. The data generated can be replicated for other species of reptiles and other pest predator groups. Such an informed approach to bioregulation is likely to advance Integrated Pest Management practices.

Advancing behavioural endocrinology with high-resolution movement data: insights from baboon studies

Ines Fürtbauer[1]

[1]Swansea University, UK

The field of behavioural endocrinology – the study of the bidirectional interaction between hormones and behaviour – has seen major advances through the establishment of various sampling techniques, allowing for non-invasive and repeated quantification of hormones and their metabolites. However, assessment and quantification of behaviour, particularly in field studies, still rely largely on traditional direct-observation techniques, leaving important gaps in knowledge. Accelerometry and GPS data are commonly used to quantify activity and behaviour in other fields of animal behaviour but, to date, have received little attention and application in behavioural endocrinology. Here, I present Cape baboon (*Papio ursinus*) case studies in which we study hormone-behaviour relationships using accelerometry and GPS data coupled with frequent urine and faecal sampling for quantification of various hormones. Together, these examples highlight the versatility and scope of advancing behavioural endocrinology with accelerometry. In particular, remote and continuous quantification of behaviour provides unprecedented insight into temporal aspects of hormone- behaviour interactions, and those involving infrequent behaviours.

Talk session 4

Collective movement decisions & 'move' calls in meerkats

Lily Johnson-Ulrich[1,2], Vlad Demartsev[2,3,4,5], Baptiste Averly[2,3,4,5], Ariana Strandburg-Peshkin[2,3,4,5], Marta Manser[1,2]

[1]Department of Evolutionary Biology and Environmental Studies, University of Zurich, Switzerland; [2]Kalahari Research Centre, South Africa; [3]Department for the Ecology of Animal Societies, Max Planck Institute of Animal Behavior, Germany; [4]Department of Biology, University of Konstanz, Germany; [5]Centre for the Advanced Study of Collective Behaviour, University of Konstanz, Germany

Animals that move collectively require coordination mechanisms to maintain cohesion and to determine both when and where to travel. Many social species use vocalizations to aid in such coordination, often including calls associated with the initiation of rapid movement. Meerkats (*Suricata suricatta*) live in highly cohesive groups that move together in order to avoid predation while foraging on prey items buried in the sand. They possess a large vocal repertoire including several calls that are used to coordinate movement. The production of 'move' calls correlates with an increase in a group's speed, but it remains unclear whether 'move' calls are used to coordinate a group's direction. Here, we used observational tracking data and experimental playbacks to investigate this possibility. Observational data from GPS collars show that move calls are associated with increased influence over direction, and that this influence is mediated primarily via alignment with an individual's trajectory as opposed to attraction to their position in the group. We then tested for this causality by conducting 'move' call playbacks on tracked groups, being stationary or moving perpendicular to the group's direction of travel in order to distinguish between attraction versus alignment responses. This difference is important because alignment responses are generally associated with information transfer, and would imply directional decision-making, whereas attraction is generally associated with sociality and maintaining cohesion.

Conflict between aversive and appetitive learning of panoramic views: how foragers shift to a new route during navigation.

Vito Lionetti[1], Trevor Murray[1], Ken Cheng[1]

[1]Macquarie University

Ants learn and store visual information to navigate in their environment. Foragers are able to form positive associations with views that lead to desired experiences. On the other hand, foragers form negative associations (aversive learning) with views leading to negative experiences. Foragers use views associated with both positive and negative experiences as guidance, following routes facing positive views while turning away from those negative. Here we tested the effect of appetitive and aversive learning of views of a specific area. We made *M. midas* foragers encounter a negative experience, undergoing a capture-release procedure, or a positive experience, reaching the feeder or returning home without any travel interruptions. The capture-release procedure occurred in a specific area along their route during either their foraging journey, homing journey, or both. The foragers avoided the area where the negative experience occurred, meandering and scanning more, thus showing an aversive response towards the views associated with a negative valence. The foragers showed lower levels of aversive responses when the encountered views were associated with both appetitive and aversive experiences (e.g. positive outbound experience, aversive homebound experience). Furthermore, after being captured and released only in a specific goal-context direction, either the foraging or homing direction, the foragers did not show evidence of context specificity in aversive and appetitive learned memories.

Talk session 5

The consequences of an increased time constraint during migration

Iris D. Bontekoe[1,2,3], Andrea Flack[2,3,4]

[1]Department of Migration, Max Planck Institute of Animal Behavior, Germany; [2]Collective Migration Group, Max Planck Institute of Animal Behavior, Germany; [3]Department of Biology, University of Konstanz, Germany; [4]Centre for the Advanced Study of Collective Behaviour, University of Konstanz, Germany

Choosing the right migration timing is essential for avian migrants because physical and social conditions encountered *en route* influence movement costs, efficiency and even survival. Yet, depending on lifetime stages, individuals may choose a different migration timing due to diverging time and energy constraints. To examine the consequences of an increased time constraint, we artificially delayed the migration of 40 juvenile white storks (*Ciconia ciconia*; hereafter storks) by about one month. Using nearly continuous 1Hz GPS trajectories, we examined their migration behaviour, ranging from sub-second level performance to global long-distance movement, in relation to two control groups. We observed that delayed storks spent the winter closer to the breeding area than control storks, in fact, none of these birds reached the traditional African wintering areas. At a finer scale, delayed storks experienced suboptimal thermalling conditions, but better wind support and thereby achieved higher flight speeds than control storks. Although this resulted in a higher energy expenditure, delayed storks had a lower mortality rate than the control storks. Thus, our results show that juvenile storks can cope with an increased time constraint. However, this has immediate and long- term consequences on their energy expenditure and migration decisions. We suggest that, when timing their migration, storks balance energy and time, and this trade-off shifts as they age and gain more experience.

Group-Hunting in Striped Marlin: from Chase to Capture

Matthew J. Hansen[1]

[1]*IGB Leibnitz-Institute*

Group hunting has been a key topic in the field of behavioural ecology, however, the descriptions of the movements of group-hunting predator and prey during hunts have traditionally been qualitative in nature due to logistical difficulties. Nowadays, the temporal and spatial resolutions of animal movement data collected in the wild can be very high, which allows for greater insight into the mechanisms of how individually identified predators interact in time and space with each other and with their prey. Groups of striped marlin (*Kajikia audax*) hunt schools of prey fish (sardine and mackerel) off the coast of Baja California, Mexico each year. This predator-prey system allows for the tracking of behaviour of predator and prey at multiple spatial scales throughout the predation event, from long distance chases through to individually identified attacks and captures. Using an analysis of underwater video I will describe how turn-taking in the predator attacks is organized and how the shared resource (the fish school) is divided between multiple predators. I will also present ongoing work exploring the spatial positioning of predators and prey as the fish schools are herded, chased and attacked at the ocean's surface. Because it is an open ocean system composed on non-kin related predators that hunt groups of small but highly evasive prey, the functions and mechanisms I will describe differ from those commonly addressed in the traditional terrestrial group-hunting literature.

How immigration can shape animal culture

Michael Chimento[1,2], Gustavo Alarcón-Nieto[1], Lucy M. Aplin[1,3]

[1]Max Planck Institute of Animal Behavior; [2]Centre for the Advanced Study of Collective Behavior, Konstanz University; [3]Australia National University

The introduction of new individuals to populations is a pre-requisite for cultural inheritance and evolution. However, how variation in the social process of immigration might influence cultural outcomes is not well understood. Using a combination of experiments and computational models, we explore the effects of the introduction of naive individuals, and of already knowledgeable individuals, into populations. In a cultural diffusion study using captive great tits (*Parus major*), we show how naive individuals are better samplers of available behaviors, and can drive cultural change, leading populations that undergo turnover to more effecient behaviors, compared to static populations. In a follow up computational model, we explore the underlying mechanisms of how turnover influences culture. We find that variation in turnover can lead to optimal, neutral and sub-optimal cultural states compared to static

populations. Further, we show how the effects of turnover depend on features of the social network, as well as individual learners. Finally, in another cultural diffusion experiment where populations of birds underwent simulated immigration events, we show that social learning strategies depend on environmental cues of an immigrants new population. We find evidence that birds which move to a novel environment are more likely to use a payoff-biased strategy. In summary, these three studies shed light on how immigration can shape animal culture.

Talk session 6

Shift in habitat selection during natal dispersal of a long-lived raptor species

Florian Orgeret[1], Martin U. Grüebler[1], Patrick Scherler[1], Valentijn van Bergen[1], Urs G. Kormann[1]

[1]*Swiss Ornithological Institute, Switzerland*

Understanding how animals select their habitats provides insight into ecological processes, species distribution, and conservation management. However, few studies have examined how habitat selection may change during dispersal, despite its importance for accurate ecological spatial predictions. In this study, we examined changes in habitat preferences during natal dispersal of red kites *Milvus milvus* in the Swiss population. By deploying solar-powered GPS transmitters on nestlings (n=204), we continuously tracked individuals from fledging to settlement. We applied habitat selection functions using hierarchical generalized additive models during the prospecting and settlement phases of dispersal. During the prospecting phase, individuals were less responsive to their environment. During the settlement phase, individuals were more responsive by selecting a narrower range of environmental gradients. The relative probabilities of occurrence during the settlement phase resulted in predicted suitable habitats being much more spatially restricted than during the prospecting phase. Using a large telemetry dataset and an advanced analytical method of habitat selection, which allows for nonlinear relationships while controlling for habitat availability, individual variation, and spatiotemporal autocorrelation, we illustrated how habitat selection can shift during natal dispersal phases in a long-lived species, with the potential to strongly influence the future of the population distribution.

There and back again: the mechanisms of avian natal homing

Joe Wynn[1,2], Tim Guilford[2], Oliver Padget[2], Henrik Mouritsen[3], Miriam Liedvogel[1]

[1]*Institut fur Vogelforschung;* [2]*University of Oxford;* [3]*Oldenburg University*

How birds precisely target their breeding sites (‘philopatry’), often at great distances after months or even years have elapsed, is both remarkable and unsolved. Spatially specific cues — learnt prior to departure and uniquely associated with the breeding site — seem prime candidates when considering natal homing, though evidence detailing which cues are used (and how) remains elusive. Here, using historic ringing data we find evidence that birds learn cues extracted from the Earth's magnetic field prior to migratory departure, and use these to guide return migration. We specifically find evidence that birds use magnetic inclination as a uni- coordinate 'stop sign' to relocate their natal site, rather than using it in conjunction with other cues as a bi- coodinate map. Further, through the reanalysis of historic laboratory data, we present evidence for the use of an inherited bearing during return migration; a key component required to solve positional ambiguities caused by multiple positions sharing the same inclination value. We suggest that it is surprisingly plausible that birds utilise uni-coordinate magnetic cues on an inherited bearing to relocate their natal sites following long-distance return migration; and highlight the utility of reanalysing historic data when investigating navigation and movement ecology.

Talk session 7

Host plant spatial memory in butterflies: does habitat fragmentation matter?

Mathilde Le Levier[1], Matteo Marcantonio[1], Stefano Masier[1], Caroline Nieberding[1]

[1]*Catholic University of Louvain*

Habitat fragmentation impacts biodiversity by reducing genetic flow, increasing habitat edges and isolating available resources, thus clustering the spatial distribution of organisms. This affects herbivorous insects, such as butterflies, that depend on specific host plants and whose larval stages have reduced mobility. Fragmentation is thus expected to impact behaviors related to oviposition in butterflies, with potential consequences on their fitness. For example, a better retention of spatial memory of host plants may be positively selected in butterflies from fragmented habitats, due to a clustered distribution of host plants. Here, we tested the retention of short- and long- term memory for host plant locations in *Gonepteryx rhamni* and *Leptidea sinapis* butterflies, from areas with varying habitat fragmentation in Belgium. Butterflies were tested in outdoor cages divided in units that contained host plants according to a checkered pattern. In total, 134 butterflies were observed during repeated 20-minutes behavioral trials and, if oviposited, they were further tested in 2 sequential memory tests (after 1 and 24-hours), during which only 2 host plants were uncovered, i.e., oviposition and control host plants. Our hypothesis is that butterflies from more fragmented habitats have a higher probability of ovipositing on the same host plants as in the training test. Moreover, we expect that such butterflies need less time and spatial exploration to oviposit during memory tests.

Continuous on-board behavior classification using accelerometry, a case study and ecological insights

Hui Yu[1,2,3], Chris Klaassen[4], Jian Deng[2], Trent Leen[5], Guozheng Li[2], Marcel Klaassen[1], Florian Muijres[3]

[1]*Deakin University;* [2]*Druid Technology Co., Ltd;* [3] *Wageningen University & Research;* [4]*University of Amsterdam;* [5]*Geelong Field & Game*

Over the past two decades, accelerometer (ACC) data have been increasingly used to study animal behaviours and energetics. However, the large amount of raw ACC data can be a burden to device storage and power consumption and in many cases may also require device retrieval for data collection. On-board data processing to reduce data volume and power consumption for data transmission may hold promise to alleviate these problems and allow for next-generation, smart trackers. We developed a tracking system processing raw ACC data on-board of trackers into behaviours using an XGBoost machine learning model. We used this system on six free-ranging Pacific black ducks to study eight behaviours every 2 s. We received behaviour data from the six ducks continuously for periods ranging between 56 days and 14 months. On- board processing of raw ACC data and data transmission proofed highly energy efficient and came at a minimal weight cost to the trackers, providing great potential to open up new areas in ecological and behavioural research. In addition, on-board processing of data collected from bioacoustics devices and cameras will also benefit researchers in these fields.

