CHESTER ZOO

2016 SCIENCE REVIEW

Reporting period January to December 2016

Calumma malthe chameleon, Madagascar

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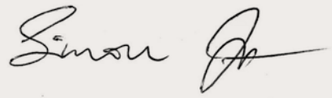
Front cover: Golden mantella *(Mantella aurantiaca)* research at Chester Zoo

FOREWORD

Science is at the heart of our mission to be a major force in conserving the living world. Our conservation activities at Chester Zoo must therefore provide evidence that we are achieving the greatest possible impact. The creation of the role of Science Director demonstrates just how important science is for Chester Zoo and I had the very great privilege of taking up this role in 2016. Our scientific activities are wide ranging and multi-disciplinary, enabling us to tackle the many challenges faced by conservation in innovative and practical ways. We are strengthening our expertise in our six conservation and science specialisms through building the capacity of our own staff and through a number of close collaborations with universities and research institutes. A particular feature of these collaborations is our growing body of Conservation Scholars and Fellows who are working on projects as diverse as elephant welfare, orchid propagation, amphibian translocation strategies and human-wildlife conflict mitigation.

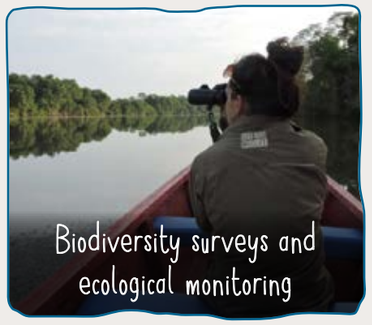
This work has never been more crucial as increasing numbers of species are added to the IUCN Red List of Threatened Species. Many of these species are already dependent on conservation management to ensure their continued survival and many more will require repeated interventions in the future. Our science is therefore directed at taking a more holistic 'One Plan Approach' to species conservation. Our world-renowned collection of animals and plants enables us to develop the expertise and technical skills that are then adapted and applied to our field programmes. This transfer of knowledge provides us with the evidence required to determine the most effective conservation strategies by answering crucial questions concerning habitat quality, population viability and the impacts of climate change.

Science also underpins the evaluation of our learning and engagement activities, enabling us to inspire and motivate people to value wildlife through carefully designed community interventions. This will be an increasing area of our future work as we continue to develop the most effective ways to connect people with wildlife.



