Symposium

ZOOLOGICAL SOCIETY OF LONDON
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14 and 15 May 2015

HEALTH AND DISEASE IN TRANSLOCATED WILD ANIMALS

Photo credits, from top: Ian Carter, Natural England; Julie Wallace, Paignton Zoo; Jenny Gill, UEA; ZSL

ABSTRACTS
POSTERS

Celebrating 25 years of the Zoological Society of London and Natural England partnership in Health Surveillance for the Species Recovery Programme

Organised by

Anthony Sainsbury (Zoological Society of London), Katherine Walsh (Natural England), Ian Carter (Natural England), John Ewen (Zoological Society of London), Matt Hartley (Royal Society for the Protection of Birds)

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HEALTH AND DISEASE IN TRANSLOCATED WILD ANIMALS

14 MAY 2015

8.30 REGISTRATION OPENS

9.00 Welcome: Tim Hill, Chief Scientist at Natural England

9.15 Keynote: Successes, challenges, and dilemmas in conservation translocations

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Introduced by John Ewen, Zoological Society of London

The magnitude, impact, and escalation of the biodiversity crisis call for strategic conservation actions that can be engaged immediately for short or long-term benefit. Translocations can have powerful effects for species and affected ecosystems; however, these impacts can range from being profoundly beneficial to irreversibly damaging. Conservation translocation is the intentional movement and release of a living organism where the primary objective is a conservation benefit. Systematic reviews will illustrate that such translocations are now increasingly ubiquitous, frequent, and taxonomically diverse. Several lines of evidence will be presented to suggest that conservation translocations may be more successful than they were believed to be 20 years ago. The 2013 IUCN Guidelines for Reintroductions and other Conservation Translocations not only encompass reinforcements and reintroductions within the indigenous range of species, but also ecological replacements and assisted colonization outside of indigenous range. All conservation translocations require careful planning, monitoring, and evaluation across numerous parameters, concerning not only the release candidates but also affected species, ecosystems, and human communities. Dilemmas can arise if best-practice considerations conflict, and the resolution of such issues may not only depend on structured decision making but also upon differences in values or risk tolerance. Conservation translocations will continue to push the boundaries of risk, as assisted colonization becomes more frequent, engineering of novel ecosystems may ensue, and the de-extinction of lost species becomes more likely. Escalating risks need to be weighed carefully and decisions need to be struck cautiously, but the consequences of fearful inaction must also be considered within the global context of escalating extinctions.

SESSION I: SPECIES RESTORATION THROUGH TRANSLOCATION
Chair: Tim Hill, Chief Scientist at Natural England

10.00 The selection of species for translocation

Ian Carter, Natural England and Jim Foster, Amphibian and Reptile Conservation
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Translocation for conservation purposes is typically undertaken with the objective of establishing a new population. Yet this objective can often be achieved by other means, commonly through habitat restoration and natural re-colonisation. In addition, species vary inherently in their suitability for translocation because of their behavioural and ecological characteristics, the availability of donor stock, and other factors such as genetic issues, disease risks, practicalities and costs. Decision-makers must therefore consider whether translocation is the most appropriate way to achieve their conservation objectives. We use examples from two contrasting groups of animals in the UK, birds and herpetofauna (amphibians and reptiles), to summarise the key factors for consideration when assessing species as candidates for translocation. We base our overview on the recently updated IUCN guidelines for reintroductions (2013), and recommend these guidelines as an essential starting point for any prospective conservation translocation project. In the UK we suggest that translocation is only appropriate in a small number of cases for birds, though for a select group of bird species it provides an invaluable conservation technique. In contrast, amphibians and reptiles are poor dispersers, and so are less able to thrive in landscapes where semi-natural habitats are highly fragmented. For these groups, translocation can play an important role in their conservation.

10.30 The role of translocation in species restoration

Leigh Lock, RSPB
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Translocation is becoming increasingly used as a conservation tool since first being widely used about 50 years ago. The development of reintroduction biology, improved translocation techniques, and improved reporting of current projects is encouraging greater numbers of species translocation projects around the world. With the recent review of the IUCN guidelines (2013) which has extended the scope of conservation driven translocations, this trend looks to continue. But what have we learned from the past 50 years of effort? And how can we use this experience to develop more successful translocation projects in the future? A brief overview of the scale of effort and level of success is presented, highlighting some general trends and issues. Some more detailed examples of bird translocation projects are presented which illustrate some of the issues in more detail. Finally, some conclusions and lessons learned are presented to inform the planning and operation of future species translocation projects and highlight the importance of health and disease management within this programme.

11.00 POSTER SESSION (TEA/COFFEE)

SESSION II: PREDICTING THE RISKS FROM DISEASE IN TRANSLOCATION

Chair: Tony Mitchell-Jones, Trustee, PTES

11.30 Methods of disease risk analysis in wildlife translocation

Matt Hartley, Zoo and Wildlife Solutions representing RSPB
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Risk analysis processes have been developed to provide an objective, repeatable, transparent and documented assessment of the risks posed by a course of action or chain of decisions. Standardised techniques have been developed and are utilised routinely to aid decision-making by governments and international organisations such as the OIE (World Organisation for Animal Health) in assessing the risk from disease.

The use of these processes to aide management of conservation interventions in relation to disease threats is developing. The ability to use structured, reasoned, recognized qualitative approaches is particularly useful when evidence and data are lacking, which is common when working with wildlife. Several different systems and formats are in use but all should follow the principles of risk analysis. The production of IUCN guidelines and protocols provide a framework for developing, interpreting and utilizing disease risk analysis in conservation.

This presentation considers the principles of risk analysis in translocation projects. The reasons why such analysis may be undertaken and who the target audiences may be, the disease hazards that should be considered and the potential sources of information, will be discussed. There are multiple hazards in wild animal translocation, which complicates the traditional risk analysis approach. The paucity of information on the identity and geographical distribution of parasites hampers hazard identification. The limitations on risk analysis and its use for translocation will be reviewed.

Co-authors: Matt Hartley, Richard Jakob-Hoff and Anthony W Sainsbury

12.00 Which parasites should we worry about?

Bruce Rideout, Institute for Conservation Research, San Diego Zoo Global
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Parasites in the broad sense, including viruses, bacteria, fungi, protozoa, and metazoa, play an important role in normal ecosystem function. As a result, parasites native to a host in its natural habitat should raise little concern, although there are exceptions. The parasites of greatest concern are those that are alien to a particular host in its natural habitat. However, not all alien parasites warrant the same level of concern. In this presentation I will propose that the parasites we should worry most about are those that have some combination of the following characteristics: Are alien to the target species in its natural habitat; are microparasites rather than macroparasites; are generalists rather than specialists; have a long incubation period (or latency); long duration of infectiousness; have vertical transmission; moderate R0 (balancing the potential for invasion versus persistence); have reservoirs or vectors; and those that are untreatable and cannot be controlled with vaccination. I will then evaluate the relevance of these characteristics by comparing them to the characteristics of some important non-native parasites of wildlife to determine which of these parasite characteristics are most valuable for disease risk analyses. Having a sound basis for evaluating the threat of particular parasites to wildlife translocation efforts is extremely important, but there are many challenges with implementation. In many real-world situations, it can be difficult to determine which parasites are native to a particular host and which are not. When that is known, we may not have sufficient data to predict whether a given parasite will be able to invade or persist, cause disease or mortality, or establish itself in reservoirs. Despite these challenges, having a starting point for determining which parasites warrant the greatest concern for a particular translocation effort is an essential step in any risk analysis.