Population viscosity promotes altruism under density-dependent dispersal

Jasmeen Kanwal[1], Andy Gardner[1]

[1] *University of St Andrews*

Population viscosity, whereby individuals do not move far from their place of birth and therefore tend to be surrounded by kin, is thought to be a basic mechanism of kin selection. In such circumstances, even indiscriminate altruism among neighbours will often involve interactions between kin, thus promoting the evolution of altruism. Population viscosity

therefore has the potential to explain altruistic behaviour across the whole tree of life, including in taxa for which kin recognition is implausible. However, population viscosity also intensifies resource competition among kin, which inhibits altruism. Indeed, in the simplest scenario, in which all individuals disperse with a fixed probability, these two effects have been shown to exactly cancel such that there is no net impact of viscosity on altruism. Using an analytical model and individual-based simulations, we show that when individuals are able to condition their decision to disperse on local density, they are favoured to disperse at a higher rate from denser neighbourhoods, which alleviates kin competition. Comparing across different populations or species, this leads to a negative correlation between overall levels of dispersal and altruism, demonstrating that population viscosity (low dispersal) does promote the evolution of altruism when density-dependent dispersal is taken into account. This result demonstrates the important role played by patterns of animal movement in explaining the evolution of altruistic behaviour across a wide range of species.

Fine-scale post-release behaviour and recovery of Atlantic bluefin tuna to catch and release in the UK

Jessica Rudd[1], Martin Collins[2], David Righton[3], Matthew Witt[3], Serena Wright[1], Lucy Hawkes[1]

[1]University of Exeter; [2]British Antarctic Survey; [3]Cefas

Following decades of overexploitation, the number of Atlantic bluefin tuna (*Thunnus thynnus*) sightings has increased over the last seven years in UK waters. Despite a recreational fishery opening for bluefin tuna in 2021, little is known about the effect of catch-and-release on the post-release behaviour and ecology of the fish. This study used high-resolution multi-sensor biologging tags on eight Atlantic bluefin tuna caught in the southwest of England which were monitored for 21 - 94 hours post-release. A further 12 fish were tagged with MiniPAT tags for 121 - 366 days to compare initial behavioural responses with long-term trends. Angling times ranged from 10 - 30 min, with tunas displaying a characteristic long deep dive immediately after release with duration increasing significantly with fight times. Activity, tailbeat amplitude and tailbeat frequency were respectively 2.5, 3.6 and 1.4 times greater within the first hour post-release than the subsequent 48 hours, stabilising within 6 - 8 hours. Long-term deployments revealed a suppressed behavioural state lasting 6.2 ± 6.6 days, after which fish regained high activity levels which would otherwise be missed by short deployments constrained by high sampling frequencies. Understanding how bluefin respond to fishing practices is required to mitigate the potential deleterious impact of this fisheries supporting over 800,000 anglers and ensuring its sustainability by informing best practices such as minimising fight times.

FLASH TALK ABSTRACTS

Flash talks session 1

Acoustic foraging network in African penguins

Andréa Thiebault[1,3], Alistair McInnes[2], Tegan Carpenter-Kling[2,3], Chloé Huetz[1], Lorien Pichegru[3], Katta Ludynia[4], Thierry Aubin[1], Isabelle Charrier[1]

[1]CNRS UMR 9197, Institut des Neurosciences Paris-Saclay, Université Paris-Saclay, France; [2]Seabird Conservation Programme, BirdLife South Africa, FitzPatrick Institute of African Ornithology, University of Cape Town; [3]Institute for Coastal and Marine Research, Nelson Mandela University; [4]Southern African Foundation for the Conservation of Coastal Birds & Department of Biological Sciences, University of Cape Town

African penguins *Spheniscus demersus* are Endangered seabirds endemic to Southern Africa. They feed on small pelagic fish, diving to 30m depth within 40km from the coast. They actively coordinate their feeding behaviour by herding fish in schools, and they benefit greatly from feeding in groups. The mechanisms by which they regulate these group activities remain unknown. We hypothesized that acoustic signals could play an important role for foraging coordination in these non-flying seabirds. To assess this, we deployed miniature acoustic recorders and accelerometer/depth loggers simultaneously on African penguins to study their vocal activities in relation to their three-dimensional movements (e.g. depth and prey pursuits) when foraging at sea. We confirmed the existence of three main types of sea-surface vocalisations, and revealed the existence of several types of underwater vocalisations in this species. Both sea-surface and underwater vocalisations were all produced in specific contexts along the foraging trip, suggesting specific functions. Our results revealed a complex suit of vocal cues used by African penguins when foraging at sea. They suggest the implementation of a foraging network based on acoustic signals that could have a strong bearing on their foraging efficiency.

Unlocking the full research and conservation potential of animal-tracking data through a global tag registry (TRACK)

Christian Rutz[1]

[1]Centre for Biological Diversity, School of Biology, University of St Andrews, UK

Animal-behaviour researchers are increasingly embracing the power of large-scale collaboration, as illustrated by the launch of the ManyPrimates, ManyDogs and ManyBirds consortia. While these initiatives focus on coordinating standardised tests of large numbers of study subjects, in some areas of research, the retrospective pooling of pre-existing data holds great promise. A good example are the datasets generated by animal-borne tags (bio-loggers), including high-resolution movement tracks. The COVID-19 Bio-Logging Initiative, for instance, has built a global collaborative network to study how wildlife movements changed during lockdowns, amassing tracking data for some 13,000 tagged animals across 200 species. But, just like earlier consortia, it faced a major challenge: not all animal-tracking datasets are discoverable. This problem can be solved by setting up a global tag registry that contains meta-data for tags (including tag type and settings, information on the tagged animal, and deployment date and location) as well as researchers' contact details -- but not the actual tracking data. This decoupling of information will unlock the field's full research and conservation potential in the short term, and build the trust required to routinely archive raw data in public repositories in the longer term. A multi-stakeholder group is currently forming to prepare the launch of TRACK (Tag Registry for Advancing Conservation Knowledge). doi.org/10.1038/d41586-022-02821-6

The impact of water as a resource on the space use of female East African chimpanzees (*Pan troglodytes schweinfurthii*)

Hella Péter[1], Walter John Akankwasa[2], Gal Badihi[3], David Eryenyu[2], Vincent Kizza[2], Catherine Hobaiter[2,3], Nicholas Newton-Fisher[1], Sarah Johns[1]

[1]University of Kent; [2]Budongo Conservation Field Station; [3]University of St Andrews

Space use can be impacted by several factors, like resources, the presence of conspecifics, or predation pressure. Chimpanzee communities occupy stable home ranges, but individual space use within that home range varies broadly between communities, especially for female chimpanzees, from ranging across the entire home range to strict, barely overlapping core areas. As female chimpanzees mainly compete for food to ensure high reproductive success, differing food availability between communities is one proposed reason for those differences, along with predation pressure, group composition, and subspecies. Here, we explore how another important resource - water, can impact female space use patterns in wild East African chimpanzees. We relied on camera trap videos, long term data, and GPS data from the Waibira community in Budongo, who, despite being a rainforest community, experience a seasonally recurring water shortage during dry seasons. We analysed the data to see if females in the group form core areas, whether those core areas are stable across seasons, or shift with water availability, and if a seasonal shift is present, is it driven by water availability. We discuss how our findings relate to previous research on female chimpanzee space use, as well as the implications of studying water as a resource impacting chimpanzees for conservation efforts & mitigating human-wildlife conflict.

Using telemetry to deepen knowledge of frostfish (Microgadus tomcod, punamu) movement ecology in Bay of Fundy, Nova Scotia tidal rivers

Lindsay A. Carroll[1], Darren Porter[2], Joseph Beland[3], Trevor S. Avery[1], Montana F. McLean[1], Michael J.W. Stokesbury[1]

[1]Acadia University; [2]Marine Institute of Natural and Academic Science; [3]Mi'kmaw Conservation Group

The Atlantic tomcod (Microgadus tomcod, punamu) is a gadid fish abundant in Northwest Atlantic coastal waters and is also known as “frostfish” given that it spawns further inshore during the winter months in estuaries and freshwater streams. Tomcod has been fished as a minor commercial and recreational species and has traditionally been used as a winter food source by Mi’kmaw First Nations communities throughout its range for generations. Despite its local relevance, abundance, and widespread distribution, there has been little scientific research on Atlantic tomcod ecology and movement. In this study, we tagged 186 tomcod over 2 years with acoustic transmitters to investigate their seasonal spawning migrations through coastal regions in the Bay of Fundy. Findings have identified potential areas of importance to tomcod and patterns of connectivity between regions across the basin. This research is part of a collaborative project between Mi'kmaw knowledge holders, commercial fishers, academia, community partners, government, and local stakeholders entitled Apoqnmatulti’k. Results will be used to inform management approaches and strategies for Atlantic tomcod in local regions to enable better stewardship of this culturally significant fish.

Shake, Wiggle, and Curl: How and Why Lizards Move Their Tails, Before and After Tail Autotomy

Michele A. Johnson[1], Amy A. Payne[1], Alexander G. Rodriguez[1], Ethan Bailey[1], Daisy M. Horr[1,2], E. Cabral Balreira[1]

[1]*Trinity University; [2]University of California, Berkeley*

Movements of an animal appendage may serve many functions, facilitating behaviors as varied as locomotion, social communication, combat, prey manipulation, or predator avoidance. The lizard tail is a fascinating appendage, as it can be used in these diverse contexts when attached to a lizard, but it can continue moving, often dramatically so, after it is autotomized (or, self-amputated). Many lizards autotomize their tails under the threat of

predation, such that a predator may be visually distracted by a flopping tail, or momentarily satisfied by this smaller meal, allowing the lizard itself to escape. In this study, we examined the extent to which pre-autotomy tail movements are associated with post-autotomy tail movements and the musculature that controls the tail. We studied seven lizard species that exhibit differences in tail size, energy storage in the tail, and complexity of tail movement. Preliminary analyses indicate that when faced with predation, lizard species with higher energy tails use pre-autotomy tail displays more frequently, and after autotomy, exhibit more complex tail movements. This suggests that tails that may be more valuable food sources are more effective tools for predator deterrence. Yet, these species also use tail displays more frequently in pre-autotomy social contexts, confounding our interpretation of the primary use of tail movement, and offering the opportunity for future study of potential trade-offs associated with autotomy.

Flash talks session 2

Inter-individual variation in the urban space-use by Cape chacma baboons (*Papio ursinus*)

Anna M. Bracken[1,2], Charlotte Christensen[1,3], M. Justin O'Riain[4], Gaëlle Fehlmann[5], Mark D. Holton[1], Phil W. Hopkins[1], Ines Fürtbauer[1], Andrew J. King[1]

[1]Biosciences, School of Biosciences, Geography and Physics, Faculty of Science and Engineering, Swansea University, UK; [2]School of Biodiversity, One Health and Veterinary Medicine, Graham Kerr Building, UK; [3]Department of Evolutionary Biology and Environmental Studies, University of Zürich, Switzerland; [4]Institute for Communities and Wildlife in Africa, Department of Biological Sciences, University of Cape Town, South Africa; [5]Cognitive and Cultural Ecology Group, Max Planck Institute of Animal Behaviour, Germany

Human activities have transformed the physical landscape through deforestation, the conversion of wild land to agriculture, and through urbanisation. This transformation reduces and fragments habitats and is the primary driving force of biodiversity loss worldwide. Wildlife species must adapt to human-altered landscapes or risk going extinct. Recent evidence suggests there is variation in how individuals in wild animal groups use urban space, however a complete understanding is lacking due to the difficulties in collecting whole-system data. Novel tracking technologies offer a solution to this, with the field of movement ecology increasingly being integrated into conservation efforts. Here, we examine inter-individual differences in the urban space use of a group of managed chacma baboons (*Papio ursinus*) living on the urban edge in Cape Town, South Africa, using direct observation and high-resolution GPS (1-Hz) data from 13 adult individuals. Our results revealed that management efforts focussed on curbing the movements of adult males from urban spaces (which, together with high-ranking females and their offspring, comprised the bulk of the group), allowed low-ranking, socially peripheral female baboons greater access to urban spaces. These results are useful for management in the development of more targeted strategies. I put these results into a broader context and discuss how research examining animal movement can be fundamental in understanding how wildlife respond to anthropogenic change.