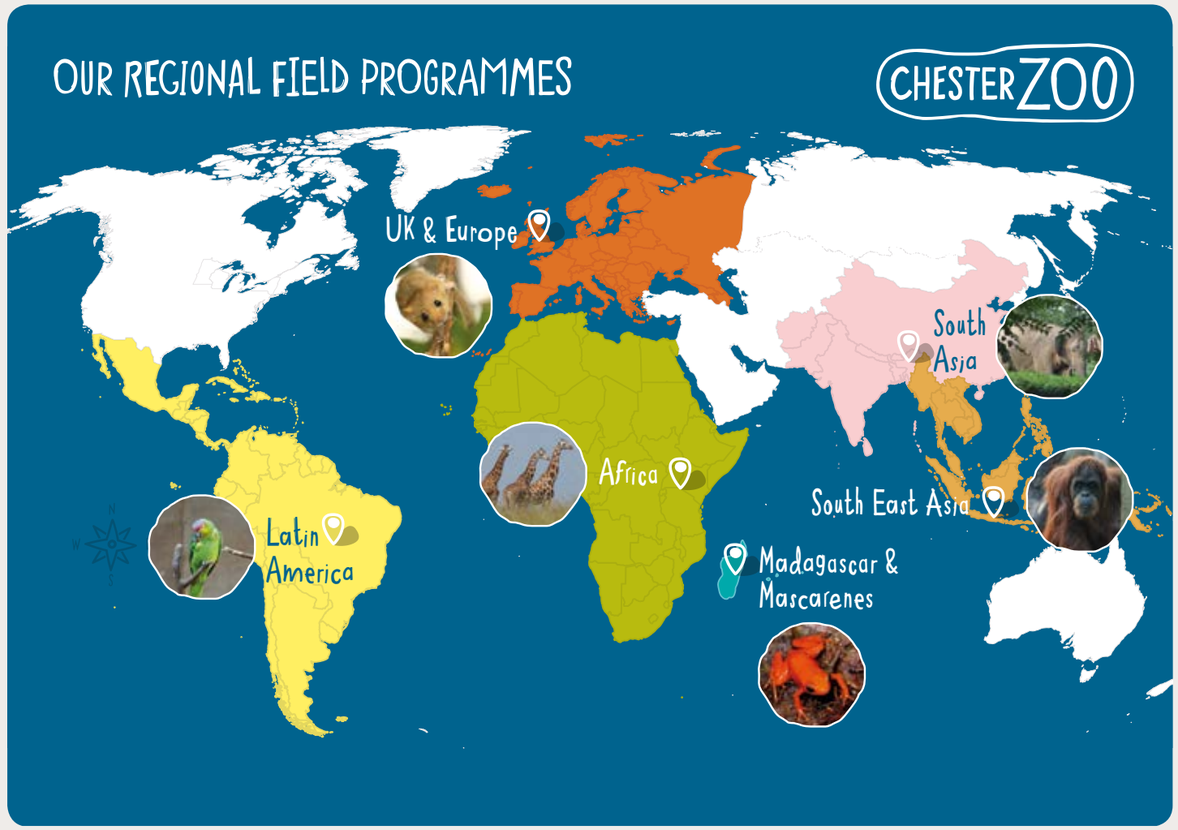
Dr Simon Dowell

OUR CONSERVATION & SCIENCE WORK FOCUSES ON SIX SPECIALISMS



SCIENCE AT CHESTER ZOO

Our science helps to promote the sustainability of wild populations and inspires the next generation of applied conservation scientists. It also provides evidence that informs decisions intended to improve the management of the animals and plants in our care. Our scientific activities within our six specialisms encompass conservation projects both within Chester Zoo and across six major global regions.



Staff from many areas of the zoo are actively conducting, supervising or advising on scientific research that informs conservation actions. We prioritise research that has a positive impact on the living world, either directly by providing evidence to support conservation strategies, furthering scientific knowledge, and improving animal management, or indirectly by evaluating and guiding perceptions and attitudes. Research proposals are reviewed by Chester Zoo's Science Committee and considered for approval based on their association with at least one of our six conservation and science specialisms and/or our regional field programmes.

In 2016 we supported 160 scientific projects, 56 of these directly involving Chester Zoo staff as leaders, supervisors or technical advisors. We also supported 30 research projects through conservation funding, provided biological samples or data to a further 23, and 50 projects were conducted through the undergraduate training scheme. This support resulted in 43 peer-reviewed publications during 2016 that included either one or more co-authors from Chester Zoo or an acknowledgment for providing support.

More information on our current and previous projects can be found on our website **www.chesterzoo.org/conservation-and-science.**

To keep up to date with our scientific activities you can follow us on twitter **@ScienceatCZ.**


Working in Chester Zoo's endocrinology laboratory

Chester Zoo Conservation Scholar and Fellow Programme

Over the past year Chester Zoo's Conservation Scholar Programme has continued to develop and we are now proudly supporting 17 postgraduate research students from nine institutions. We welcomed six new Conservation Scholars to our Programme in 2016. These students are working on a diverse range of topics across a variety of species such as population monitoring of Ecuador Amazon parrots, scent communication and physiology of eastern black rhinoceros, human-tiger conflict in Nepal, conservation genetics of mountain bongo, and exploring the immune system of Asian elephants. Our commitment to capacity building and equipping the next generation with the skills required to make a difference in international conservation is exemplified by our recently graduated Conservation Scholar Ee Phin Wong. Ee Phin completed her PhD this year focussing on the management strategies of Asian elephant-human conflict in Peninsular Malaysia, and is now an Assistant Professor at the University of Nottingham Malaysia Campus. Ee Phin's research is featured on page 17. In 2016 we also announced the new Fellowship Programme for postdoctoral researchers. Dr Ximena Velez-Liendo is the first of these Conservation Fellows and introduces herself and her research on Andean bears on page 18.

Award Winning Science

For the fourth consecutive year we were awarded a Gold Research Award at the BIAZA Annual Conference. The research, led by our Conservation Social Scientist, Andy Moss measured the global educational impact of the world's zoos and aquaria over two surveys involving 10,000 visitors to 30 institutions worldwide. This study provides valuable evidence reaffirming the important role of zoos and aquaria as providers of biodiversity-related education. Find out more about this research on page 24.