12.30 Parasites as drivers and passengers of human-mediated biological invasions?

Tim Blackburn, University College London
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Alien species constitute an enormous “experiment in nature” that may potentially provide insights into how nature is structured. Parasites have frequently been invoked as drivers of biological invasions, but have received less attention as invasion passengers, especially when one considers that they may comprise half of all species. This talk provides an overview of the current state of knowledge of parasites in biological invasions. The evidence to date that parasites drive invasions by hosts is weak. Particular case studies are suggestive – and their consequences in some cases devastating – but not yet informative about general effects. What evidence there is for parasites as aliens suggests that the same kind of factors determine their success as for non-parasites. Thus, availability is likely to be an important determinant of translocation. Establishment and spread are likely to depend on propagule pressure, and on the environment being suitable (in this case, all necessary hosts and vectors are present) – the likelihood of both of these dependencies being favourable will be affected by traits relating to life history and demography. The added complication for the success of parasites as aliens is that often this will depend on the success of their hosts. I discuss how these conclusions help us to understand the likely effects of parasites on the success of populations we would like to succeed in establishing viable populations, whether those populations are alien or native.

13.00 **LUNCH**
Prince Albert Suite

14.00 **Safeguarding reintroduced and free-living populations of hazel dormice *(Muscardinus avellanarius)* from the introduction of alien parasites using molecular techniques**

Gabriela Peniche, Zoological Society of London
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One of the greatest threats posed by translocations is the precipitation of disease outbreaks induced by alien parasites. Similarly, releasing immunologically naïve species into an environment where they may face infectious agents not encountered previously can be counterproductive to the success of the reintroduction.

A reintroduction programme for the common or hazel dormouse *Muscardinus avellanarius* was instigated in England in 1992. Health and disease monitoring pre-and post-release commenced in 1999 and since then dormice destined for reintroduction have been quarantined and screened for suspected alien parasites before release. In 2000 a cestode parasite was detected in captive dormice destined for reintroduction. Further cestode-like ova were found in subsequent years in quarantined and free-living dormice but attempts to identify the cestode species through morphological techniques on adult cestodes collected from the large intestine were stymied by decomposition.

Using DNA barcoding and ITS1/18S rRNA PCR sequencing we aimed to identity and assess if the same species of tapeworm was present in captive and free-living wild hazel dormice, and clarify whether elimination prior to reintroduction was advisable. Cestode ova found in captive individuals produced a molecular match for a species closely related to *Hymenolepis microstoma* while *Rodentolepis straminea* ova were identified in free-living dormice. Since captive and free-living dormice harboured different species, cestode parasites have been eliminated from captive dormice prior to reintroduction.

Molecular techniques allowed the identification of the parasite species complement of dormice awaiting release and their free-living counterparts, and reduced uncertainty regarding the best management decision to reduce the risk from disease due to alien parasite introduction in the free-living population, potentially increasing the chances of reintroduction success.

Co-authors: Peter Olson, Chris Durrant, Dominic J. Bennett, Louise Wong and Anthony W Sainsbury

14.30 **Invertebrate parasites and re-introductions: a case study in bumblebees**

Mark Brown, Royal Holloway College, University of London
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Species reintroduction programmes are governed by IUCN criteria. A key aspect of these criteria is the need to consider parasites and their impacts on both the reintroduction population and the reintroduction site. While reintroduction projects for vertebrates are increasingly common, invertebrate projects are scarce. As IUCN reintroduction criteria are largely designed for vertebrates, the question as to whether they can be applied successfully to invertebrates remains unanswered. The bumblebee *Bombus subterraneus* was last seen in the UK in 1988 and declared locally extinct by the IUCN in 2000. The short-haired bumblebee project (http://www.bumblebeereintroduction.org/) aims to reintroduce a sustainable population of this species to the UK from thriving populations in Sweden. Initial Disease Risk Assessment and Disease Risk Management plans were drawn up in 2010–2011, based on existing literature and an initial parasite screening of Swedish *B. subterraneus* queens captured in May 2011. Based on these plans, which included both quarantine and monitoring provisions, formal annual reintroductions started in 2012. Over the first three years of the project, quarantine has been successful in preventing the release of infected queens, and in identifying new parasitic hazards that were absent from the original DRA and DRM. The DRA and DRM are updated annually, based on results from quarantine as well as advances in the broader literature. Here I will present the development process of both of these plans, how they have been impacted both by quarantine data and broader literature, and discuss future potential developments.

15.00 Disease invasion and persistence in translocated populations

Peter J Hudson, Center for Infectious Disease Dynamics, Pennsylvania State University
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Individuals used in translocation to augment populations are invariably vaccinated, treated with anthelmintic and disease free on introduction. However their release produces a number of disease opportunities that can result in disease related issues within the established population. Translocations produce naïve offspring that increase the abundance of susceptible hosts, the translocated animals move about and disrupt the contact network of established hosts and this can result in disease outbreaks. We explore these issues and aspects of the disease invasion of translocated hosts by asking “What is the pattern of disease invasion of translocated animals?” and “What type of infections become established?” and “How do some infections persist?” We refer to our own work on disease invasion in translocated wolves in the Yellowstone National Park and the dynamics of disease in released bighorn sheep, desert tortoises and pheasants.

SESSION III: ANTHROPOGENIC THREATS AND DISEASE IN TRANSLOCATED SPECIES
Chair: Ruth Cromie, Wildfowl & Wetlands Trust

15.30 Managing epidemic lead exposure rates in the California condor and implications for recovery

Myra Finkelstein, University of California, Santa Cruz
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The endangered population of California condors *(Gymnogyps californianus)* has increased from no birds in the wild in the mid-1980s to greater than 200 today, a testament to the success of the recovery program. However, condors are lead poisoned at epidemic rates with ~20% of the wild California population lead poisoned annually. Lead ammunition is the principal source of lead exposure and ~80% of wild condors exhibit blood lead isotopic compositions consistent with lead-based ammunition. Management actions to mitigate lead poisoning are based in part on blood lead testing of condors during routine health checks. Typically if a bird has a blood lead >35 µg/dL, chelation therapy and supportive treatment is administered. Lead concentrations in feathers show that blood monitoring is a poor predictor of lead exposure history, with many exposure events going undetected or occurring several weeks to months prior to blood testing. As a result, significant lead poisoning events are often missed or treated after a long delay, which raises concerns about the effectiveness of the current lead poisoning management strategy. Feeding stations provide non-contaminated food to condors, and our analyses show that a condor’s use of feeding stations is a strong negative predictor for a condor’s risk of lead poisoning as well as a strong positive predictor of future survival. However, the use of feeding stations is not a viable long-term solution to help reduce lead poisoning rates in condors. Our findings indicate that an almost complete reduction in the use of lead-based ammunition is the only solution to assure the long-term survival of the wild condor population in California.

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16.00 Monitoring toxins in rare and reintroduced species: the red kite

Richard Shore, NERC Centre for Ecology & Hydrology
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The red kite *(Milvus milvus)* is a native species in Britain that declined severely in numbers through persecution and has subsequently been subject to reintroductions at various sites in Britain. Red kites feed on a range of scavenge, including dead and dying rats that may have been poisoned during control operations, and game species that have been shot but unretrieved by hunters. Consequently, red kites are at particular risk from exposure to second generation anticoagulant rodenticides (SGARs) and to lead. Investigation of the exposure of kites to toxins has been carried out across four laboratories in the UK but a recent initiative, conducted as part of the WILDCOMS network, has pooled the dispersed data on kites into a single database. Our research aims to present a first evaluation of this comprehensive dataset on the extent of exposure of reintroduced red kites in Britain to SGARs and Pb. We investigate how exposure varies with age class and sex, and determine if exposure has changed over time. We also compare birds from different release areas to determine if risk of exposure has varied between release sites. Finally, we will evaluate the extent of risk (in terms of mortality) that these toxins may pose to reintroduced kite populations.