What are birds looking at? A motion-capture system reveals the selective use of visual fields in freely-behaving pigeons

Fumihiro Kano[1,2], Hemal Naik[1,2,3,4,5], Göksel Keskin[6,7], Iain D. Couzin[1,2,5], Máté Nagy[2,6,7]

[1]Centre for the Advanced Study of Collective Behaviour, University of Konstanz; [2]Department of Collective Behaviour, Max-Planck Institute of Animal Behavior; [3]Department of Ecology of Animal Societies, Max-Planck Institute of Animal Behavior; [4]Computer Aided Medical Procedures, Teschnische Universiät Munchen; [5]Department of Biology, University of Konstanz; [6]MTA-ELTE Lendület Collective Behaviour Research Group, Hungarian Academy of Sciences; [7]Department of Biological Physics, Eötvös Loránd University

We used a motion-capture system to reconstruct the head-centric view, or the visual field of freely behaving pigeons, and to examine how they orient their visual fields to attention-catching visual targets. We attached small reflective markers to pigeons' heads and bodies in order to reconstruct their postures, namely their relative head and body locations and orientations, and tracked the locations of reflective markers in a motion- capture system large enough to allow pigeons to behave freely inside the system. In experiments, we tested whether pigeons orient specific locations of their visual fields, particularly retinal specializations (foveas and areas) to attention-getting objects that were presented at various relative locations. Pigeons predominantly used their retinal specializations to view a visual target, namely their foveas projecting laterally at an azimuth of ±75° into the horizon, and their visually-sensitive "red areas" projecting broadly into the lower-frontal visual field. Moreover, pigeons used their red areas to view a nearby object on the ground (e.g., grain) while they used their foveas to view any distant object. Furthermore, pigeons showed a bias to use their left and right eye when they examined different types of objects (e.g., threatening, social). Despite the known difficulty in identifying where a bird is looking, we show that it is possible to infer the visual attention of freely behaving pigeons by tracking the projections of their retinal specializations with cutting-edge methods.

Fish without borders: International tracking reveals seasonal distributions and connectivity pathways of European fishes

Jena E. Edwards[1,2], Hendrik V. Winter[2,3], Anthonie D. Buijse[2,4], Allert I. Bijleveld[1]

[1]NIOZ Royal Netherlands Institute for Sea Research, Netherlands; [2]Wageningen University & Research, GE, Netherlands; [3]Wageningen Marine Research, Netherlands.

Acoustic telemetry allows researchers to monitor both small-scale movement behaviours and large-scale migratory patterns remotely, for prolonged periods, and across regions encompassing multiple habitat types, thereby informing management and conservation approaches. We here use detection data from the European Tracking Network (ETN), an international network of independently managed acoustic arrays, to track the movements of migratory adult fishes between coastal Dutch waters, the southern North Sea, and the English Channel. Movement data from European sea bass (*n=52,* 41-75 cm LT), thicklip grey mullet (*n=13,*45-70 cm LT), and thinlip grey mullet (*n=4,* 51-56 cm LT) tagged and released in the Dutch Wadden Sea were used to demonstrate seasonal variation in large-scale distribution and regional connectivity between coastal summer foraging grounds and potential offshore overwintering sites. These findings provide a first glimpse at the full migration pathway, or 'swimway', of three large migratory species for which movement patterns at this scale have not previously been recorded using a modern telemetry approach.

Ocean nomads or island specialists? Culturally driven habitat partitioning contrasts in scale between geographically isolated sperm whale populations

Felicia Vachon[1], Taylor Hersh[2], **Luke Rendell**[3], Shane Gero[4], and Hal Whitehead[1]

[1]Department of Biology, Dalhousie University, Canada; [2]Max Planck Institute for Psycholinguistics, The Netherlands; [3]Sea Mammal Research Unit, University of St Andrews, UK; [4]Department of Biology, Carleton University, Canada

culturally segregated, social structure. While sperm whales have previously been described as 'ocean nomads', this might not be universal. We conducted surveys of sperm whales along the Lesser Antilles to document the acoustic repertoires, movements and distributions of Eastern Caribbean (EC) sperm whale cultural groups (called vocal clans). In addition to documenting a potential third vocal clan in the EC, we found strong evidence of fine-scale habitat partitioning between vocal clans with scales of horizontal movements an order of magnitude smaller than from comparable studies on Eastern Tropical Pacific sperm whales. These results suggest that sperm whales can display cultural ecological specialization and habitat partitioning on flexible spatial scales according to local conditions and broadens our perception of the ecological flexibility of the species. This study highlights the importance of incorporating multiple temporal and spatial scales to understand the impact of culture on

ecological adaptability, as well as the dangers of extrapolating results across geographical areas and cultural groups.

Investigating a body shake behaviour in *Lasius niger* and its potential role as a pathogen alarm behaviour

Rachael Brown[1], Nathalie Stroeymeyt

[1]*University of Bristol*

Group-living animals often use body movements to communicate threats to other group members. Alarm signals are just as important for social insects and can also incorporate body movements, such as vibratory alarm signals in termites. Living in densely populated colonies incurs associated costs, such as increased risk of disease transmission between colony members. Social insects have evolved a series of cooperative disease defence mechanisms to limit the risk of epidemics. It is vital for colony members to communicate a disease threat so they can mount a rapid, collective response. Here, we aim to characterise a whole-body shake in the ant *Lasius niger*, first observed in the presence of disease, and test its potential as an alarm signal. We measured the frequency and characteristics of the body shake in different sized groups of workers during controlled exposure to the entomopathogenic fungus *Metarhizium brunneum*. Workers performed significantly more body shakes when a nestmate was subject to manual stress. However, when a nestmate was exposed to pathogenic spores, the individual performed significantly more shakes. Overall, the body shake is likely to be a general alarm behaviour that increases in pathogen-exposed workers. This may provide new information on how *L. niger* workers use body movements as alarm signals, to rapidly spread disease information to nestmates for a collective response.

Flash talks session 3

Using precision technology to investigate personality and plasticity of movement in farmed calves

Francesca Occhiuto[1], Jorge Vázquez-Diosdado[1], Andrew King[2], Jasmeet Kaler[1]

[1]*University of Nottingham;* [2]*Swansea University*

Consistent differences between individuals in behaviour, known as personality, can affect individual requirements, disease susceptibility and welfare in farm animals. In addition, differences in levels of behavioural plasticity can determine how they will cope with change. Recent developments in precision livestock technologies have allowed the collection of extensive and detailed data on farm animal behaviour. We measured inter-individual variation using ultrawide band sensors that continuously recorded the location of 64 calves for the first 5 months of their life, following their move between 3 different housings. The data were analysed by fitting mixed-effects models with the individual calf as a random intercept and housing as a random slope. This allowed us to calculate how consistent calves were in their movement from the amount of variation attributed to the individual, and their level of plasticity from the slope of the model. The results showed consistent differences in average daily walked distance as the proportion of the total variation due to the individual was 0.84. There was also a high positive correlation between the intercept and slope indicating that the calves that walked more increased even more after being moved to a different housing. Overall, movement patterns in young calves are affected by their personality type and the type of housing they are in, but their personality determines how much they will be impacted by the change in housing.

3D posture tracking of bird flocks by automated annotations using machine learning and computer vision tools: towards markerless tracking in the wild

Alex H. H. Chan[1,2], Hemal Naik[2,1], Fumihiro Kano[1,2], Urs Waldmann[1], Mate Nagy[3]

[1]Center for the Advanced Study of Collective Behaviour, University of Konstanz; [2]Max Planck Institute of Animal Behaviour; [3]MTA-ELTE Lend ü let Collective Behaviour Research Group, Hungarian Academy of Sciences

Automated methods for animal posture tracking and behavioral annotations had rapidly developed in the past decade, with user-friendly frameworks being more accessible to various research fields. While these automated methods are now widely available, it is often limited to 2D-keypoint tracking from single camera views and requires a large amount of manual annotation. Here, we take advantage of our unique motion capture facility to obtain accurate 3D positions of reflective markers attached to the bodies of pigeons while they freely behave as a flock. Using both motion-capture data and multi-camera RGB images, we reconstructed the postures of pigeons from the positions of reflective markers and key morphological points (e.g. eyes, beak), which gives us automated annotations with minimal efforts of manual labelling. The method produces large amounts of training data for the postures in 2D and 3D, which can be used to train machine learning models to automatically detect 3D postures of multiple individuals. Estimating the 3D postures of birds can provide fine scaled behavioral data that would have been difficult to be observed directly; for example, one can reconstruct the visual fields of each individual and infer all individuals' attention in a flock. In the future, the framework can be expanded to applications in field settings and a range of avian species, with potential across fields, including the study of social cognition, collective foraging, social learning and more.

Do Procellariform seabirds adapt their migratory behaviour in response to climatic changes?'

Katrina R. Davies[1], Joseph Wynn[2], Patrick Lewin[1], Joe Morford[1], Lewis Fisher-Reeves[1], Paris Jaggers[1], Tim Guilford[1]

[1]University of Oxford; [2]Institut für Vogelforschung

In a changing climate, long lived migratory seabirds may be subject to varying oceanographic conditions between annual migrations. It is important to understand how populations adapt, and whether these adaptations can occur at an individual level. Miniaturised biotelemetry has allowed the development of long- term datasets of migratory movements. Manx shearwaters *(Puffinus puffinus)* are burrow nesting procellariforms with a trans-equatorial winter migration. Using a 13-year dataset from geolocator tags deployed on 243 birds at 6 colonies of Manx shearwaters, this study investigates temporal patterns in migratory behaviour. Individual flexibility in foraging location, over wintering activity and phenology are explored to see if birds can adapt to changing environmental conditions, or if behavioural shifts occur as a result of selection.

Space retention, memory capabilities and habitat fragmentation: a study on Belgian butterflies

Stefano Masier*[1]*, Matteo Marcantonio*[1]*, Mathilde Le Levier*[1]*, Caroline Nieberding*[1]*

[1]Universitée Catholique de Louvain-la-Neuve

Presently, for many species, natural undisturbed habitat is becoming more and more uncommon, replaced by fragmented, frequently disturbed patches of suitable environment in-between a hostile matrix. Populations evolving in such environments are expected to adapt to different stressors; compared to undisturbed habitats, behavioural and plastic responses are often favoured to deal with a fast-changing environment. We tested behavioural responses of females butterflies (*Gonepterix rhamni*) collected from different areas in south Belgium, by following a gradient of disturbance and fragmentation. Individuals were tested inside a fly cage (24mx24mx4m) where host plants had been previously placed, recording their flying patterns and oviposition events. Inside the cage could or could not be present social cues, in the form of tethered-flying template conspecifics, to test their influence on host choice. Several trials were performed for each individual; we also tested short- and long-term memory capabilities by repeating behavioural tests of individual that oviposited with some of

the host plants (e.g., plant where eggs were laid) covered, to evaluate if and how previous oviposition-related experiences influence successive behaviours. Over one field season we were able to test 36 individuals, with 42 oviposition events over >180 trials. Our results, albeit preliminary, aim to shed light upon how different populations perceive, memorise, and interact with the surrounding environment.

Flash talks session 4

Group living limits the energetic efficiency of movement

James A. Klarevas-Irby[1], Mina Ogino[2], Brendah Nyaguthii[3], Damien R. Farine[2]

[1]Max Planck Institute of Animal Behavior; [2]University of Zurich, Department of Evolutionary Biology and Environmental Studies; [3]Mpala Research Centre

There is a growing body of evidence showing that individuals can express energetically-efficient movement strategies—moving faster and straighter—to mitigate the costs of large-scale displacements. However, little is known about whether moving as part of a collective enhances or limits the ability for animals to express such strategies. Drawing on 6 years of population-level high-resolution (1Hz) GPS tracking of group-living vulturine guineafowl (*Acryllium vulturinum*), we detected 886 events from 94 tagged individuals where their groups made large displacements to shift their home ranges in response to changing environmental conditions. We complemented these data with 94 movement events from lone, dispersing individuals. By combining our high-resolution GPS data with laboratory models of guineafowl physiology, we find that individuals moving in groups express a significant (15.5%) reduction in their energetic cost of transport during these extreme movements, relative to their normal daily ranging behaviors. However, this was dwarfed by the energetic savings that individuals achieved when moving alone (34.9% more-efficient than individuals in groups). This effect was predominantly the result of differences in the speed and continuity of movement, with both lone and grouped individuals expressing similar increases in the straightness of movement. Overall, this study provides evidence for a substantial, and previously hidden, energetic cost arising from collective movement.