Our international conservation efforts were also recognised as we received a Gold Conservation Award in recognition of our collaboration with Madagasikara Voakajy and Paignton Zoo for our project on Madagascan amphibians, the Critically Endangered golden mantella *(Mantella aurantiaca)* and the Endangered harlequin frog *(Mantella cowanii)*. This research featured the first ever census of the golden mantella in Mangabe and vital environmental and ecological data were collected for the conservation of the harlequin frog. Chester Zoo staff were directly involved in leading this fieldwork and developing techniques that were shared with our Madagascan colleagues. Our support for this project has not only benefited amphibians but many other taxa due to habitat protection and restoration and ultimately the newly classified protected area of Mangabe.


Harlequin mantella frogs *(Mantella cowani)* are endemic to Madagascar

We were also recognised for our conservation activities closer to home and awarded a Silver Conservation Award along with the Lancashire Wildlife Trust for a project that focussed on the conservation breeding and reintroduction of the large heath butterfly *(Coenonympha tullia)* to Heysham Moss, which is described in detail on page 17. Another Gold Award was earned through our collaboration with nine other BIAZA collections for efforts to conserve the fen raft spider *(Dolomedes plantarius)*, one of the UK's rarest animals. The ten institutions joined efforts in the conservation breeding of this species resulting in the release of 6,000 spiders to East Anglia over a three year period.

New partnership with the University of Oxford

In 2016, Chester Zoo formed a partnership with the University of Oxford's Wildlife Conservation Research Unit to work together on major challenges in conservation by combining a number of our overseas projects with top quality science. Over the next seven years this collaboration will span ten Chester Zoo Conservation Scholars and Fellows placed into Chester Zoo's conservation projects around the world. This collaboration will provide new research to assist conservationists in developing innovative approaches to mitigate human-wildlife conflict, promote sustainable development and livelihoods, and to monitor populations of endangered species in the wild.


Camera trap image from Bardia National Park, Nepal

MAXIMISING AND MEASURING CONSERVATION IMPACT

To ensure that Chester Zoo's conservation and science activities produce the best possible outcomes we employed our first Conservation Impact Officer in 2016. Dr Kay Farmer was welcomed to the zoo in April and below outlines why and how we must evaluate our conservation and science projects.

Many modern zoos state that they contribute to conservation, education and research. Indeed, The Secretary of State's Standards of Modern Zoo Practice states that zoos should demonstrate measurable performance in these three areas to comply with legislation. This contribution may be through research, sharing skills or training and conservation breeding, and must also include promoting public education and awareness. Zoos are free to make their own decisions about the exact contributions (e.g., the kind of projects undertaken, whether participation is through financial or 'in kind' support, how to target efforts, where the work is carried out, to work alone or in partnership, and how to fund conservation activities). Zoos are urged however, to put in place measures to evaluate the effectiveness of their contribution to conservation by collecting evidence and/or engaging in research projects to do this. Conservation professionals have also recognised the importance of evaluation for both accountability and improving interventions (Margoluis *et al.* 2009). The Chester Zoo 5-year

strategy 'Natural Vision' reflects this recognition in Strategic Objective 1 "to ensure that our conservation and educational activities, both in the zoo and globally, achieve the greatest conservation impact" – this means evaluating the conservation impact of our activities.

The range in the scope and scale of our conservation projects is considerable and we work in partnership with a wide range of organisations worldwide. Over the past three decades Chester Zoo has worked with 465 partner organisations on more than 800 conservation projects in 117 countries, targeting more than 350 species. These include projects on both local and regional scales, with recipients including students (undergraduate and post graduate), national and international NGOs, and research institutions. Our financial support ranges from less than a hundred to several hundred thousand pounds and we support short-term projects that may last just a few months as well as providing ongoing assistance for long-term initiatives. In some cases we design and implement our own projects with the help of in-country partners to ensure delivery, such as the Assam Haathi Project – see page 21 for further information. We also provide resources to projects operated by other conservation NGOs who are best placed to implement effective conservation on the ground, such as the Mauritian Wildlife Foundation. The type of technical support we provide ranges from helping with the design of nest boxes for hornbills, to developing education plans with partner organisations.

Recognising this range in scope and scale, Chester Zoo and WAZA developed the Project Conservation Impact Tool in 2006 (http://www.waza.org/en/site/conservation/conservation-impact). Chester Zoo has adopted the system to inform how the projects are both selected and evaluated. Whilst a pilot phase of the selection scoring system found the basic method and structure sound and easy to use, scoring the five different types of projects (research, species, habitat, training, and education) comparatively proved problematic (Mace *et al.* 2007). To better reflect current thinking, Chester Zoo is now exploring how best to both maximize and measure the impact of the conservation projects it supports and leads.