Co-authors:
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16.30 POSTER SESSION (TEA/COFFEE)

SESSION IV: MANAGING DISEASE IN WILD ANIMALS DURING TRANSLOCATION

Chair: Bruce Rideout, San Diego Zoo's Institute for Conservation Research

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17.00 Reintroduction: What to do when a disease emerges early in the process?

Richard Kock, Royal Veterinary College, London
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Re-introduction and translocation planning should involve disease risk analysis. This involves identifying the potential hazards, establishing the risk of a disease emerging during the process, managing that risk prior to and during translocation and after release, in addition to communicating that risk at all stages and to all stakeholders. Zero risk is a fantasy and despite best intentions and protocols disease events will arise. Translocation of animals is inherently stressful and risky, prior identification of all potential pathogens carried in the candidates is also near impossible, given limitations of disease test sensitivities and specificities, and resources. Even so, examples of catastrophic disease introduction, is rarely associated with formal reintroduction programmes. The majority of global emerging disease events result from changing ecological conditions or unintended transport of pathogens and their release into the environment and naïve populations, during domestic and wild animal and product trade, as fomites in planes, ships and vehicles, and with the unregulated movement of humans and their luggage around the planet.

Where an unexpected disease event occurs in pre-release animals at source or in quarantine, with some batches already released, a number of mitigating measures are possible, including, where feasible, recapture of released animals for further assessment, culling of marked released animals where capture is impractical, and further analysis of risk from the possible introduction to inform decisions. In most cases, once a pathogenic microbe is metaphorically out of the bag, there is little that can be done to guarantee subsequent freedom from infection in the recipient environment so the onus is on prevention. On the positive side introduction may not be catastrophic. If the environment for release is naturally resilient the organism will likely lose virulence, or die out for lack of hosts or supporting environment. And finally disease introduction occurs naturally without direct human intervention and most species are adapted, through evolution, to handle this challenge. Examples and case studies illustrate these points.

17.30 Managing disease during translocations: case studies from Mauritius

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Abstract unavailable at time of print

18.00 POSTER SESSION with cash bar

19.00 SYMPOSIUM DINNER – tickets booked in advance

SESSION IV: MANAGING DISEASE IN WILD ANIMALS DURING TRANSLOCATION – CONTINUED
Chair: Bruce Rideout, San Diego Zoo's Institute for Conservation Research

9.00 Managing behaviour; appropriate socialisation and early learning enhances survival and productivity

Carl Jones, Mauritian Wildlife Foundation and Durrell Wildlife Academy
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Early learning and socialisation are not given enough thought in many reintroduction and translocation projects, many projects have failed because the animals have behavioural problems or are not supported adequately post-release. We will look at early learning and socialisation along the precocial-altricial continuum and establishing how animals go through various learning and imprinting type processes, during sensitive periods, learning, social, locomotor, foraging, predator avoidance, other survival, and perceptual skills as well as forming imprinting like attachments to nest-sites and habitats. In higher vertebrates these learning processes are more extensive and are particularly complex in long lived, social species with altricial young and long developmental periods. Failure to manage the animals appropriately during these early stages will compromise survival and productivity. We will look at the three stages of a reintroduction and the behavioural considerations.

1) Pre-release considerations. For species being reared in captivity there is a need to ensure the young are reared in social groups that replicate the size of a family unit, and they are exposed to appropriate stimuli and receive adequate behavioural interactions with siblings and their surroundings. We will evaluate the different rearing methods, crèche rearing, parent rearing, foster rearing and puppet rearing.

2) The reintroduction process. Comparing the different approaches, hard releases for translocations and soft-releases for captive reared birds. Very soft releases with training for social birds that show a lot of post-release learning. The importance of releasing at ages close to the normal fledging period for many species, and the need for proper socialisation for some of the more behaviourally complex species (ground hornbills and condors). Merits and limitations of fostering and cross-fostering.

3) Post-release management. This is where we will highlight the importance of proper care for released animals, supporting them adequately while they learn their survival skills, and in compromised habitats how we may have to manage populations for multiple generations.

We can also discuss the merits of long-term management, supplemental feeding, predator control, population and health monitoring and how for some species the management will continue for decades/centuries.

9.30 The link between stress and disease in translocations

Molly J Dickens, University of California, Berkeley
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Physiological stress response pathways show direct connections to the immune system. While these connections have evolved to aid in survival when animals face acute stressors, they also underlie the link between chronic stress and disease. Chronic stressors are generally considered maladaptive, the stress response no longer promotes recovery, survival, and preparation and

instead the response itself causes pathological effects such as immunosuppression. Translocation presents the perfect storm that can push the stress response system into a state of chronic stress: multiple anthropogenic stressors that often last for hours to days, occurring in a persistent pattern that does not allow for adequate recovery. My research has shown that in even the most conservative model of animal translocation, stress physiology is disrupted in a way that suggests downstream effects on other systems. However, the seemingly inevitable effects of chronic stress does not necessarily seal the fate for translocated populations. In the case of stress and disease, there are multiple variables that cause disease in a population. Although chronically stressed animals are likely immunocompromised and, therefore, more vulnerable to succumbing to disease, these animals will not exhibit pathologies unless they encounter pathogens in the wild. In addition, chronic stress is not an all-or-nothing physiological state or a permanent condition. Animals can show mild, sub-threshold effects on the immune system and/or recover before problems occur. Targeting the degree to which released animals are affected by the stress of translocation through careful planning to minimize and/or eliminate stressor exposure will decrease the level of physiological vulnerability in the released individuals and improve the outcome for the translocated population.

10.00 Developmental limb disorders in avian reintroduction projects

Katie Beckmann, Wildfowl & Wetlands Trust, Zoological Society of London & Royal Veterinary College
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Avian reintroduction projects frequently involve a seasonal, intensive captive rearing phase, however, juvenile captive-reared birds are susceptible to developmental limb disorders such as metabolic bone disease (MBD) and angular limb deformities (e.g. bowed or splayed legs).

Corncrakes (*Crex crex*) have been captive bred for reintroduction in Eastern England since 2003. The chicks are fed (i) specially formulated rearing mix, and (ii) farmed, supplemented invertebrates in increasing proportion until release at 5–6 weeks of age. Metabolic bone disease was first diagnosed in juvenile corncrakes in 2012; further investigations identified 27 cases of suspected or confirmed MBD in carcasses submitted for post mortem examination from 2009–2013. The diet was found to be deficient in calcium. Subsequent modifications to the supplementation of feed invertebrates, and attempts to increase rearing mix intake, were associated with a marked decrease in MBD prevalence.

The Eurasian crane (*Grus grus*) was reintroduced in south-west England from 2010–2014. Each year, chicks were hand-reared and released at 3–4 months of age. They were fed specially milled pellet (crude protein <24% DM), more or less *ad libitum* in 2010–2013 then rationed according to bodyweight in 2014, and exercised daily. Ninety-three individuals were released and survival is currently >80%. Twenty-six (23%) of 114 hatched chicks developed notably splayed and/or bowed legs, which resolved in 19 cases following veterinary management. There was a lower prevalence of limb deformities in 2014, when chicks received more exercise and rationed pellet.

These results demonstrate how developmental limb disorders can negatively impact health and survival of birds in reintroduction projects with a captive rearing component, and that appropriate husbandry, including feeding, is critical to rearing success. Health management requires close collaboration between veterinary and animal care staff, detailed record keeping, and annual review of husbandry protocols in light of observed disease conditions.