Fine-scale aerial video tracking of collective movements reveals group dynamics in Przewalski's horses

Katalin Ozogány[1,2], Viola Kerekes[3], Attila Fülöp[1,2], Zoltán Barta[1,2], Máté Nagy[4,5,6,7]

[1]ELKH-DE Behavioural Ecology Research Group, University of Debrecen, Hungary; [2]Department of Evolutionary Zoology, University of Debrecen, Hungary; [3]Hortobágy National Park Directorate, Hungary; [4]MTA-ELTE "Lendület" Collective Behaviour Research Group, Eötvös Loránd Research Network, Hungary; [5]Department of Biological Physics, Eötvös Loránd University, Hungary; [6]MTA-ELTE Statistical and Biological Physics Research Group, Eötvös Loránd Research Network, Hungary; [7]Department of Collective Behaviour, Max Planck Institute of Animal Behavior, Germany

In a moving animal group, collective movement patterns arise as a result of the interactions between the individuals, and hence are often modulated by social relations and reflect the structure of the society the animals are living in. The relationship between social structure and movement patterns is even more interesting in a multilevel society, where sub-units aggregate into larger, more complex groups. We investigated this topic in Przewalski's horses, the last extant wild horses, in the Pentezug Reserve of the Hortobágy National Park, Hungary. Przewalski's horses live in long-term stable harems which aggregate into a large herd in this reserve, forming thus a multilevel society. We observed this herd's movements by capturing 4k videos with multiple drones. To analyse collective movements, we tracked simultaneously the movement trajectories of around 240 individually identified horses on the recorded videos, in high temporal and spatial resolution. Movement observations were combined with a long-term population monitoring including records on life history and kinship relations of individuals. Analysis of movement variables revealed details about the structure and dynamics of the society. We found that aggregation of harems is related to male and

female sibling relationships and the history the individuals share as former harem mates. Furthermore, movement variables may also predict member transfer between the harems in the future.

Motion Capture Energetic Performance of Avian Movements

Katherine R. S. Snell[1], Mathias Günther[2], Lara Keicher[1], Jesko Partecke[1], Martin Wikelski[1]

[1]Max Planck Institute of Animal Behavior; [2]University of Konstanz

The integration of biomechanics, energetics and behavioural ecology necessitates a formal understanding of the animal's movement. We quantified the trajectories of the common blackbird *Turdus merula* in 3D space at 100Hz with simultaneous heart rate recordings, to directly attribute the energetic requirements to typical behaviours. Harnessing 'Optical Motion Capture' technology we tracked birds continuously in a large flight aviary, equipped with perches and a foraging area to replicate and capture multiple behaviours highly conserved in the wild. Birds were marked with reflective spheres to obtain body and head orientation and wing-tips motion, to quantify behaviours, flight trajectories and wingbeat frequency. By incorporating the multiple sensing streams of precise 3D movements and heart muscle electrical potential we are able to quantify energetic load concurrently. Utilising this state-of-the-art technological framework, we aim to understand the energetic demands of life history events of a passerine at high resolution. We can partition energetic costs of known behaviours, including foraging, resting, roosting, and the flight modes that occupies the vast majority of a typical passerines' budget. While it is impossible to study migratory flight under laboratory conditions, this behavior only occurs for a few nights each year. Here we can investigate numerous ecologically important flights: prospecting, conspecific interactions, predator avoidance and the energetically expensive take-off phase.

Information content in bottlenose dolphin whistles during a cooperative task

Mackenzie Meier[1], Pernille M. Sørensen[1], Abigail Haddock[2], Emily Guarino[2], Kelly Jaakkola[2], Stephanie L. King[1]

[1]School of Biological Sciences, University of Bristol, UK; [2]Dolphin Research Center, Grassy Key, USA

A select number of species have demonstrated the recognition of their partner's role, referred to as actively coordinated collaboration, when performing cooperative behaviour. Yet, there is a lack of data on the underlying mechanism(s) of collaboration in nonhuman species. Bottlenose dolphins are known to actively coordinate cooperation with a partner and rely on vocal communication to mediate social relationships and maintain group cohesion. We previously demonstrated that common bottlenose dolphins can use vocal signals to aid success in a cooperative button pressing task. Here, we further analysed acoustic patterns of whistle type use. With acoustic data from hydrophone arrays, and sound-and-movement recording tags (DTAG3) attached to each dolphin, we demonstrate how the vocal information shared changes as a result of animal location, behaviour, and stage of the cooperative task. Additionally, we explore how whistle exchanges enable precise coordination. This study will lead to a more comprehensive understanding of vocally mediated behavioural coordination in dolphins, thereby adding to our understanding of cooperation facilitated via vocal communication in the animal kingdom.

Multimodal, high-throughput measurement of behaviour and interactions in animal collectives

Máté Nagy[1,2,3,4,5,6], Hemal Naik[1,2,3,7], Fumihiro Kano[1,2,3], Nora Carlson[1,2,3,8], Jens C. Koblitz[1,2,3], Martin Wikelski[2,9], Iain D. Couzin[1,2,3]

[1]Department of Collective Behaviour, Max-Planck Institute of Animal Behavior, Germany; [2]Centre for the Advanced Study of Collective Behaviour, University of Konstanz, Germany; [3]Department of Biology, University of Konstanz, Germany; [4]MTA-ELTE "Lendület" Collective Behaviour Research Group, Hungarian Academy of Sciences, Hungary; [5]MTA-ELTE Statistical and Biological Physics

Research Group, Eötvös Loránd Research Network, Hungary; [6]Department of Biological Physics, Eötvös Loránd University, Hungary; [7]Department of Ecology of Animal Societies, Max-Planck Institute of Animal Behavior, Konstanz, Germany; [8]Department of Zoology, Graduate School of Science, Kyoto University, Kyoto, Japan; [9]Department of Migration, Max Planck Institute of Animal Behavior, Radolfzell, Germany

We developed a new instrument (SMART-BARN) to study groups of animals in a large spatial environment, which allows researchers to measure naturally-occurring complex behaviour, communication, and interactions through multiple information channels. It consists of a 3D environment (14.7x6.6x3.8 m3, housed in a barn), where up to 100 individuals can be tracked simultaneously. With quasi real-time measurement capabilities, it also allows for closed-loop experiments (e.g., automated recognition of a behaviour triggers changes in the environment). While most parts of the system already exist separately (with some being commercially available), we combined them in unique ways in order to meet the needs of experiments on group living animals such as arthropods, birds, and mammals (including humans). The key advantages of our system come from the synergy of multiple measurement techniques including: motion capture, acoustic imaging, computer vision-based automated behavioural recognition, and computer- controlled interactive units (including food dispensers and animal-born vibration signaling devices). In this presentation, we show the potential of this type of system through proof-of-concept case studies which were carried out on groups of pigeons and starlings, and hope that this presentation fosters new collaborations and novel applications for the usage of this unique instrument.

POSTER ABSTRACTS

(1) Explorative behaviour of naïve herring gulls in complex and variable environments

Reinoud Allaert[1], June Heene[1], Luc Lens[1], Frederick Verbruggen[1]

[1]Ghent University

The ability to alter a behaviour that is unlikely to be rewarded, is generally regarded as beneficial. In thisrespect, Optimal Foraging Theory predicts that individuals will stop exploiting one foraging area and switchto another if this either increases their net energy gain or reduces the time spent obtaining a fixed amount ofenergy. Herring gulls (*Larus argentatus*) are known to exhibit such behavioural flexibility but with strongindividual variation. For example, some but not all urban Herring gulls are known to match their foragingbehaviour with the timing of school breaks and waste centre closures. Being able to respond flexibly tochanges in the environment can have a positive effect on fitness, especially in complex and variable environments. Here we remotely test explorative behaviour in juvenile Herring gulls along part of the NorthSea coast. For this purpose, we raised 80 individuals from egg to fledgling. When the birds were ca. threeweeks old, they were subjected to a series of cognitive and behavioural lab tests broadly related to stop-change behaviour. After ca. six weeks, 60 individuals with known cognitive profile were fitted with a GPStracker and released into a nearby nature reserve. Using high-resolution tracking data in combination withfield observations, we attempt to quantify variation in explorative behaviour in a fine-grained mosaic ofmarine, agricultural and urban habitats and relate this to early-life survival.

(2) Using biologgers to understand the fertility gap in Pekin ducks

Cammy Beyts[1], Anne Rae[2], Andreas Kranis[1], Kellie Watson[1]

[1]The Roslin Institute and R(D)SVS, University of Edinburgh, UK, [2]Cherry Valley Farms, UK;

Within the commercial duck industry, there is a demand for day-old chicks. Whilst females can lay up to one egg per day, many of these will be infertile, so understanding the factors which may increase fertility rates is of great economic concern. Despite the commercial importance, very little is known about the reproductive behaviour of commercial ducks. Using ultra wideband technology, we collected positional and accelerometer data from tags attached to the legs of 37 breeding ducks (29 males, 8 females) over a 12-week period. Malesand females were freely allowed to interact and mate during this period. Every 2 weeks, we incubated the eggs laid and used genomic DNA to assign the parentage of each hatched chick. This enabled us to determine the activity and reproductive output of every tagged individual. Individuals differed from each other in the average distance they travelled each day but were highly consistent in their movements day today, making duck activity highly repeatable ($R = 0.68$, $p = <0.001$). Males sired on average 21.4 (SD ± 22.3) chicks each over 12 weeks but varied in their reproductive success, with the top three males siring 40% of the total number of chicks. We discuss the relationship between individual activity and other distance-based metrics with reproductive success and its implications for commercial breeding programmes.

(3) Migratory physiology in a changing world: Linking individual eco-physiology to lifetime fitness in a long-distance migratory bird, the Alpine swift.

Alex Brighten[1], Thomas Bodey[1], Pierre Bize[2], Ana Payo-payo[1]

[1]University of Aberdeen; [2]Swiss Ornithological Institute

Migratory birds experience a range of conditions and threats across their annual cycles, including unpredictable weather conditions and resource fluctuations. With ongoing global anthropogenic change, these pressures are predicted to increase. However, whole life cycle studies remain challenging, particularly for species with extreme life histories. Advances in biologging technology have enhanced our understanding but, importantly, have also revealed

significant individual variation in strategies, suggesting a potential central role for carry-over effects. However, we currently know little about how such individual-level differences can drive variation in key life-history metrics including survival and reproduction. We will utilize a multi-decadal dataset on the Alpine swift *Tachymarptis melba*, that includes life-history, tracking, and physiological data to investigate the role of carry-over effects from movement strategies and dietary variation on survival and reproductive success in the context of both changing prey availability and an increasingly unpredictable climate.

(4) Biomechanics of grey squirrel (*Sciurus carolinensis*) movement

Yavanna Burnham[1], Robbie McDonald[1], Geoff Goss[2], Eugene Starostin[2], Lisa Leaver[1], Rebecca Cummins[1], Amelia Southern[1], Paige Hare[2], Andrea Byekwaso[2]

[1]University of Exeter; [2]London South Bank University

Arboreal animals, including tree squirrels, must successfully cross gaps in the canopy to evade predation. Previous work indicates that heavier individuals may be at an enhanced risk of predation, with greater substrate deflection resulting in a reduced jump distance and speed. Yet, for tree squirrels, a higher mass maybe crucial for winter survival, providing the animal with sufficient fat reserves when resources are scarce. Thus, squirrels may incur a trade-off between successful predator evasion and winter survival. To explore this potential trade-off, we investigated whether an increased mass impaired measures of jump performance in grey squirrels. We filmed squirrels of varying weights jumping from a platform to a feeder set at different distances and analysed video footage to obtain measures of jump performance, including maximum height, take-off angle, and velocity magnitude. We observed that heavier squirrels showed the greatest increase in both maximum height and velocity with an increase in distance to the feeder. Squirrels of an average mass possessed the highest rate of jump success, suggesting they possess the optimal physiology for jump performance. Our results indicate that mass differentially effects measures of jump performance at varying distances. Further work simulating predation risk will help explore how this variation may influence escape success and indicate whether squirrels truly do face a trade-off between predator evasion and winter survival.

(5) Size difference in winter foraging area between resident and long distance Trans-Saharan migrant Lesser Kestrels (*Falco naumanni*) of the same population.

David Ramón-Martínez[1], Lina López-Ricaurte[1], Carlos Marfil[1], Ricardo García-Martínez[1], Daniel García-Silveira[1], Jesús Hernández-Pliego[2], Juan José Negro[1], José Prenda[3], **Javier Bustamante**[1]

[1]Estación Biológica de Doñana, Consejo Superior de Investigaciones Científicas (CSIC), Sevilla, Spain; [2]Independent Researcher, Sevilla, Spain; [3]Dpto. de Ciencias Integradas. University of Huelva, Huelva, Spain

During the breeding season, birds behave as central place foragers and their movements tend to be restricted to the proximity of the nest. This is not true for the non-breeding season when birds can move freely following resource abundance. During this period, the food resources are generally scarcer and more dispersed, and there's no need to return to the nest. Lesser Kestrels (*Falco naumann*i Fleischer, 1818) from the breeding population of the southwestern Europe perform two different migratory strategies. Some Individuals are long distance migrants that travel to their wintering grounds in the Sahel whereas other individuals remain near their breeding grounds. In this study we compare the size of the foraging areas between non-migratory and long-distance migratory Lesser Kestrels of the same population. We hypothesize the existence of a trade-off between the costs of performing a long-distance migration and the benefits of spending the non-breeding period in more productive areas. Thus, we expect that non-migratory LesserKestrels should use larger foraging areas than those wintering in the Sahel, in order to fulfill their energetic requirements. For this purpose, we tagged non-migratory individuals during winter and migratory individuals during the breeding season with NanoFix-GEO+ RF loggers (Pathtrack) at Doñana National Park

(Andalusia, Spain). We performed Generalized Linear Mixed Models (GLMM) in order to compare daily foraging areas between both strategies, controlling also for possible differences among sexes.