It is important to recognise that measuring and demonstrating conservation impact presents unique challenges. The parts we act on (e.g., individuals, communities, governments, society) are not the parts we ultimately want to influence (e.g., species, habitats or ecosystems). Links between interventions, outcomes and impacts are often relatively untested and unknown. Evaluation can take place at many times during a project, from inputs (money, equipment, expert time), activities (workshops, training courses, surveys), outputs (reports written, people trained, fences built, etc.), to impacts (a measurable improvement in the conservation status of the species or habitat). It is often, however, focused on inputs and outputs due to the time lag between intervention and impact. Many conservation evaluations are an afterthought, and as a result, no baseline data are collected and little or no data are collected throughout the project's life. An additional complication for Chester Zoo is the vast range in scope and scale of the conservation projects that we support.

If we want to understand what works best and under which conditions however, we must stop, look, listen, analyse, and learn – this means improving our ability to evaluate. See pages

Assessing the effectiveness of Chester Zoo's education and outreach activities is essential to achieve the greatest conservation impact

26-31 to read more about the evaluation work we do on zoo based education activities, and on the health and wellbeing of the animals at Chester Zoo. We must understand the conditions under which, specific evaluation designs are appropriate (for Chester Zoo led and supported projects) to ensure they are useful and lead to sound management decisions. For evaluation to be meaningful it is crucial to consider expected outcomes at the beginning, not just at the end, and collect data along the way. This takes us to the principle of ensuring an adequate theory of change by which the project design starts with thinking about impact first and works through the process backwards (from impact to outcomes, then outputs, activities and inputs), forcing us to think through the logic and assumptions between each stage, and to measure incremental change at various points. Good, continuous, systematic monitoring is crucial to tweak ongoing activities in the face of changing circumstances or poor decisions. To know whether we have achieved what we set out to, we need good measurable indicators, most likely a mixed methods approach combining quantitative and qualitative data. We need to bridge the biologist-social scientist and practitioner-researcher gaps to accelerate learning and optimise effectiveness. Ultimately evaluating impact is much more than measuring effectiveness; it is about engaging the conservation community in evaluation so that it is integrated into project design, management and practice to maximise impact.

References

Margoluis, R. *et al.* (2009) *New Directions for Evaluation,* 122, 85-96
Mace, G.M. *et al.* (2007) *Zoos in the 21st Century,* 21, 322-342

BIODIVERSITY SURVEYS AND ECOLOGICAL MONITORING

Biodiversity surveys and ecological monitoring are key research tools that help to identify areas and species of most conservation value and need, and also provide data to allow effective monitoring and evaluation of implemented conservation measures. Chester Zoo staff and partners offer a broad range of survey skills, taxonomic knowledge and regional specialisms associated with our well-established field programmes.

Where have all the pigs gone? Tracing the last populations of Javan warty pigs

The Javan warty pig *(Sus verrucosus)* is endemic to Java, Indonesia. It is categorised as Endangered by the IUCN but is not protected under national legislation. Threats to the species include persecution such as hunting and poisoning to prevent damages to crops, habitat loss, hunting and possibly competition and hybridisation with European wild boar *(Sus scrofa)*, a historically introduced species that is very common on Java.

The current geographical distribution and population size of this species are unknown but an interview-based survey conducted in 2003 found a 53% decline in reported sightings since 1982. Assuming that the decline detected in 2003 is real and ongoing, it is possible the Javan warty pig may be locally extinct in many locations. The species might even be at immediate risk of becoming extinct in the wild as there are currently no confirmed wild populations. The aim of this project, led by Dr Johanna

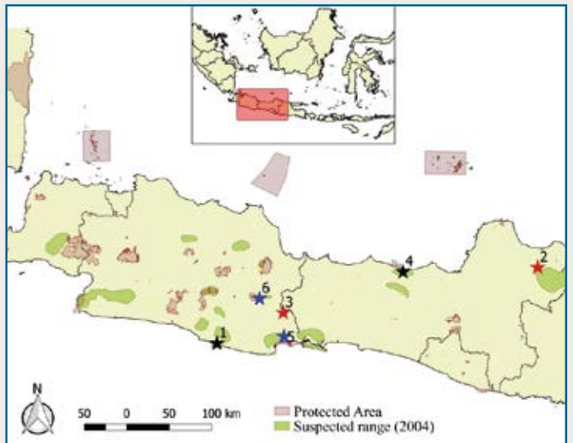


Figure 1: Field sites of the Javan warty pig survey. Red star = presence, black star = absent, blue star = survey to be conducted. 1 = Leuwang Sancang (protected area), 2 = Blora, 3 = Banjar, 4 = Subah, 5 = Pangadaran, 6 = Ciamis.