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10.30 POSTER SESSION (TEA/COFFEE)

11.00 Mitigating the risk from disease while conserving parasites in future ecosystems: case studies from cirl buntings and corncrakes

Anthony W Sainsbury, Zoological Society of London
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Empirical evidence from invasive species biology shows that hosts translocated to new geographic regions have fewer parasites than their populations of origin. Therefore concerted action may be required to conserve parasites in future ecosystems where translocation is used as a conservation tool. Conservation of parasites may be important to (i) maintain ecosystem function, (ii) sustain biodiversity, and, (iii) in translocated host populations, to stimulate host immunity. Translocated populations which have lost parasites, may, over several generations, lose immunity and be susceptible to epidemic outbreaks if they encounter the same parasites later in the new environment.

Translocated species may be placed in circumstances where parasites transmit readily amongst the population, for example, when at high density in captivity. At the same time, stressors may increase the animals susceptibility to disease. Translocation managers may need to administer prophylactic agents to combat diseases associated with parasitism but, at the same time, may wish to avoid eradicating the parasites.

Cirl buntings (*Emberiza cirlus*) translocated from Devon to Cornwall in the UK, were captured from nests, reared in captivity and soft released when fully fledged. In captivity, isosporosis, was associated with the death of two of 17 cirl buntings in the trial translocation and the causal coccidian parasite, *Isospora normanlevinei,* was known to be native to cirl buntings. Treatment of translocated, captive cirl buntings was carried out using toltrazuril, and the frequency of administration was modified to prevent eradication of the parasite. Birds, from which coccidia have been eradicated, are known to be more susceptible to disease when re-exposed, and the released population of cirl buntings might eventually come into contact with infected conspecifics. Faecal samples collected from three birds post-release verified that *Isospora normanlevinei* was present in the translocated population.

Corncrakes (*Crex crex*) bred and reared in captivity and soft-released in the Nene Washes in Cambridgeshire have been susceptible to coccidiosis. Two coccidial organisms were identified, using morphological characteristics, as *Eimeria crecis* and *Eimeria nenei* and these same species of coccidia were present in faecal samples collected from a free-living population of corncrakes in the Outer Hebrides. Treatment with toltrazuril throughout the rearing period was implemented and coccidial parasites were detected in corncrakes one week prior to release.
These examples demonstrate that it is possible to control parasitic diseases and conserve the same parasites in the translocated populations. However, these programmes to conserve parasites have been restricted to pathogenic parasites associated with prevailing disease in translocated animals. In future, there may be advantages in actively conserving the full complement of parasites harboured by translocated species.

11.30 The Great Crane Project: management of infectious disease risks

Ruth Cromie, Wildfowl & Wetlands Trust
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Managing the risks from infectious disease in the Great Crane Project (a reintroduction of Eurasian cranes *Grus grus* to South West England) began in the library, travelled through the practical challenges of the rearing and release of nearly 100 birds, from 2010 to 2014, and continues today in the remote monitoring of (and quiet worrying about) free-living individuals as the next generation emerges.

A disease risk analysis was conducted by ZSL which highlighted a range of infectious agents as source, carrier, host-immunodeficiency, transport and/or destination hazards. This document formed the starting point for health management undertaken by the Great Crane Project team (a partnership project between the Wildfowl & Wetlands Trust, RSPB, Pensthorpe Conservation Trust and Viridor Credits).

A range of measures were used to mitigate risks from infectious disease, including:

- design and build of the rearing facility;
- strict protocols for personnel and vehicle access to the facility;
- disinfection protocols within the facility;
- annual decontamination of the facility; and
- preventative medicine and reactive veterinary treatment.

A range of pathogens were found in the birds with an increased incidence of parasitic infections over the five years of rearing. Despite this, no infectious agents have seriously affected the success of the project *to date*, likely due to the measures undertaken.

Weaknesses in diagnostic support (false positive and false negative results) caused problems, and reintroduction projects, like all conservation projects, need to be resilient and expect the unexpected.

Whilst good planning documentation, design and protocols are essential, management of risks on the ground is facilitated by productive team dynamics with good integration of the project team in particular veterinary and animal care staff. Management of infectious disease risks is sometimes in tension with other health risks or project priorities and success lies in getting this balance right.

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12.00 Biosecurity for translocations: Fisher's estuarine moth, short-haired bumblebee, pool frog and cirl bunting translocations as case studies

Rebecca Vaughan-Higgins, Perth Zoo & Murdoch University Western Australia
Presented by Nic Masters, Zoological Society of London
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The possibility of infection of translocated wild animals through interaction with human, domestic animal, other wild animal or inanimate elements during translocation is always present and in practice difficult to predict. Biosecurity in conservation-based translocations is therefore thought to be of paramount importance. The purpose of biosecurity in conservation translocations varies dependent on which hazard category represents the greatest risk from disease and the location in the translocation pathway at which this hazard acts. Quarantine, the use of a barrier to separate the translocated species from a perceived hazard, could be used (1) within a captive rearing element of a translocation to protect the translocated animals from exotic parasites, (2) during transit to prevent contact with transport hazards, such as parasites derived from domestic animals, humans or fomites (inanimate objects harbouring parasites), (3) during transport to prevent escape of source hazards, and (4) at the destination to protect the newly translocated small population from destination and / or population hazards. The possible importance of quarantine of wild animals prior to reintroduction was illustrated by Walker *et al.'s* (2008) finding that reintroduced populations of Mallorcan midwife toads *(Alytes muletensis)* were infected with *Batrachochytrium dendrobatidis*, a parasite linked to amphibian extinctions, which had originated from a captive breeding facility in which the midwife toads had been housed with a carrier species, *Xenopus gilli,* apparently without separation by a quarantine barrier.

Using case examples we illustrate how the principles of biosecurity can be applied in practical translocation scenarios. For example, The Fishers' estuarine moth *(Gortyna borelii lunata)* translocation involved a captive rearing stage and the captive breeding facility was sited at the perimeter of a zoological collection which housed exotic species of invertebrates (including some Lepidoptera). Quarantine was implemented to protect the moths from exotic parasites in the zoological collection using a barrier, including a footbath, dedicated clothing, and the wearing of disposable gloves. Dedicated tools were used in the facility and staff caring for the moths serviced the moths prior to servicing the zoo collection. A similar quarantine barrier was established when cirl bunting *(Emberiza cirlus)* chicks were captive reared prior to release. In this case a disease risk analysis (DRA) advised that the captive rearing facility should be sited distant from the zoological collection to reduce the risk of disease from exotic parasites and it was moved to the remote destination field site. Keeping staff were managed by the zoo but worked at the remote location. Short-haired bumblebees *(Bombus subterraneus)* reintroduced to England from Sweden were housed in a University facility to allow for screening of potentially alien parasites prior to transit to the destination site. Quarantine was implemented to prevent escape of any alien parasites into England before and during screening, and, in addition, to protect the bumblebees, and destination ecosystem, from parasites harboured by invertebrates housed in the University. Pool frogs *(Pelophylax lessonae)* were also reintroduced to England from Sweden, however in this case they were moved directly to the destination and released immediately (screening of source and destination populations had been carried out prior to reintroduction and informed the DRA). A quarantine barrier was implemented in the field at the destination site to reduce exposure of the pool frogs to parasites in England analysed as representing a high disease risk. This barrier also had the potential additional benefit of reducing the rate of spread from the release site of any unknown alien parasites harboured by the pool frogs.