(6) Investigating the impacts of acoustic noise on group dynamics in guppies (*Poecillia reticulata*)

Molly A Clark[1], Andrew N Radford[1], Steve D Simpson[1], Christos C Ioannou[1]

[1]University of Bristol

Group-living has essential fitness benefits for many species. A central component of group-living is how decisions are made in a social context, which can be altered by individual states and environmental context. Anthropogenic impacts can alter environmental conditions, reducing access to information and signals used for effective group decision-making. Anthropogenic noise pollution is a growing concern, particularly in aquatic environments, due its impact on accessing information. In this study, we assess how acoustic noise impacts the group decision-making, cohesion and activity of fish shoals, using Trinidadian guppies (*Poecilia reticulata*). Individual movements within a radially-symmetric five-armed maze were measured using high resolution trajectory data from video tracking software. The behaviour of groups with and without continuous acoustic white noise were measured over a four-day testing period in a repeated measures design. We found no change in individuals swimming speed, exploration or group cohesion with additional noise. Agreater proportion of the moves were leadership attempts in the added noise treatment, which was due to there being more following events in the noise treatment than the control, rather than there being more leadership attempts. These results provide novel evidence for how anthropogenic noise can alter decision-making dynamics in fish shoals, even when group cohesion and activity remain consistent.

(7) Effects of early-life conditions on age-related flight performance in *Nicrophorus vespilloides*

Kynan Delaney[1], Jacob Moorad[1]

[1]University of Edinburgh

Flight is vital in wild burying beetle populations for dispersal, foraging, and gaining timely access to locally scarce resources required for reproduction. Flight performance encompasses many traits, and these components (the ability to fly faster, further, more often, etc.) may each be sensitive to individual quality, age, or morphology. While it is understood that early-life conditions are important in generating variation in body size and individual quality, how this may affect the many compound traits involved in flight is unclear. Our understanding of the relationship between early-life conditions and late-life outcomes is particularly lacking in the context of age-related functional declines. We manipulated early-life conditions through adjusting food availability to explore the role early-life-environments play in shaping the lifetime trajectories of several flight traits. Individuals from higher quality early-life environment exhibited superior peak flight-speed than those from poor early-life environments. Across treatments, peak flight speed was seen to decline only in the oldest-aged beetles. Beetles were less likely to engage in flight at increasing ages, but no accompanying decrease in time spent in flight was detected. This suggests that early-life conditions can play a role in shaping aspects of flight, but we lack evidence to suggest that these contribute to variation in the ageing of flight performance.

(8) The spatial energetics of male Indian peafowl.

Lewis Fisher-Reeves[1,2], Hannah J. Williams[3], Gemma Johns[1], Mark D. Holton[1], Luca Börger[1], Kayleigh Rose[1]

[1]Swansea University, [2]University of Oxford, [3]Max Planck Institute of Animal Behaviour

Animals must choose to spend their energy wisely. They often invest significant portions of their energetic budgets into behaviours that promote their survival and reproduction, but where these behaviours take place can also be crucial to their success. The importance of spatial preferences in energetic expenditure are particularly exemplified in lekking birds, where males must defend territories, termed display courts, during the breeding season, whilst also conducting exaggerated displays in an attempt to attract a mate. Here, using advanced biologging data (accelerometry, magnetometry, and GPS) from Indian peafowl, we show that lekking males invest significantly more time and energy into their display courts than comparatively across their home ranges, and find that the presence of rival males within these areas influences these spatial preferences. This study demonstrates the use of coupled GPS and tri-axial accelerometers for quantifyingmovement-related energy expenditure and behavioural performance across spatial scales.

(9) Movements by young male African elephants during natal family dispersal

Vicki Fishlock[1,3], Norah Njiraini[1], Catherine Sayialel[1], Cynthia Moss[1], Joseph Mukeka[2], Shadrack Ngene[2], Patrick Omondi[2], Phyllis Lee[1,4]

[1]Amboseli Elephant Research Project, Amboseli Trust for Elephants, Nairobi, Kenya; [2]Wildlife Research & Training Institute, Naivasha, Kenya; [3]Centre for Ecology & Conservation, University of Exeter, Exeter, UK, [4]University of Stirling, Stirling, Scotland, UK

Elephant ranging varies between individuals, sexes and seasons, and movements represent social and ecological strategies developed over decades. In rapidly changing landscapes movements indicate areas of pressure at the human-elephant interface. Male elephants disperse from natal families between 8-15 years old and spend several years developing distinct ranging strategies. Their dispersal is poorly understood but is a critical phase to future reproductive success – the choices males make during dispersal affect survival, growth and learning prior to reproductive opportunities from their 30s onwards. We collared eight males of known age and family history in Amboseli, Kenya in 2019 and present their movements over three years as a function of socio ecological parameters, including family size and number of peers. We examine overlap with family ranging, and the area used by young male elephants during this life history phase and link it to patterns observed from 611 males known to disperse since 1972. Each collared male is finding an individual path through the social and ecological landscape. Only one male continues to overlap in range with his natal family, one is largely settled in a small but productive area, four continue marked exploratory movements across the 8000 km2 ecosystem and into neighbouring landscapes. These long-distance movements facilitate genetic connectivity between neighbouring populations, and across international borders.

(10) I'm coming home! Evidence of homing capabilities within a highly anthropized landscape by the brown bear (*Ursus arctos*)

Lorenzo Frangini[1], Marcello Franchini[1], Andrea Madinelli[1], Stefano Pesaro[1], Andrea Vendramin[2], Sara Vezzaro[2], Francesca Davoli[3], Ettore Randi[4], Stefano Filacorda[1]

[1]Department of Agri-Food, Environmental and Animal Sciences, University of Udine, Italy; [2]Il Villaggio degli Orsi, Stupizza, Pulfero, Italy; [3]Unit for Conservation Genetics (BIO-CGE), Department for the Monitoring and Protection of the Environment and for Biodiversity Conservation, Italian Institute for Environmental Protection and Research (ISPRA), Ozzano dell'Emilia, Bologna, Italy; [4]Department of Chemistry and Bioscience, Aalborg University, Aalborg, Denmark.

Homing is the ability of an animal to navigate towards an original location through unfamiliar areas. Despite In Europe brown bear avoid highly anthropized areas, under specific scenarios (e.g., dispersal), it may show homing capabilities toward human dominated landscapes. To describe such behaviour, we used as a case study the movement patterns of a brown bear captured and fitted with a GPS collar in NE Italy. After collar removal, we monitored it opportunistically within the Padania plain through genetic sampling and direct sightings. Bear identity was confirmed by PCR amplification of 15 autosomal microsatellite loci. To describe the homing capabilities, we compared landcover (LC) types occurred during

telemetry monitoring with those observed during lowland displacements. We calculated the percentage of LC types within the utilization distributions (UD) estimated through Brownian bridge models and along a buffered area around the empirical pathway obtained from opportunistic data. The main LC types within UD were represented by natural areas (93.6%), meanwhile along the straight line of 82 km within the plain the bear crossed agricultural areas (73.2%), urban (12.2%) and natural areas (10.9%). Reasons ahead of this behaviour may be linked to the return to native area within Slovenian population. We showed that even bears may cross highly anthropized areas during their displacements, highlighting the importance of studying such phenomena, even in terms of public safety (i.e., road accidents).

(11) Exploring group fissions in wild vervet monkeys

Miguel Gareta Garcia, Charlotte Canteloup, Andres Quiñones, Redouan Bshary, Erica Van der Waal, Alecia J. Carter

University of Neuchatel

Group living allows to avoid predation, outcompete neighbouring groups and defend territories. Characteristic tradeoffs emanate from group living, like within-group competition for resources. Studies on different taxa reveal the linkage of ecological constraints and group fissions, although how fissions unfold remains poorly known. Here, we study adult female vervet monkeys (philopatric sex) of three wild groupsbefore they fissioned amid a severe drought in South Africa. We use a mixed approach of specific hypotheses and exploratory research to unveil if early identifiable signs of individual/group cohesion deterioration pave the way for fissions using two years of data spaced in time windows. The analysis of activity budgets exposes different patterns of change in feeding, resting, and social behaviours and group spread in the three groups. Also, female-female grooming increased close to the fission. The evaluation of whether the female adopted risk-prone (leaving their natal group) or risk-averse (staying in the group) strategies suggests that females having experienced the death of a close kin member were associated with the leaving option. Finally, all female dyads that groomed over 50% of the time windows we studied and were kin remained together, independently of the strategy. This study offers insights into the heterogeneity of the fission phenomenon in female-bonded groups suggesting that different groups may respond differently to tipping points and that grooming and kinship may facilitate assortment processes.

(12) Connecting feeding behavior, diet, and movement of dunlins (*Calidris alpina*) in the Dutch wadden sea

Evy Gobbens[1]; Janna van Burik[1], Christine E. Beardsworth[1], Allert I. Bijleveld[1]

[1]*Royal Netherlands Institute for Sea Research (NIOZ)*

Understanding the relationship between the diet of an animal and its spatial habitat use is essential to predicting current and future population distributions. Dunlins (*Calidris alpina*) are the most abundant wader species in the Dutch Wadden Sea, yet little is known about their diet and preferred habitat. We recorded foraging behaviors of individual dunlins on the mudflats of the Western Wadden Sea and collected faeces of the same individuals from August until November. Videos will be analyzed for different foraging behaviors and prey intake success rates while faeces will be used to carry out DNA metabarcoding and microscopic analysis to identify prey species. Additionally, we equipped 34 dunlins with lightweight (~1.3 gram) ATLAStags to identify important foraging areas. This paper aims to identify dunlin foraging hotspots in the DutchWadden Sea, by combining data on foraging behavior, relative prey abundance in faeces, and movement.

(13) Landscape energetics in the Carneddau feral ponies: contrasting strategies in home range use and foraging paths in a heterogenous landscape.

Jessica Granweiler[1], Susanne Shultz[1]

[1]*The University of Manchester*

Heterogeneity of land surfaces creates a gradient of high and low energetic costs for individuals travelling across a landscape, shaping species' movement and space use. The Carneddau ponies, a wild population in the Welsh mountains, range from flat plateaus to high ridges. GPS points were recorded during 3-hour follows. To assess differences in habitat use and locomotion due to topography, we considered space use within groups' home ranges and path choice. More specifically, point locations, path length, sinuosity and associated energetic cost were compared across groups and topographic properties. Moreover, behaviour time-budgets and metabolic rate, through faecal hormones concentrations were considered. Groups strongly differed in home range use, with some groups foraging at random while other preferred, or avoided, areas with strong elevation and slope incline. Moreover, groups foraging on higher ridges moved shorter distances but did not incur a greater energetic cost per meter travelled compared to groups residing in flatter grasslands. Overall, individuals moved less and rested more at higher elevation, and when the terrain was more rugged. No differences in metabolic rate were found between groups in high ridges and flat plains. These results suggest behavioural flexibility from each group to optimise space use within their home range,where knowledge of local topography enabled travel in a heterogeneous landscape, without suffering from predicted energetic costs.

(14) Moving prey = tastier prey? A study on common wall lizards' preference

Bianca Guadin[1], Andrea Gazzola[1], Edoardo Bello[1], Daniele Pellitteri-Rosa[1]

[1]*Department of Earth and Environmental Sciences, University of Pavia, Pavia, Italy*

Prey mobility influences predators' behaviour: a moving animal is more visible, and thus more approachable by a predator, rather than an immobile prey. Previous studies on amphibians and reptiles discovered that retinal neurons show a bias in responding to specific patterns of prey movement, velocity and orientation. In Addition, different species show different preferences and abilities to attack moving rather than immobileprey, or fast rather than slow prey. Overall, a clear preference for moving prey has been identified in the majority of the analysed species. In our study, we tested whether the common wall lizard (*Podarcis muralis*),a vision-oriented lacertid lizard, prefers moving *Tenebrio molitor* mealworms rather than still ones, by following two different experimental approaches: the "wire method", where each subject had to make a quick choice between a single moving or still worm; and the "box method", where we observed for 20 minutes each subject's interaction with two small boxes full of moving or still worms, kept at opposite sides of the arena. Our results showed that lizards, in both situations, had a clear tendency to choose the moving prey in comparison to the still one. In addition, in the wire method lizards did not show any bias for a particular side of the arena, ruling out the presence of lateralization.