Figure 2. Camera trap image of a male Javan warty pig *(Sus verrucosus)*

Rode-Margono, Chester Zoo's South East Asia Programme Coordinator, is to find extant populations of the species, assess relative abundances at each study site, investigate existent threats, and increase knowledge about their ecology and habitat requirements.

Based on interview surveys conducted in 2003 and informal reports from local people, six study sites were selected in West and Central Java to perform intensive camera trapping, nocturnal reconnaissance surveys and interviews (Figure 1). This work began in June 2016 and so far the field team have visited a total of six sites to conduct interviews and intensive surveys. Seventeen independent videos of clearly recognisable Javan warty pigs were recorded at two of the sites. Pigs that were captured on video from the single protected area were all confirmed as wild boar, despite results from questionnaires suggesting that people believed approximately 10% of the pig populations would be warty pigs.

The next phase of the study will include detailed habitat assessments of all sites and the camera trap locations. Based on our results we will be able to plan conservation and protection measures and to inform conservation breeding and reintroduction plans. In particular, a more intensive conservation and research project has the potential to be established in order to secure at least one of the remaining healthy populations of Javan warty pigs.

A previous study (Rademaker *et al.* 2016) investigated the population size and socio-ecology of the closely related Bawean warty pigs *(Sus blouchi)*, and will be integrated into this research. This species is endemic to a 196 km^2 large island off the coast of East Java, an island free of wild boar. Around 250 animals are estimated to inhabit the island and with no threats posed by potential hybridisation and competition, the population offers a natural control to study their effects in Javan warty pigs.

Publications

Rademaker, R., Meijaard, E., Semiadi, G., Blokland, S., Neilson, E. W. & Rode-Margono, E. J. (2016) First Ecological Study of the Bawean Warty Pig *(Sus blouchi),* One of the Rarest Pigs on Earth. *PLoS ONE,* 11, e0151732

Assessing the status of Grauer's gorilla and chimpanzees in eastern Democratic Republic of Congo

This study assessed the distribution, abundance and status of the world's largest primate, Grauer's gorilla *(Gorilla beringei graueri),* and the eastern chimpanzee *(Pan troglodytes schweinfurthii)* in eastern Democratic Republic of Congo (DRC). It represents the most comprehensive review and survey of these species yet conducted. One of the most biodiverse regions on the African continent, eastern DRC has been characterised by insecurity and lawlessness since the start of the Congolese civil war in 1996. Many militia groups have controlled different areas and established artisanal mining camps to fund their operations. Most of these mining camps are focussed on the illegal extraction of minerals associated with the global micro-electronics trade and rely on access to bushmeat to feed miners. Great apes are among the more highly prized bushmeat species because of their relatively large size. While declines in both species had been suspected previous to this study, the true status of these great apes was largely unknown.

To address this, between 2012 and 2014 The Wildlife Conservation Society (WCS) and Fauna & Flora International (FFI) worked with Institut Congolais pour la Conservation de la Nature (ICCN) and local communities to undertake surveys across the region using a variety of methods: line transects, reconnaissance walks, and patrol data were collected by National Park and community based rangers. Chester Zoo's Africa Field Programme Coordinator, Stuart Nixon, was a principal collaborator on this study with FFI and colleagues from WCS, ICCN, University of Stirling, Smithsonian Tropical Research Institute, University of York and CIRAD. The team carried out multiple analyses that identified a threshold occupancy probability, estimating the area where each ape is likely to occur in the landscape. Using measures of average density from across the landscape it was estimated that only 3,800 (95% confidence limits: 1,280–9,050) Grauer's gorillas remain in the wild across their range, while about 37,740 (95% confidence limits: 14,019–67,196) chimpanzees are still present in the landscape (Figure 3). Transect data collected by WCS in 1994 was also made available for this study which was reanalysed and compared with transect data collected in the same regions between 2013 and 2015. This comparison revealed a catastrophic decline in both species of ape across the region since 1994 with an estimated 77–93% decline in Grauer's gorilla and declines of 22-45% in eastern chimpanzee populations.