On the basis of our understanding of epidemiological principles, we would expect biosecurity, through barrier techniques and quarantine, as illustrated above to protect translocated and recipient populations. However, there is minimal evidence to date which supports this premise and we know of no studies which have evaluated the ability of biosecurity to prevent transfer of infectious agents between populations in translocation scenarios. Indeed biosecurity protocols may risk stress or injury and there is a monetary cost involved (Ewen *et al.,* 2012). Furthermore there may be difficulties and practical limitations in instituting biosecurity. Biosecurity, including quarantine barriers, should attempt to prevent transfer of all infectious agents because the identity of hazardous agents might not be known: *Batrachochytrium dendrobatidis*, the pathogen causing the disease chytridiomycosis, in Mallorcan midwife toads was unknown at the time the toads were reintroduced. Yet, even when the epidemiology of an infectious disease is known breakdowns in quarantine can be difficult to prevent. This has recently been illustrated in the Ebola haemorrhagic fever outbreak in West Africa. Despite considerable investment in barrier quarantine techniques, highly trained health professionals became infected and developed Ebola fever, when the barrier was broken in changing protective clothing. Investment in biosecurity techniques for wild animal translocations has not even reached the level used in fatal infectious human diseases such as Ebola fever, and we must therefore question its' effectiveness. Breakdowns in quarantine, such as in the Ebola fever outbreak, imply that instruction of staff in implementing biosecurity for translocation programmes is crucial. Biosecurity protocols should be continually updated in response to findings from disease risk analysis and post-release disease surveillance. We advocate further studies to evaluate the effectiveness of biosecurity to prevent transfer of infectious agents between populations affected by translocations and assess whether improvements in techniques are required.

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Co-authors: Rebecca Vaughan-Higgins, Nic Masters, Anthony W Sainsbury

12.30 **LUNCH**
Prince Albert Suite

SESSION V: MAKING DISEASE MANAGEMENT DECISIONS IN THE FACE OF UNCERTAINTY AND RISK

Chair: Richard Kock, Royal Veterinary College

13.30 Structuring our objectives and evaluating our disease management alternatives

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Most methods of disease risk analysis (DRA) deal with uncertainty about what the key disease hazards are, what their probabilities of occurrence are, and the likely impacts of the diseases if they occur. Another repeated request arising from DRA is a desire for monitoring of disease hazards. I will argue that the current DRA approaches can be improved by more clearly linking our reintroduction objectives with management alternatives for key disease hazards, so that we can directly compare the consequences of available options, including the need for monitoring. This can best be done using structured decision making. Structured decision making is defined as the collaborative and facilitated application of multiple objective decision making and group deliberation methods for environmental management problems. It is based on an iterative process in which objectives are explicitly stated, clearly defined alternative management strategies are evaluated in terms of their expected outcomes, and trade-offs are solved while explicitly accounting for uncertainty. The beauty of this approach is that it more directly links the risk analysis and risk management components of current DRA methodology. This forces our decisions to be focussed on management outcome and provides valuable approaches to confronting uncertainty, including how best to use expert opinion and how to ensure monitoring is strategically invested on areas most likely to improve our future choices. Using these tools will provide a more collaborative, transparent and defendable approach to managing health and disease in translocation of wild animals.

14.00 Expected value of information for disease risk assessments in threatened species management

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The analysis of disease risks in threatened species management is often influenced by incomplete knowledge about the state and dynamics of host-pathogen relationships. This uncertainty in turn affects the choice of risk management strategies. Further research is often advocated, in the expectation that it will allow more informed management decisions and ultimately lead to improved outcomes. However, additional information will prove beneficial only if it is possible to collect and interpret it (that is, if the relevant parameters are observable, the cost of learning can be sustained and reliable inference can be made) and if it can be translated into management by adapting actions to the new knowledge. So how can managers determine whether the collection of further information is actually warranted?

Value of information analysis (VOI) can be used to evaluate the expected improvement in management outcomes brought by learning about the system. This benefit can be assessed against the cost of collecting information, accounting for imperfect learning processes, and for stochasticity that will influence our ability to make inferences. Here, I provide an explanation of how VOI analysis works, and how it can be implemented in a simple spreadsheet, using Bayesian updating. I illustrate the use of VOI in endangered species translocations under disease risk.

14.30 POSTER SESSION (TEA/COFFEE)

15.00 Decision analysis and expert judgment: implications for disease risk analysis in reintroductions

Sarah Converse, Patuxent Wildlife Research Center, United States Geological Survey
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In developing management plans for threatened species, we often begin with tremendous uncertainty and little empirical information. However, because of the immediacy of threats, management decisions often can't be delayed until better information becomes available. A major focus of decision analysis is informing decisions under uncertainty, and a key part of the decision-analytic process is the development of models to predict how the system will respond to management. Often, judgment elicited from experts is critical for developing first iterations of such management models.

We describe a preliminary model for management of boreal toads *(Anaxyrus boreas boreas),* a species threatened by chytridiomycosis caused by *Batrachochytrium dendrobatidis* (Bd). The model is based on a 2-species dynamic site occupancy framework. We consider two management actions: translocation of toads and efforts to reduce Bd colonization risk. Major uncertainties in the system include whether a Bd-resistant genotype exists in the toad population, the background rate of Bd colonization, and effects of management on Bd colonization. Initial estimates of parameters associated with these uncertainties, and other basic model parameters, will be based on judgment elicited from experts, and models will be built to identify optimal management actions based on those initial estimates, with the plan to update the parameters over time as targeted monitoring is carried out. Certain forms of monitoring – including efforts to detect Bd at sites, and efforts to detect resistant-type toads – are likely to be particularly expensive, and the costs of such monitoring will need to be traded off against the potential benefits of the monitoring. This model can be used to establish an adaptive management program to improve the outlook for boreal toad conservation into the future.

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15.30 Monitoring for the management of disease risk in animal translocation programs

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A key to successful monitoring is to tailor it to the larger scientific or management process of which it is a component. Animal translocation programs are management processes that frequently include multiple objectives, one of which is to either augment existing animal populations or to establish new populations in areas not currently occupied by the focal species. This objective includes reducing to the degree possible sources of mortality for translocated birds, including that resulting from disease. Another important objective is to not exceed acceptable risk levels of disease transmission from translocated birds to wild conspecifics and other species. Both objectives require monitoring data that emphasize two specific uses: (1) making state-specific decisions, and (2) discriminating among competing models of disease transmission, spread, and treatment effectiveness.

We outline three broad classes of monitoring program: (1) pre-release monitoring of translocated birds, and also wild birds (conspecifics and perhaps related species), in the area of release; (2) post-release monitoring in the release area for both translocated birds and wild birds; (3) post-release monitoring for both translocated birds and wild birds of focal and related species in locations beyond the release area. For each class of program, we specify uses of resulting data for making state-dependent decisions and discriminating among competing models of disease dynamics and treatment.

Armed with these specific monitoring targets, we can think about conduct of such monitoring. Estimation of disease burdens and discrimination among competing models of disease dynamics can be addressed using multistate capture-recapture models, with either certainty or uncertainty in assignment of disease state to detected individuals. These models permit inferences about disease dynamics of wild animal populations under the realistic sampling situation in which individual detection probabilities are not only <1, but also are likely to vary by disease state. Discrimination among competing models of geographic disease spread can be addressed using dynamic multistate occupancy models with neighborhood effects, which also deal with the issues of possible non-detection and false positives, but with a focus on spatial units rather than individual animals.

These recommendations are necessarily very general in nature. As in any other program of conservation or management, the key to useful monitoring is to tailor it to the specific uses of resulting data and inferences.

Co-authors: T Hollmen and JB Grand

16.00 Discussion Session

16.30 END OF SYMPOSIUM

POSTER PRESENTATIONS

Disease risk analysis and disease risk management for avian reintroduction projects

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Ambitious interventions for wildlife conservation, such as reintroductions, have had relatively low success rates to date, and further research into their limitations and methods is needed in order to improve outcomes. Disease is one of the potential constraints on successful reintroduction. Guidelines for disease risk analysis (DRA) and health management for reintroduction of specific taxonomic groups would be beneficial. This PhD project is using reintroduction projects for the Eurasian crane (*Grus grus*) and corncrake (*Crex crex*) as case studies by which to review, and further develop, DRA and health management strategies for avian reintroductions, and comprises:

1. A literature review, to identify the DRA methods and diseases encountered in avian reintroduction projects to date;
2. Risk factor analyses, to determine factors affecting a) survival of corncrake chicks to the point of release, and b) incidence of specific non-infectious disease conditions (in corncrakes and cranes);
3. A retrospective critical review of the DRA for crane reintroduction in light of disease outcomes;
4. Leading from the above, development of avian-specific DRA and health management guidelines for reintroductions.