(15) Wind and oceanography effects on movement decisions and foraging energetics in Manx shearwaters at two colonies in the Irish Sea

Stephanie Harris[1], Charles Bishop[1], Paul Fernandes[2], Tim Guilford[3], Patrick Lewin[3], Oliver Padget[3], Peter Robins[1], James Waggitt[1], Sophie Wilmes[1], Line Cordes[1]

[1]*Bangor University;* [2]*Heriot-Watt University,* [3]*University of Oxford*

Foraging animals are expected to make movement decisions which maximise their net energetic intake, and their ability to do so is often regulated by variation in environmental conditions. Many marine top predators must navigate dynamic fluid media (e.g. wind, currents) when foraging, and target predictable foraging areas associated with oceanographic features, such as tidal mixing fronts. The movements of many such marine predators, including breeding seabirds, are constrained by the need to return to the breeding colony, and it is not fully understood how such animals minimise energetic costs while navigating dynamic windscapes. We simultaneously tracked Manx shearwaters (*Puffinus puffinus*) breeding at two colonies in the Irish Sea, on opposing sides of the same windscape. Here, making use of the quasi-experimental conditions of our study design, we combine

shearwater tracking data with oceanographic and meteorological data to assess how dynamic winds and oceanographic characteristics influence movement decisions and foraging energetics. Our results have implications for understanding the mechanisms underpinning marine predator movements and space use.

(16) Virtual prey with Lévy motion are preferentially attacked by predatory fish

Christos C. Ioannou[1], Luis Arrochela Braga Carvalho[1], Chessy Budleigh[1], Graeme D. Ruxton[2]

[1]School of Biological Sciences, University of Bristol, Bristol, UK; [2]School of Biology, University of St Andrews, St Andrews, UK

Of widespread interest in animal behaviour and ecology is how animals search their environment for resources, and whether these search strategies are optimal. However, movement also affects predation risk through effects on encounter rates, the conspicuousness of prey, and the success of attacks. Here we use predatory fish attacking a simulation of virtual prey to test whether predation risk is associated with movement behaviour. Despite often being demonstrated to be a more efficient strategy for finding resources such as food, we find that prey displaying Lévy motion are twice as likely to be targeted by predators than prey utilising Brownian motion. This can be explained by the predators, at the moment of the attack, preferentially targeting prey that were moving with straighter trajectories rather than prey that were turning more. Our results emphasise that costs of predation risk need to be considered alongside the foraging benefits when comparing different movement strategies.

(17) How crows view the world: Using a motion-capture system to study the gaze behavior of large-billed crow

Akihiro Itahara[1], Fumihiro Kano[2,3]

[1]Kyoto University; [2]University of Konstanz; [3]Max-Planck Institute of Animal Behavior

Previous studies have examined the visual system and behaviors of corvids (Corvidae) from the perspective of cognition (e.g., gaze-following, theory of mind), ecology (e.g., vigilance), and both (e.g., tool use). However, due to the lack of relevant technologies, little is known about how those birds orient their visual fields to a visual target in a 3D space. This study addressed this question in large-billed crows (Corvus macrorhynchos) by first identifying their visual field configuration using an established ophthalmoscopic reflex technique (Study 1) and then examining how freely-moving crows orient their visual field to an attention-getting visual target in a motion-capture system (Study 2). In Study 1, we found that this species of crow has a relatively large binocular field, as also found in other corvid species. In Study 2, we developed a motion-capture-based system to reconstruct and the visual field of crows and track their head movements while they are presented with various attention-getting visual targets. Crows mainly used their binocular fields, especially around their eye-beak line when visual targets were moving in space. When the visual targets became static, crows then frequently used their non-binocular frontal fields, especially around their optic axes, preferentially on their right. Relatively large binocular overlap and frequent use of the binocular fields in this species suggest that their binocular field is optimized for visual tracking of objects, even those objects moving at a distance. Our system can be utilized in future studies not only to study the visual strategy during object manipulation (e.g., tool use) but also to study the socio-cognitive behaviors of crows during free conspecific interactions.

(18) Black Guillemot (*Cepphus grylle*) foraging and diving behaviour in relation to Marine Protected Areas

Daniel T. Johnston[1], Elizabeth A. Masden[2], Katherine A. Booth Jones[1], Tom J. Evans[3], Rich J. Howells[4], Elizabeth M. Humphreys[1]

[1]British Trust for Ornithology; [2]Environmental Research Institute, University of the Highlands and Islands; [3]Royal Society for the Protection of Birds; [4]Marine Scotland Science

The Black Guillemot (*Cepphus grylle*), is the only UK seabird included as a feature of the Marine Protected Areas (MPAs) network as it does not qualify as a Special Protection Area (SPA) feature. Currently little is known about the habitat use and movement ecology of Black Guillemots and addressing these gaps is essential to the conservation management and protection of this species. We present novel tracking of breeding Black Guillemots using GPS and TDR tags conducted to quantify distribution and habitat use in Northern Ireland. This knowledge will be used to inform cross-border MPAmanagement plans for the region. Through the combination of GPS/TDR records, maximum dive depth were observed to correspond with seafloor depth profiles, indicating benthic foraging behaviour. Habitat characteristics associated with foraging were often found to be individual- or colony-specific. Inter-individual variation was most frequently seen to relate to tidal currents and benthic substrate. Overall birds forage within the shallow circalittoral zone (<30m), despite greater depths being available. We discuss how these novel insights into Black Guillemot foraging ecology may be applied to MPA management. Wehighlight the how this research improves current understanding of fine scale habitat use in benthic foraging seabirds. This work was part of the Marine Protected Areas Management and Monitoring Project (MarPAMM) supported by EU's INTERREG VA Programme, managed by Special EU Programmes Body.

(19) Nest complexity reflects individual worker behavior of termites

Kensei Kikuchi[1], Nobuaki Mizumoto[1]

[1]Okinawa Institute of Science and Technology

Termite nests are complex group-level patterns created by collective building. The complexity of nested structures can be largely variable across termite species. As living nest structure influences inter-individual interactions and collective behavior, individual-level behavior should be adjusted to the species-specific nesting environments. However, it remains unknown how innate individual behavior can be variable across termite species. Here we show that movement of termite workers is strongly correlated with their nesting strategy. Our observation in a petri dish arena revealed that one-piece nesting termites, whose colony life is completed within a single piece of wood that serves as both their nest and food source, moved less distance than multiple-piece nesters or separate-piece nesters, who come out of their nests and forages beyond single food source. We further fitted truncated power-law and stretched exponential models to the distribution of move/pause durations and found that movements of one-piece nesters are not limited by confined space. In contrast, those of multiple-piece nesters or separate-piece nesters were bounded, suggesting that the latter could travel larger space within a limited time. Further investigation on a larger number of species and on more complex social contexts could provide the evolutionary relationship between nesting structures and collective behavior in termites.

(20) Scale-dependency in movement modelling: Benefits of a multiscale perspective

Megan Laxton[1], Juha Heikkinen[2], Jouko Kumpula[2], Janine Illian[1]

[1]University of Glasgow; [2]Natural Resources Institute Finland (LUKE)

Animals with high levels of cognition make movement decisions at multiple spatial and temporal scales. For example, the extent and grain of environmental variables affecting the direction of an animal's long-term movement trajectory (e.g., dispersal, migration) will differ from the resolution of variables affecting hourly movement decisions (e.g., local foraging). Incorporating multiple scales into habitat preference models can allow for different windows of insight into the movement system as a whole. In this presentation, I will investigate the habitat preferences of a semi-domesticated population of reindeer (*Rangifer tarandus*) in the Oraniemi herding district of Finnish Lapland. I will explore the reindeer's relationship with several spatial land-use covariates. Modelling is carried out in the R-INLA framework using GPS-telemetry data from 105 individuals. I will also discuss future work which extends the

models used to a hierarchical, nested, multiscale modelling framework. By modelling resource selection at multiple spatial scales, we may be able to reveal scale-dependencies in habitat preference which alter wildlife management decisions.

(21) The biomechanics of jumping in Grey squirrels

Lisa Leaver[1], Rebecca Cummins[1], Yavanna Burnham[1], Geoff Goss[1], Dominic Farris[1], Geoff Goss[2]

[1]University of Exeter, [2]London Southbank University

Grey squirrels are well known for their ability to jump across the tree canopy in order to travel safely and to escape predators, but their agility has not been studied in any detail. In this talk, I will outline a collaborative research programme we have developed using a broad perspective across psychology, engineering and sport science to generate a series of kinetic and behavioural predictions about everyday jump efficiency (as opposed to peak performance measures) in grey squirrels (*Sciurus carolinensis*). We have measured jumping in a variety of contexts where we varied substrate flexibility, jump distance and target size. I will give a snapshot of the process starting with an outline of the methods that we have developed to measure jump characteristics such as trajectory, work and mass-specific power from diving boards and a force plate in free-living squirrels with a focus on some of the challenges we have faced in the field. I will discuss some preliminary data on squirrel jumping techniques as well as considering the role of body weight in jump efficiency.

(22) Beyond bearings: complex navigational strategies in shearwaters

Patrick Lewin[1], Oliver Padget[1], Tim Guilford[1]

[1]Department of Biology, University of Oxford

After foraging hundreds of kilometres from the colony, shearwaters orient homewards with remarkable accuracy. Experiments have revealed that birds and other animals may use magnetic and olfactory cues as part of a map, to estimate their bearing to a goal. However, experimental approaches have limited potential to investigate the cognitive strategies animals employ during natural navigation. In contrast, previous GPS-tracking studies of free-flying shearwaters show that they appear to estimate the distance and direction home after foraging trips, even when intervening landmasses block the beeline route, suggesting that they use an extrapolated gradient map to estimate their position relative to the colony. Nonetheless, gradient maps represent just a single navigational mechanism, one which can only be used to estimate the beeline route. There are numerous sources of information available to homing shearwaters which might be used to improve route efficiency, reduce navigational uncertainty and negotiate obstacles. Such information might be derived from the outward journey, familiar landmarks or an approximate map of large landmasses. Yet we have no understanding of how such information is used during homing. Drawing upon over a decade's worth of GPStracks, collected during the natural foraging trips of Manx shearwaters, we investigated whether shearwater use information provided by large landmasses, prominent landmarks and their outward journeys to find their way home.

(23) Cognitive abilities of migrating European eels

Tyrone Lucon-Xiccato[1], Gaia De Russi[1], Mattia Lanzoni[2], Bertolucci Cristiano[1], Giuseppe Castaldelli[2]

[1]Department of Life Sciences and Biotechnology, [2]University of Ferrara; Department of Environment and Prevention Sciences, University of Ferrara

European eels (*Anguilla anguilla*) are catadromous fish that undergo an astonishing 1-year migration at the larval stage, from the Sargasso Sea to the European coasts, followed by an upstream migration in the freshwater environment. Evidence suggests that simple sensory mechanisms like rheotaxis and salinity preference control the oceanic migration; yet, eels

might arguably require more complex behaviour once in the freshwater phase. We asked whether eels are already equipped with complex cognitive abilities when they begin their freshwater journey. We collected migrating eels at the entrance of the river Po in Italy and we assessed their spatial learning, problem solving, and quantity discrimination abilities. Eels learned the route of a T-maze spatial task relatively quickly, although not at the level of other teleost fish. When presented with a problem-solving task (i.e., removing an obstacle to reach a prey), eels showed an excellent performance, although with a certain inter-individual variation. Last, if presented with two different-sizedprey, eels selected the larger prey, suggesting efficient quantity discrimination abilities. Interestingly, spatial learning and problem-solving performance of individual eels covaried, indicating a cognitive syndrome. Overall, our findings suggest that eels might be 'cognitively ready' to the demands of freshwater habitats as soon as they entered them.

(24) Habitat fragmentation affects the spatial behaviour of the Wood White

Matteo Marcantonio[1], Mathilde Le Levier[1], Stefano Masier[1], Caroline Nieberding[1]

[1]Biodiversity Research Centre - Earth and Life Institute, University of Louvain

Solid spatial orientation skills are essential for animals to move successfully. Female butterflies need to locate host plants efficiently; immature stages are indeed unable to move far from the hatching site. The Orientation skills of adult butterflies should align with the spatial characteristics of the local environment to adequately allocate energies among life history traits. Environmental changes degrade natural habitats, chiefly through fragmentation that progressively increases edges and isolates the remaining habitat patches. Thus, butterflies from habitats with different levels of fragmentation are expected to have altered orientation behaviours and life history traits. Here, we quantified the orientation behaviours of *Leptidea sinapis* originating from areas with different fragmentation in Belgium. These butterflies have limited dispersal capacity, and are thus particularly impacted by local habitat changes. We first carried out spatial analysis to locate areas on a gradient of habitat fragmentation. From these areas, we collected 120 female *L. sinapis* and tested their orientation behaviour in the presence of host plants and conspecifics in large outdoor cages. We collected data on fecundity and life span of each tested individual. Findings will for the first time shed light on the implication of habitat fragmentation on *L. sinapis* spatial behaviour and life history traits. This will advance our understanding of the effect of habitat changes on insect movements.

(25) abmAnimalMovement: An R package for simulating animal movement using an agent-based model

Benjamin Marshall[1], Brad Duthie[1]

[1]University of Stirling

As the complexity of questions and analyses used in animal movement studies increase, deciding on the best approach can become more difficult. A potential solution is to simulate an array of synthetic datasets under varying study designs and scenarios to gain insight into the impact of analysis choice(s) in different contexts. The abmAnimalMovement R package provides the means of simulating animal movement for this purpose. The abmAnimalMovement simulations use a discrete time agent-based model and does not require movement data as an input. The simulations include key internal and external movement influences, as well as parameters for animal's navigation and mobility capacity. Internal influences include three predefined behavioural states and multiple activity cycles. External influences are implemented via matrices describing landscape characteristics. Navigation capacity is defined by the range the animal can dynamically choose a foraging location to which it is subsequently attracted. Mobility capacity is implemented by user defined distributions, from which step length and turn angles are drawn. The navigation capacity (the choice of destination) operates on a different time scale to the mobility capacity, allowing the internal state of the animal to differ from the observed movements. When

combined with other emergent properties the simulations offer opportunities to test whether movement analyses can accurately recover hidden mechanisms, states, and drivers.

(26) Do Eucalyptus plantations have any ecological role for Iberian Mesocarnivores?

Gonçalo Matias[1], Francesca Cagnacci[2], Luís M. Rosalino[1]

[1]Centre for Ecology, Evolution and Environmental Changes - cE3c; [2]Department of Biodiversity and Molecular Ecology, Research and Innovation Centre Fondazione Edmund Mach

Production forests have expanded their range worldwide throughout the last decades, particularly exotic Eucalyptus production forests (EPF) that cover nowadays > 20 million ha worldwide. This global landscape change affects native communities, particularly those of higher trophic levels, such as carnivores. One of my Ph.D. aims is to uncover the fine-scale spatial ecology patterns of two mesocarnivores (ref fox, and stone marten) and determine the role of each landcover unit that composes the studied EPF landscape to mesocarnivores in Portugal. I will capture six individuals of each species, which will be monitored usingGPS collars. The GPS device, coupled with an accelerometer, will provide data that will also allow us toassess the average daily movements, associated energy expenditure, and individual instantaneous responses to eucalyptus plantation maintenance and harvesting activities. Alongside, I intend to use resource selection functions to determine the habitat selection for each species and individual. For the third-order selection, and to understand how EPF influences the movement patterns, we will also use Step-Selection-Functions.Moreover, I will infer the type of activities that individuals perform within the EPF that will allow linking wildlife movement ecology with plantation management and, ultimately conservation outcomes. The results will allow identifying how the monitored mammals use the EPF, and how EDF management activities may influence this use, allowing sustainable exploitation of EPF.

(27) The effects of social relationships on flocking dynamics in homing pigeons

James Mayson[1], Jasper Chaplin[1], Alex Thornton[2], Steve Portugal[1]

[1]*Royal Holloway University of London; [2]University of Exeter*

Cluster flocking has a higher energetic cost than flying for solo birds, as individuals must avoid colliding with flock mates, match the pace of their conspecifics, and remain aware of movements of nearby birds in the flock. In Jackdaws, a strictly monogamous species, less energy is expended on the individual level when flying closer to their mate, and mates fly closer together than with any other birds in the flock. However, it is unclear if this relationship is ubiquitous amongst cluster flocking birds, or unique to strictly monogamous species. To determine this, we examined the relationship between social networks and flocking dynamics in free-flying homing pigeons, a less strictly monogamous species than Jackdaws. We determined the social networks and dominance ranks within pigeon flocks during local flights around their home loft, before releasing the birds from greater distances. Using biologging technology, we aimed to test (1) whether birds preferentially flew nearest to individuals close in their social network ('friends') over long flights, and then (2), using flap frequency as a proxy for energy expenditure, determine whether birds would expend less energy when flying close to 'friends'. By comparing these results to past research on Jackdaws, this study additionally provides insight into whether the effects of social relationship on flocking are conserved or unique across evolutionary and life history.

(28) Plasticity in foraging behaviour and individual-level variation in responsiveness to envrionmental change

Frederick C. Mckendrick[1,2], Sébastien Descamps[2], Kathryn E. Arnold[3], Stéphanie Jenouvrier[4], Philip Bertrand[5], Stephanie M. Harris[6], Natasha E. Gillies[1], Samantha C. Patrick[1]

[1]University of Liverpool; [2]Norsk Polarinstitutt; [3]University of York; [4]Woodshole Oceanographic Institute;[5]Université du Québec à Rimouski; [6]Bangor University

The ability to demonstrate behavioural plasticity, the adjustment of behaviour in response to different environmental conditions, is a key predictor of an individual's capability to respond to environmental change. In species such as seabirds which forage in highly dynamic and variable environments, plasticity in foraging behaviour is particularly important to ensure sufficient resources are acquired for reproduction and survival. However, although large variability in foraging strategies is present within-populations, how individuals differ in their response to specific environmental variables is rarely quantified for movement behaviour. Using GPS logger data obtained from 222 individuals at 7 black-legged kittiwake (*Rissa tridactyla*) colonies in the Arctic, we highlight individual-level variability in foraging strategy both within-and between-years. We then quantified plasticity by investigating how individuals varied foraging strategy in response to key dynamic environmental parameters such as daily glacial run-off, zooplankton abundance and chlorophyll concentration, all of which are rapidly changing due to sea ice melt and the increasing inflow of warm Atlantic water into the Arctic. Although individuals showed large variation in responsiveness to environmental change, future studies must quantify the potential costs of demonstrating enhanced phenotypic plasticity to better understand the capability of individuals to respond to climate change in the Arctic.

(29) Dynamics of flocking in birds: the role of hunger and motivation in determining leadership

Robin S. Mehlhausen-Franks[1], Jasper Chaplin, Steve Portugal[1]

[1]Royal Holloway University London

The movement of groups is among the most widespread of animal behaviours, and key to the success of many species. Famous examples include the herding of migratory mammals, pack-hunting behaviours, and the dynamic three-dimensional grouping of fish shoals and bird flocks. Individuals within groups enjoy a variety of benefits, ranging from greater reproductive success to improved defence against predators. A popular model for the study of flocking behaviours are homing pigeons (Columba livia domestica). Generally, group leaders are determined by personality traits, but the 'need-to-lead' theory of leadership suggests that non-leaders can become leaders under certain pressures, such as increased hunger. An Immediate, and thus-far unaddressed question this poses is whether or not leadership can come about as a result of increased motivation to return home for food. This study aims to test this by manipulating the motivation of individual pigeons within flocks. Using GPS and accelerometer biologgers, leaders can be identified as those whose movements are followed by the rest of the flock, and from this leadership hierarchies can be mapped out. This study first identified non-leaders during normal flights, then targeted these to see if their motivation could be increased through temporary short-term food deprivation. If Individuals can be made into leaders in this way, it would suggest leadership is transient, and at least as reliant on an individual's state as on its personality.

(30) Multidimensional plasticity of spring phenology

Maria Moiron[1], Birgen Haest[3], Céline Teplitsky[2], Andreas Dänhardt[4], Sandra Bouwhuis[1], Anne Charmantier[2]

[1]Institute of Avian Research, Wilhelmshaven, Germany; [2]CEFE, Univ Montpellier, CNRS, EPHE, IRD, Montpellier, France; [3]Department of Bird Migration, Swiss Ornithological Institute, Sempach, Switzerland

Changing environmental conditions cause changes in the distributions of phenotypic traits in natural populations. Understanding the mechanisms responsible for these changes is crucial for predicting populations' viability. In this study we investigated individual and additive genetic variation in, and selection on, plasticity in three phenological traits: the timing of arrival from wintering grounds, the interval between arrival and initiation of breeding, and the timing of reproduction, in response to two key environmental factors. We made use of 7438 observations of phenology from 1719 individuals of a long-distance migratory bird, the common tern (*Sterna hirundo*), measured across 25 years, as well as information on the sea

surface temperature at the wintering grounds and food availability at the breeding grounds. We found evidence for individual variation in multidimensional plasticity of arrival and laying dates, and, to a lower extent, additive genetic variation in arrival date's reaction norm. The intercepts of the three phenological traits were under strong directional selection, favoring an earlier phenology, while the plastic adjustment of arrival date to fish availability was the only response under selection, favoring individuals that expressed greater plasticity.Altogether, there is little evolutionary potential for multidimensional plasticity in spring phenology in this natural population, but we expect the population's phenotypic composition to change as sea temperatures rise and food availability decreases.

(31) Learning in groups on the move: neural networks reveal dynamics of collective learning

Joe Morford[1], Patrick Lewin[1], Dora Biro[1,2], Tim Guilford[1], Oliver Padget[1], Julien Collet[1]

[1]Department of Biology, University of Oxford, UK; [2]Department of Brain and Cognitive Sciences, University of Rochester, Rochester, NY, USA

Learning to navigate efficiently is a crucial process for animals, facilitating wide ranges of importantbehaviours like foraging, homing and migration. However, many animals do not navigate alone but in groupsand must learn to navigate in collective environments. Further, as group members learn, collectiveperformance may improve, with individuals contributing to group movements through collective decision-making processes. We investigated how individual learning during collective actions produced improvementsin collective performance, and how collective decision-making processes impacted upon learning, in a taskbased on collective navigation in animals. We trained artificial neural networks, either solo or paired, at anorientation task. In pairs, we implemented "democratic" and "despotic" rules of collective decision-making, and varied leadership between individuals, generating "leaders" and "followers". Nearly all pairs improved their orientation, but more slowly than solo learners. Within pairs, leaders learnt more quickly than followers ("the passenger-driver effect"). In democratic pairs, collective performance improved through individualscompensating for partner error, whereas in pairs with despotic decision-making, individuals learnt similarlyto solo learners. Our model helps to clarify the links between individual learning, collective decision-makingand collective performance, in the context of collective navigation, and collective behaviour, more generally.

(32) How to identify encounters with extreme conditions in movement data

Elham Nourani[1], Sophie de Grissac[3], David J. Anderson[4], Nik C. Cole[5], Adam Fell, David Grémillet, Manos Lempidakis[2], Miriam Lerma, Jennifer L. McKee[4], Lorien Pichegru, Pascal Provost, Niels C. Rattenborg, Peter G. Ryan, Carlos D. Santos, Stefan Schoombie, Vikash Tatayah, Henri Weimerskirch, Martin Wikelski[1], Kamran Safi[1], Emily L. C. Shepard[2]

[1]Max Planck Institute of Animal Behavior, Germany; [2]Swansea University, UK; [3]Diomedea Science – Research & Scientific communication, France; [4]Wake Forest University, USA; [5]Durrell Wildlife Conservation Trust, Jersey

Global warming is expected to increase the intensity and severity of extreme weather events. To predict the impact of these phenomena on animals, it is important to study animals' responses to extreme events in the past and the present, even if these events have been rare. Seabirds are a great study system for this purpose. Flying seabirds are adapted for windy environments. Despite this, storms can cause widespread strandings and wrecks, demonstrating that these seabirds are not always able to avoid or compensate for extreme conditions. The maximum wind speeds that birds can operate in has been hard to quantify due to the challenges of collecting data during infrequent events. We combine step-selection and randomization approaches to assess avoidance of particular wind conditions in >300,000 hours of already-existing tracking data from 18 seabird species. Maximum wind speeds were avoided in only nine of the 93,104 movement steps analyzed. These avoidance circumstances involved four species, including albatrosses. Albatrosses avoided speeds below their operable maxima, demonstrating that even the most wind-adapted birds avoid

extreme speeds in particular scenarios. Furthermore, Atlantic yellow-nosed albatross and the wandering albatross avoided the maximum wind speeds by flying towards and tracking the eye of the storm. Our study provides a simple method for identifying instances of encounter and/or avoidance of extreme conditions in opportunistically collected movement data.

(33) Catching roe deer with box-traps: lesson learned from a decadal experience

Federico Ossi[1], Nathan Ranc[1,2], Simone Dal Farra[1], Sandro Nicoloso[3], Francesca Cagnacci[1]

[1]Fondazione Edmund Mach, Unit of Animal Ecology, Italy; [2]INRAE Occitanie-Toulouse, Comportement et Écologie de la Faune Sauvage (CEFS), France; [3]DREAM Italia, Italy

The study of animal movement necessarily relies on the acquisition of data from tagged animals and is thus strongly dependent on the capture success of the target individuals. Box-trapping is a quite common methodology implemented to live-catch animals, especially in those contexts where the adoption of other methodologies such as drive nets is logistically complex (e.g., in mountain environments) and/or tele-anesthesia is not a viable option. Despite their wide usage by field ecologists and wildlife managers, we feel that information about the best practices to successfully capture animals through box-trapping remains quite often in the grey literature. Therefore, we present the lesson learned from over 10 years of box-trapping activity on roe deer (*Capreolus capreolus*) in an alpine environment, where we captured more than 100 individuals in two different study sites. We describe all the phases of roe deer captures, from pre-baiting to the release of the animals, showing the modalities that increment capture success but also the mistakes to be avoided. Among other, we investigate circadian patterns in the capture probability, as well as the link between animal immediate post-release behavior and capture-to-handling interval. Based on the above, we propose a 'vademecum' on capture modalities that we hope can be beneficial to ecologists and wildlife managers for tagging wildlife of interest.