Both infectious and non-infectious disease conditions have been significant threats to crane and corncrake reintroductions. Husbandry modifications were required to reduce the prevalence of non-infectious diseases during both projects. Strict biosecurity measures and prophylactic medication successfully prevented infectious disease outbreaks during captive rearing for crane reintroduction. Disease threats (including those related to husbandry) need to be factored into project planning at an early stage, in order to maximise animal health, welfare, and reintroduction success.

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DRA for herptofauna translocations

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Disease Risk Analysis (DRA) is a tool that helps to identify, justify, assess and communicate disease hazards faced in translocations of wildlife. DRA also can describe mitigation methods which could be applied to reduce these risks. This review shows how DRA has been applied in four herpetological translocations in the United Kingdom. It focuses on the ecological, evolutionary and/or geographic barriers crossed in each pathway for common European adder, sand lizard, pool frog and smooth snake translocations. A concise summary of each translocation case study is included, but we focus on illustrating how crossing barriers along the translocation pathway alters the risk profile. The difference in ecology and translocation pathway for each species also illustrates the flexibility in application of qualitative DRA tools.

Co-authors: John G. Ewen, Jim Groombridge and Anthony W Sainsbury

Retrospective health screening of beavers on the River Otter, Devon

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Two families of breeding beavers were reported on the River Otter, Devon, in February 2014. After a successful public campaign to see them remain in place, Natural England granted a 5 year licence to monitor the beavers. A condition of this licence was that the animals were healthy and free of any diseases and parasites of concern. Though beavers are not especially recorded as being major reservoir of disease, as rodents they can harbour pathogens of health concern. *Echinococcus multilocularis* has been recorded in an imported beaver in an English captive collection. An additional consideration of any health screening was to assess the adaptability of beavers to survive in an English landscape after an absence of over 400 years. This study found that all five animals examined were physically healthy and presented no obvious signs of disease. Evidence of previously healed wounds on all adult tails were observed, most probably as a result of former territorial disputes which are common for this species. All beavers were in good to very good body condition and appear to be adapting well to an English landscape and presented no welfare cause for concern. The two adult females were pregnant. Haematology and serum biochemistry were judged against previously established normal values for beavers and were largely unremarkable. No haemoparasites were recorded. All beavers were negative for Tularemia, bovine TB and EM. One beaver tested positive for Leptospirosis (Aleppo strain). All individuals were passed fit for re-release, presenting no health concerns to humans, livestock or other wildlife. All beavers were released back into their respective territories on 23rd and 24th March 2015.

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Health screening for water voles *(Arvicola amphibious)* released in England since 2012

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It has been estimated that over the course of the last century the water vole *(Arvicola amphibius)* has undergone a range decline in mainland Britain in excess of 90%. Concerted attempts are now being made to breed water voles in captivity for release projects in the UK. This project team was tasked with designing and carrying out pre-release health plans to prevent introduction of novel, damaging or zoonotic diseases and so ensure healthy voles were released. Pre-release testing involved: faecal analysis for endoparasites including *Cryptosporidium* spp. and *Giardia* spp.; pelage examination for ectoparasites/dermatophytes; blood sampling for serological testing for Hantavirus and *Leptospira* spp. exposure as well as haematology and serum biochemistry; post-mortem of any sick/debilitated voles which included examination for intermediate-stage cestode infestation, histopathology of all major body organs and PCR of fresh liver samples for *Franciscella tularensis*. Results over 3 years show very low levels of infectious disease at pre-release with *Cysticercus fasciolarus* the intermediate stage of the carnivore cestode *Taenia taeniformis*, a positive *Leptospira* titre and occasional carriage of *Cryptosporidium parvum* being seen. No evidence of Hantavirus exposure, *Echinococcus mutlilocularis*, *Giardia* spp. *Franciscella tularensis*, *Salmonella* spp., *Campylobacter* spp. or *Yersinia* spp. were isolated. Further work on pre-and post-release monitoring is planned to follow-up on this work.

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Development of a mAb library targeting *Batrachochytrium dendrobatidis* antigens for the field diagnosis of chytridiomycosis

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Fungal diseases are a growing threat to the health of global ecosystems. The chytrid fungus *Batrachochytrium dendrobatidis* (Bd) causes chytridiomycosis, a catastrophic disease of amphibians (frogs, salamanders and caecilians) responsible for the greatest disease-driven loss of biodiversity ever documented. Rapid detection and biosecurity are essential to prevent further extinctions as the global spread of a hyper-virulent lineage of Bd is linked to the international trade in amphibians. The World Organisation for Animal Health has listed Bd as an internationally notifiable disease and yet current diagnostic methods for monitoring occurrence and spread of the fungus are time-consuming and cannot be carried out in the field. DNA-based techniques such as PCR are the most effective detection methods at present, but require transportation of potentially infectious material to diagnostic laboratories manned by skilled scientists and equipped with costly and sophisticated equipment. While results are potentially available in a matter of hours, they typically take several days or even weeks to appear by which time diseased amphibians have been transported from sites of infection. Consequently, there is a pressing need for the development of cheap and user-friendly diagnostic assays that can be used by unskilled workers in the field to rapidly identify infected animals and prevent the spread of the disease to fungus-free populations. One such method is the lateral-flow assay (LFA), a rapid (10 min), cheap, point-of-care test (POCT) that incorporates monoclonal antibodies (mAbs) specific to disease-causing organisms and utilises the same simple but powerful technology as pregnancy tests. The goal of the present study is to develop an LFA for the rapid field diagnosis of chytridiomycosis. To this end, we have developed a library of monoclonal antibodies (mAbs) targeting Bd antigens and have begun characterising these based on isotype, affinity, and specificity, in order to determine the best possible candidates for a prototype LFA.

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Garden Wildlife Health

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The Garden Wildlife Health (GWH) project investigates reports of sick or dead wildlife including garden birds, amphibians, reptiles and hedgehogs *(Erinaceus europaeus)* from across Great Britain. A combination of two independent but complementary surveillance schemes is employed: opportunistic reports are solicited from the public and systematic surveillance is undertaken by a citizen science network. For the latter, both the presence/absence of species and the presence and perceived absence of ill-health in garden wildlife are recorded on a weekly basis throughout the calendar year. Post mortem examinations are performed on a subset of wildlife mortality incidents. Integration of surveillance data with relative abundance trends enables quantification of the impact of disease at the population level.

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The Scottish Code for Conservation Translocations

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Conservation translocations can provide a conservation benefit by increasing the number of individuals or places in which a species occurs. They can also offset biodiversity declines caused by habitat loss, climate change, or other human impacts on the environment. Many conservation translocations are low-risk. However, some have the potential for negative impacts on the environment and other land-uses. The Scottish Code for Conservation Translocations has been produced by the National Species Reintroduction Forum. The Code sets out when conservation translocations may be appropriate and the types of situation in which they may cause problems to wildlife, people, and the environment.

A summary of the Code:

- Work out whether translocation is the best option
- Where translocation is the best option, develop a clear plan to deliver well-defined conservation benefits
- Obtain necessary permissions and licences
- Maximise the chances of success by understanding the biological needs of the species
- Take great care to protect the species being moved, the habitat it is being released into, and avoid the spread of invasive species, pests and diseases
- Where translocations may affect people, consult with land-users and other interested groups and individuals to identify potential benefits, and do not undertake translocations that would cause unacceptable harm to people's wellbeing, livelihoods and recreational activities
- Monitor the translocation and respond to any issues that arise
- Keep people informed and share information about the translocation to guide future projects

A full version of the Code, and the associated Best Practice Guidelines for Conservation Translocations in Scotland, can be found at www.snh.gov.uk/translocation-code

Genomic analysis of enteric bacteria in isolated translocated wildlife populations

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The process of translocation of threatened wildlife may have unknown consequences on pathogen transmission and evolution in host populations. Our understanding of some of the epidemiological features of infectious disease in vulnerable populations can be enhanced by the use of genomic sequencing of microbes in natural ecosystems. The genomic epidemiology of a prevalent rail-associated endemic bacterium, *Campylobacter* sp. *nova 1,* was explored in a well-described population of a New Zealand endangered flightless bird, the takahe (*Porphyrio hochstetteri*). The distinctive population structure of translocated takahe provides a unique opportunity to investigate the influence of host isolation on enteric microbial diversity. Whole genome sequencing, ribosomal multi-locus sequence typing (rMLST) and CRISPR analysis was performed on 70 *C.* sp. *nova 1* isolated from multiple takahe populations. *C.* sp. *nova 1* was genomically diverse and multivariate analysis of 52 rMLST alleles revealed location-associated differentiation of *C.* sp. *nova 1* sequence types. Possible explanations for the observed pattern include; the spatial expansion and isolation of hosts resulting in reduced gene flow of *Campylobacter* spp. and allopatric speciation, the presence of heterogeneous environmental attributes influencing sequence type carriage or cross-species transmission of *Campylobacter* spp. from sympatric reservoir hosts. This study suggests subtle but important differences in host-microbe relationships may occur as a consequence of conservation management which has important implications when relocating wildlife populations.

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The Scottish Beaver Trial – Veterinary health monitoring and disease screening

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Sixteen Norwegian wild-caught beavers (Castor fiber) were released in Scotland between 2009 and 2010 as part of a five year reintroduction programme, the Scottish Beaver Trial. The veterinary health monitoring was divided into three phases. During the pre-release phase while the beavers were in statutory quarantine all animals underwent a thorough clinical examination and were screened for a variety of animal and human pathogens, based on a disease risk analysis and statutory requirements. No significant pathogens were isolated that precluded any animal for release. The beavers came with a host of endogenous parasites but as they did not clinically affect the individual or pose a risk to other hosts were left untreated. Six animals died while in quarantine due to unrelated causes. The period in captivity or quarantine should be kept to a minimum for animal welfare. The second phase was immediately after release, during which two animals died; one with circulatory failure and one for which the cause of death was not determined. The final phase was longer term after release and during re-establishment in the wild, until the end of the trial duration. Monitoring at this stage was reliant on visual observations by field workers and an attempt to catch at least all individuals once during this period. Once caught, animals were weighed, measured and samples taken to repeat the pathogen screening. As a result of this monitoring one animal was removed from the trial due to poor body condition. Two kits died, most likely due to predation.

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The Scottish Beaver Trial – Monitoring beaver ecology 2009–2014

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In partnership with Scottish Natural Heritage (SNH), the Wildlife Conservation Research Unit was responsible for independent analysis of data on the ecology of the beavers translocated from Norway to Knapdale, Argyll. During the 5 year trial, that ended in June 2014, four pairs of beavers and their offspring were monitored. Using monthly records of beavers present at Knapdale, we compared the survival of released beavers, the reproductive success of individuals that settled at the site, survival of wild-born kits, and the rate of population growth over the duration of the trial, with that of other reintroductions in Europe and the source population in Norway. We used field sign locations collected by the Scottish Beaver Trial to map the ranges of each beaver family, and used data collected from GPS tags, and dataloggers that recorded depth in the water, to describe their behaviour, with the aim of assessing whether the beavers were behaving ‘normally’. SNH carried out annual otter surveys to ensure that the presence of otters at Knapdale was not negatively impacted by the trial.

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The Scottish Beaver Trial – Public health monitoring 2009–2014

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Argyll and Bute Council led the independent public health monitoring during the Scottish Beaver Trial at Knapdale, Argyll. The primary objective was to monitor water for signs of significant contamination with the parasites *Cryptosporidium* or *Giardia*, so that appropriate action could be taken to protect public health if this occurred. Water samples were taken downstream of the four lochs into which beavers were released. Each catchment was sampled on a quarterly, seasonal basis. Water samples were taken using a PMU 7 Backpack Sampling Unit, which is specifically designed to sample for *Cryptosporidium* in raw water by passing a known volume of water through a filter. The filter was then returned to the laboratory for analysis. Analyses of water samples were undertaken by Scottish Water. Samples were analysed for the presence of *Cryptosporidium* oocysts and *Giardia* cysts.

No significant increases in numbers of *Cryptosporidium* oocysts or *Giardia* cysts were found during monitoring. The observed levels were not liable to give rise to disease in consumers of the water, and no interventions to protect public health were required. The study was not able to reach firm conclusions as to whether beavers represent an additional factor responsible for the presence or absence of *Cryptosporidium* or *Giardia* in the study area. Therefore a public health risk assessment was recommended and is being taken forward at a national level. It will report in May 2015.

Disease risk analysis and management for Steller's eider *(Polysticta stelleri)* reintroduction in Alaska

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Reintroduction of captive bred individuals to historical nesting grounds is planned to aid recovery of the Alaska-breeding population of the Steller's eider (*Polysticta stelleri*), listed as threatened under the US Endangered Species Act. Disease transmission and mortality risks associated with translocation of birds have been identified as key risks to be considered in decision-making and planning of reintroduction efforts. Disease management objectives to address the risks are to 1) maintain disease transmission risk from captive to wild populations of eiders and sympatric species below an acceptable level (considered a critical risk; "risk-to-birds") and 2) minimize disease-related mortality of released eiders (considered a risk to success of reintroduction; "risk-to-success"). To meet risk management objectives, we elicited input on acceptable risk levels from resource managers and stakeholders, conducted a formal disease risk analysis, and developed disease monitoring and risk management protocols for captive source populations and release candidates. Identification and ranking of disease risks were based on disease monitoring of captive population, disease surveys at planned release location, regulatory guidelines for avian pathogens of concern in the region, published literature, and expert opinion. We used qualitative and quantitative methods to assess risk levels. For selected disease agents, a demographic population model and epidemiological data were used to quantify population level effects to assess potential magnitude of impact. Disease management strategy involves biosecurity, pre-release monitoring of captive population and release candidates, vaccinations and other pre-release treatments, post-release monitoring of released population and sympatric species, and disease response plans.

Health surveillance for an osprey (*Pandion haliaetus*) reintroduction project in south of Portugal

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Breeding ospreys (*Pandion haliaetus*) were still common along the Portuguese coast at the beginning of the 20th century. By 1978 only two pairs remained on the coast of south-west Portugal and in 2003 the last remaining individual disappeared. A five year reintroduction project was set up in 2011 at the Alqueva dam in the Alentejo region. It was implemented by the CIBIO, with funding from EDP, the Portuguese Electric Company and collaboration with organisations in the donor countries of Finland and Sweden.

Prior to air transportation, prophylactic antioxidant therapy was administrated to avoid capture myopathy. Individual health-screening was undertaken when the birds arrived in Portugal to characterize health status through clinical examination and through establishing physiological parameters, including blood biochemistry and hematology, age, sex and body condition. This was repeated during hacking and/or before the birds were released. No pathogenic agents were detected in the screening process (which included tests for Avian Influenza, Newcastle's Disease and *Salmonella*) except for one individual in which an internal parasite (trematode) was found.