(34) Wearable reproductive trackers: quantifying a key life history event remotely

Luke Ozsanlav-Harris[1], Larry R. Griffin[2], Mitch D. Weegman[3], Lei Cao, Geoff M. Hilton[2], Stuart Bearhop[1]

[1]University of Exeter; [2]Wildfowl and Wetlands Trust; [3]University of Saskatchewan

The scope offered by biologging data sets is increasing and there is potential to gain unique insights into a suite of ecological and life history phenomena. We use multi-stream data from global positioning system (GPS) and accelerometer (ACC) devices to quantify breeding events remotely in an Arctic breeding goose. From a training set of known breeders we determine the movement and overall dynamic body acceleration patterns indicative of incubation and use these to classify breeding events in individuals with unknown reproductive status. Given that researchers are often constrained by the amount of biologging data they can collect due to device weights, we explore the relative merits of GPS vs ACC data and how varying the temporal resolution of the data affects the accuracy of classifying incubation. Classifier accuracy deteriorates as the temporal resolution of GPS and ACC are reduced but the reduction in precision (false positive rate) is larger in comparison to recall (false negative rate). Our dataset could have been reduced by c.95% while maintaining precision and recall >98%. Our resampling-based sensitivity analysis of classifier accuracy has important implications with regards to both device design and sampling schedules for study systems wheredevice size is constrained. It will allow researchers with similar aims to optimize device battery, memoryusage and lifespan to maximise the ability to correctly quantify life history events.

(35) The effects of food predictability on the foraging ecology of African white-backed vultures (*Gyps africanus*)

Mattie Purinton[1], Adam Kane[1], Corinne Kendall[2], Evan Buechley[3]

[1]*University College Dublin;* [2]*North Carolina Zoo;* [3]*The Peregrine Fund*

Vultures provide essential ecosystem services from regulating the vertebrate scavenger guild to reducing disease transmission; they are specially adapted to find and feed on carrion - a patchily distributed and ephemeral resource. Several important traits in their physiology and behaviour reflect this: their large wings that allow for efficient soaring over long distances and social foraging that creates aerial networks to improve chances of finding carcasses. Decreasing natural areas and ungulate herds, as well as increasing human activity in Africa, have led to shifts in feeding behaviour to use human-mediated sources. The most prominent of which are abattoirs - slaughterhouses that discard scraps and offal, and vulture restaurants -supplementary feeding sites. Both are more predictable temporally and spatially than natural sources. Understanding how African vultures are affected by this change in food predictability will give better insight to their adaptability. To determine this impact, I am analysing GPS telemetry data from three populations of African white-backed vultures (*Gyps africanus*) over several years. Two sites are natural areas with ungulate herds and elephants, the third site has many abattoirs. I am determining foraging patterns of the vultures by comparing movement patterns that reflect feeding behaviour for each population of vultures. Identified differences can be used to better inform conservation efforts and further knowledge on vulture foraging.

(36) Using kinematic data from suction-cup tags to identify suckling events in humpback whales: an opportunity to study mother-calf behaviors comprehensively

Maevatiana N. Ratsimbazafindranahaka[1,2,3], Chloé Huetz[1], Olivier Adam[1,4], Aristide Andrianarimisa[2], Anjara Saloma[3], Isabelle Charrier[1]

[1]*Institut des Neurosciences Paris Saclay, Université Paris Saclay/CNRS;* [2]*Département de Zoologie et Biodiversité Animale, Université d'Antananarivo;* [3]*Association Cétamada, Sainte Marie, Madagascar;* [4]*Institut Jean le Rond d'Alembert, Sorbonne Université, Paris, France*

A recent study involving suction-cup tags equipped with a camera (CATS cam tags) showed that humpback whales' suckling behavior is highly stereotyped and can be detected automatically using kinematic data recorded by tags. We tested this approach to detect suckling events in data from comparable tags but not equipped with a camera (Acousonde tags). We conducted our test off Sainte Marie Island, Madagascar. Weused labeled kinematic data from CATS cams tags deployed on three humpback whale calves to train a machine learning model that can detect suckling periods. We then used the trained model to detect sucklingevents in Acousonde tags data from six humpback whale calves. The suckling events detected from eachcalf's tag data were correlated with data from the corresponding mother, as mothers were also tagged. A total of 33 events very likely corresponding to suckling events were detected. The events represented 3% of the duration of deployment on average. The corresponding vertical distance between the mother and the calf was about 2 m on average (maximum 6 m). Our results comply with previous descriptions of the sucklingbehavior, thus supporting that kinematic data from suction-cup tags equipped with a camera can be used to detect suckling events in comparable data not coupled with visual cues (no camera and nighttime recordings). It opens opportunities to comprehensively study the diel variation of humpback whale mother-calf pairs' behaviors and to investigate suckling behavior's implication on their movements.

(37) Understanding the drivers of foraging route fidelity in seabirds in the age of offshore renewables

Charlotte Regan[1], Maria Bogdanova[1], Kate Searle[1], Francis Daunt[1]

[1]*UK Centre for Ecology and Hydrology*

Individuals often exhibit foraging specialisation, such as fidelity to particular sites, and such specialisations are expected to be critical in shaping population dynamics. Though foraging specialisations are expected to be advantageous, they can prove maladaptive when environments change or become less predictable. Seabirds are experiencing dramatic

changes in their foraging environments due to climate change and the development of offshore renewable energy. Thus, understanding the timescales over which fidelity persists, and pinpointing the drivers of fidelity is critical for understanding seabird responses to environmental change. Here, we used breeding season GPS data for four species (common guillemot, Atlantic puffin, razorbill, and black-legged kittiwake) over nine years to quantify fidelity within- and among-years and identify its relationship with foraging behaviour and social context. We found strong evidence for within-year fidelity in all species, indicating that birds exhibit foraging fidelity across the breeding season. All three species also exhibited among-year fidelity, though this was strongest for guillemots. We also found that the strength of fidelity between consecutive trips was influenced by both the average foraging bout length and the total time spent foraging, suggesting that birds use the experience gained during foraging to inform their next trip. We use this inference to understand how fidelity may shape seabird responses to environmental change.

(38) At-sea activity of an Atlantic seabird, the Black-legged Kittiwake, reveals broad dispersal strategies during migration

Pia Ricca[1,2], Helen Wade[3,4], Beth E. Scott[1], Jared M. Wilson[3]

[1]School of Biological Sciences, University of Aberdeen, Aberdeen, UK; [2]Faculty of Agricultural and Environmental Sciences, McGill University, Sainte Anne de Bellevue, QC, Canada; [3]Marine Scotland Science, Aberdeen, UK; [4]Scottish Natural Heritage, Perth, UK

Knowledge on seabird movements has been rather restricted to the breeding period, yet pressures during the non breeding period may significantly impact seabird survival and population demographics. This study tracked Black-legged Kittiwakes from Isle of Canna, Scotland, using combined geolocators and wet-dry sensors to understand overwinter distributions and activity patterns, and the oceanographic characteristics of overwintering sites. Two dispersal strategies were evident: 1) short-distance migrants, where birds traveled further than the Central Atlantic; and 2) long-distance migrants, where individuals travelled to theNorthwest Atlantic, also showing evidence of stopover sites. The Labrador Sea and the Grand Banks ofNewfoundland were important staging and overwintering areas, with 69% of long-distance migrants showing evidence of stopovers. Two individuals showed rapid outward migration, travelling around 2500 km in 4 days. Individual differences in strategy were not influenced by the departure date or the arrival to the colony, with all individuals showing high variability in timings and site selection. Activity data revealed a potential moulting period of outer primaries between September and October, likely staging in the Labrador Sea. Thisstudy provides insight on the variability in non breeding dispersal strategies of a relatively unstudied population of kittiwakes, highlighting the drivers of dispersal and factors that may affect them during overwintering.

(39) Effect of cuing bottom-up attention on the flight trajectories of bumblebees (*Bombus terrestris*)

Théo Robert[1], Marion Callendret[1], Chloe Sowels[1], Vivek Nityananda[1]

[1]Newcastle University

Bottom-up attention is the process through which attention is captured by a sudden or salient cue and has been shown to increase the perceived contrast of a following target in primates. We investigated similar processes in bumblebees through the analysis of their flight trajectory in two different experiments. Experiment 1, bees were trained to drink a sugar reward at one of two artificial flowers on each side of a green computer screen. The reward was indicated by a black circle target displayed above the correct flower. Post training, bee attention was cued in tests: a blue square cue was flashed either on the side of the target or the opposite side before the target appeared. A condition without a cue was used as a control. The target was then presented with various contrasts. We predicted that bees would detect the target at a lower contrast when the cue appeared on the same side than when the cue was on the other side or when it was not shown. In experiment 2, bees learned to choose a high contrast

target instead of a distractor of lower contrast. Duringtests, the cue was presented either on the target side, the distractor side or not displayed. We predicted that the cue would hinder the bees' ability to discriminate the target from the distractor when it was on the side of the latter. Here, we present results about the bees' early responses to the cuing conditions using data on bee trajectories analysed with fine temporal resolution using DeepLabCut.

(40) Automating the study of sanitary behaviours using individual-level tracking provides novel insight in the ant colony life

Adriano Alistair Wanderlingh[1], Thomas Richardson[1], Vasudha Kulkarni[2], Nathalie Stroeymeyt[1]

[1]School of Biological Sciences, University of Bristol, Bristol, UK; [2]Indian Institute of Science Education and Research Pune, Pashan, Pune, India

Eusocial insects are expected to experience a heightened risk of disease transmission due to frequent contacts, high population densities and high genetic similarity between nestmates. However, collective disease defence mechanisms, including behavioural, physiological and organisational features, have been shown to provide additional protection against disease known as "social immunity". The division of labour typical of social insects is one of such organisational features, as it leads to bottleneck effects that inhibit colony-wide transmission dynamics. As division of labour is expected to be greater in larger groups, the effectiveness of organisational immunity has been predicted to increase with colony size, thus relaxing the need for alternative sanitary behaviours. However, testing these predictions experimentally has been hindered by the difficulty of obtaining comprehensive records of individuals' behaviours in large colonies. Using automated behavioural tracking and a novel methodology to infer behaviours from movement coordinates, we investigate how colony size affects the incidence of sanitary behaviours and the pathogen transmission risk in colonies of the ant Lasius niger exposed to the conidiospores of the fungus Metarhiziumbrunneum. Our experiment reveals links between group size, social organisation and active sanitary behaviours, providing further insight on how social insects modulate their disease defence strategies depending on the social context.

(41) Bumblebees food preferences are guided by perceived value rather than energy gain

Yonghe Zhou[1,2], Shuyi Ding[1], Caiying Liao[3], Jianing Wu[3], Lars Chittka[2], Cwyn Solvi[1,4], Fei Peng[1,5]

[1]Department of Psychology, School of Public Health, Southern Medical University, China; [2]Biological and Experimental Psychology, School of Biological and Behavioural Sciences, Queen Mary University of London, UK; [3]School of Aeronautics and Astronautics, Sun Yat-Sen University, China; [4]Ecology and Genetics Research Unit, University of Oulu, Finland; [5]Department of Psychiatry, Zhujiang Hospital, Southern Medical University, China

Animals are assumed to follow a strategy of energy maximisation, and therefore should choose feeding options based on the offered energy intake rates. However, both humans' and monkeys' choices are better explained by their subjective evaluations of sensory food qualities rather than by energy content. Bumblebees (*Bombus terrestris*) are classical models for economic decision making and are faced with floral choices with various sensory properties. However, it remains unclear whether their choices are driven by energy maximisation irrespective of the perceived values of options. Here we show that when trained with flowers offering similar energy intake rates, bumblebees developed preferences for the sweeter option. In contrast, with two options that differed in energy intake rates, bees had no preference between options because sweetness and resistance had been balanced. Further, decision dynamics during training indicate that bumblebees simultaneously evaluate sweetness and resistance but not energy gain. These results indicate that instead of energy maximisation, bumblebees' food preferences are jointly affected by their subjective evaluation of nectar sweetness and resistance. Our findings suggest that the perceived value of sensory food qualities as a driving force for food preferences is shared by evolutionarily distant species.


ASAB Winter 2022
6 & 7 Dec, Edinburgh: Animal Movement
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