During the project we have faced some challenges, with 10 clinical cases (involving nine out of 44 nestlings) including birds diagnosed with nutritional deficiencies (secondary osteodystrophy and weight loss), traumatic lesions (fractures, luxations, tendon ruptures), and behavioural disorder (feather-plucking). Despite these issues 40 ospreys have been successfully released into the wild through hacking. Four post-release casualties have been detected involving one collision with a fence and three deaths from predation. The first birds returned to the hacking area in April 2015, offering encouragement that the project will succeed in its aims.

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To treat or not to treat? Investigating the impact of polyparasitism in translocated woylies (*Bettongia penicillata*), and the effect of anti-parasite treatment on host fitness and survivability

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The woylie or brush-tailed bettong (*Bettongia penicillata*) is currently listed as critically endangered, and parasitic disease is suspected of playing a role in the recent decline of this endemic Australian marsupial. Polyparasitism, in which a host is co-infected with various parasite species or intraspecific strains, is common in wild animal populations. Whilst parasites have been implicated in a number of species declines, the role of polyparasitism as a potential factor contributing towards translocation failures has never been investigated. This project is currently evaluating how fauna translocations impact the transmission of blood-borne, endo- and ectoparasites in woylies, and what consequences this has for translocated hosts and other cohabiting species. We are testing the hypothesis that fauna translocations lead to a higher diversity of parasites within the resultant host-parasite community, and therefore a higher incidence of polyparasitism; which in conjunction with the disruption of established host-parasite associations, may exacerbate the negative impacts of parasites on their hosts to the detriment of translocation success. Secondly, as the effects of anti-parasite treatment in translocated hosts are relatively unknown, we are also assessing the effect of parasite removal in translocated hosts. In particular, we aim to test the hypothesis that anti-parasite treatment reduces the incidence of polyparasitism, thereby improving host fitness and survivability post-translocation. One year into this 3-year study we have observed changes to the predominant species of *Trypanosoma* in woylies pre- and post-translocation, and that anti-parasite treatment has had a significant effect on both target and non-target parasites of the translocated hosts.

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Prevalence of the zoonotic pathogenic bacteria, *Salmonella* and *Campylobacter*, in translocated populations of a New Zealand reptile, the tuatara (*Sphenodon punctatus*)

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Tuatara (*Sphenodon punctatus*) are New Zealand endemic, cold-adapted reptiles and the sole extant representatives of the order Rhynchocephalia. Once widespread throughout New Zealand, human colonisation and the introduction of mammalian predators resulted in their extirpation from the mainland and restriction to isolated, predator-free offshore islands. Translocations to extend the range of tuatara have been essential to their conservation. In October 2012, several unprecedented large-scale translocations moved 220 adult tuatara from Stephen's Island in the Cook Strait to four North Island New Zealand sanctuaries. It is unknown how movement outside of their ecological region and the associated changes in climate might affect their susceptibility to potentially harmful pathogens. Despite presence in the environment and other fauna, previous attempts to detect *Salmonella* in tuatara were negative, suggesting that tuatara may be innately resistant or their low body temperatures may not support bacterial proliferation. Similarly, *Campylobacter* prevalence in tuatara was equivocal. To investigate prevalence, cloacal swabs were taken from tuatara at multiple study sites. Analyses involved selective culturing, serotyping and PCR analysis. My research has identified *Salmonella saintpaul* for the first time in a translocated individual, indicating that tuatara are able to carry these bacteria. Preliminary *Campylobacter* results suggest that prevalence may range between 57% and 100% of sampled individuals, indicating that *Campylobacter* could be commensal in tuatara. This work provides critical information to inform the conservation of a species of evolutionary and cultural significance, as well as testing for shifts in a reptilian bacterial community under increased environmental temperature.

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Translocation of head-started Burmese star tortoises *(Geochelone platynota)* into the wild

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Burmese star tortoises (*Geochelone platynota*), were considered functionally extinct in the wild (CITES I) and have been the focus of conservation efforts by the Wildlife Conservation Society (WCS) and Turtle Survival Alliance (TSA) for more than a decade. As of 2014, there were approximately 5,000 captive bred and 200 wild born (founders) star tortoises in three propagation facilities in Myanmar. WCS and TSA have conducted in-country training programs, and assisted in development, facilitation, and implementation of management plans to ensure effective turtle conservation. In 2013,150 captive bred tortoises (4-5 years of age) were placed into soft release pens after extensive health assessments were performed on all individuals. Testing performed included physical exams, molecular diagnostics (ranavirus, intranuclear coccidia, herpesvirus, Mycoplasma), complete blood counts (WBC, differential, PCV, TS), and fecal parasitology, using portable hematology and molecular laboratories. Of the first 150 tortoises, 50 were released to the wild 6 months later, then another 50 at 12 months and the final 50 at 18 months. Another group of 300 tortoises were placed into soft release pens in January 2015 after similar health work-ups. Of the first 100 animals released to the wild, there have been two confirmed deaths and three confirmed wild nests. All tortoises in soft release pens are weighed and measured monthly. The first 100 tortoises released are monitored in the wild via radio telemetry. To date, no known pathogens have been found in the captive, head started or released tortoises.

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Primate relocations: a way to success

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Habitat loss is one of the main threats to the survival of primates. Therefore, relocation is an increasingly popular tool to solve conflicts between humans and animals or simply to restock small populations threatened by inbreeding. Although the review of these operations is an essential component to improve them, little has been done to summarize the available information for primates.

In this study we explored the main predictors of success in primate relocation. In order to investigate this, we searched published data on primate relocations. We then created a database where we included most of the variables known to affect relocation success, according to the IUCN guidelines for the relocation of non-human primates. We tested the association between each of the predictors and two criteria of success: success declared by the author and success based on relocated population dynamics.

The results indicate that no one of the predictors we included in the analysis were associated with any of the criteria of success. This may imply that other factors are crucial to determine successful operations. We found, however, a correlation between the two criteria of success, proving that authors generally base their opinion on population dynamics. As a caveat of this analysis, we must stress that these results may have been biased by the small sample size and the difficulties in quantifying the results in many of the project reports.

A new qPCR for identifying the most common strains of Avian Malaria in translocated birds in New Zealand

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Avian malaria parasites (genus *Plasmodium*) have the ability to cause morbidity and mortality in naïve hosts, and their impact on the native biodiversity of New Zealand is potentially serious. These parasites have been found in 35 different bird species in New Zealand and has been diagnosed as causing death in threatened species such as dotterel (*Charadrius obscurus*), South Island saddleback (*Philesturnus carunculatus carunculatus*), mohua (*Mohoua* sp), hihi (*Notiomystis cincta*) and two species of kiwi (*Apteryx spp*.). Most avian malaria infections in New Zealand are caused by three common strains with a wide host range, namely Linn1, Novyella SYAT05 and *Plasmodium elongatum* GRW6. Of concern is also the *Plasmodium relictum* strain GRW4 which had a devastating impact on the native birds of Hawaii.

New Zealand relies heavily on translocations of its endemic birds to predator free reserves (offshore and mainland Islands) for wildlife conservation and avian malaria is one of the target diseases for health screening in birds prior to translocation.

We are developing a new method for diagnosing the three most common and ubiquitous strains of avian malaria in New Zealand as well as GRW4 by using real time PCR and high resolution melt (HRM) technology. This method will be faster, more sensitive and cheaper than previously used PCR protocols. In addition, this method is also helpful in finding potential mixed infections with different strains of *Plasmodium*, which is advantageous compared to standard PCR methods which underestimate mixed infections. This method will be invaluable for rapid screening of endemic birds for translocation.