Grauer's gorilla *(Gorilla beringei graueri).*

Eastern Chimpanzees *(Pan troglodytes schweinfurthii).* © A. Plumptre, Wildlife Conservation Society

BIODIVERSITY SURVEYS AND ECOLOGICAL MONITORING

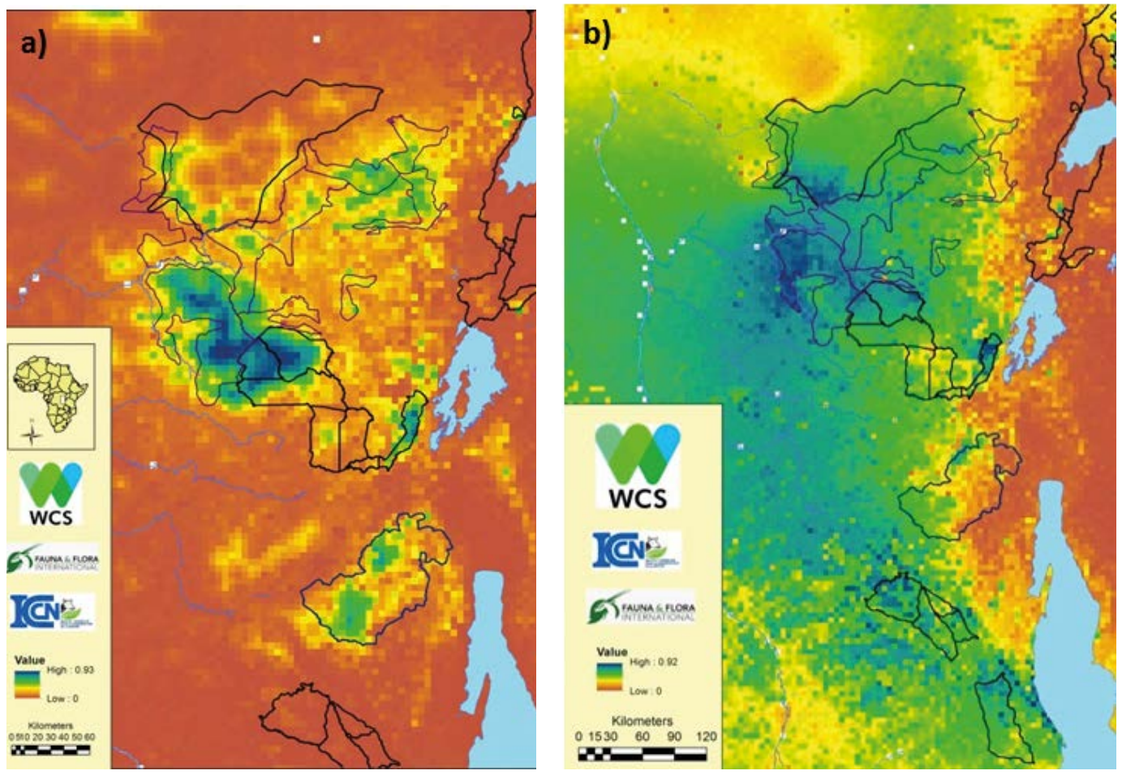
As a direct result of this research the conservation status of the Grauer's gorilla was changed from Endangered to Critically Endangered in 2016 (IUCN 2016) justified by an 80% decline in 20 years. The eastern chimpanzee is more widespread, occurring across northern and eastern DRC as well as in Central African Republic, Uganda, Rwanda, Burundi, western Tanzania and western South Sudan, and may not be as threatened across its range but given the precipitous decline in this part of DRC it should be monitored closely. The results of this study have led to the gazetting of a new protected area, the Itombwe Nature Reserve, increased global awareness of conservation issues facing great apes in eastern DRC and triggered the mobilisation of significant funding for Grauer's gorilla conservation.

Publications

Plumptre, A.J., **Nixon, S.,** Critchlow, R., Vieilledent, G., Nishuli, R., Kirkby, A., Williamson, E.A., Hall, J.S. & Kujirakwinja, D. (2015). Status of Grauer's gorilla and chimpanzees in eastern Democratic Republic of Congo: Historical and current distribution and abundance. Report to Arcus Foundation, *USAID and US Fish and Wildlife Service.*

Plumptre AJ, **Nixon S,** Kujirakwinja DK, Vieilledent G, Critchlow R, Williamson EA, et al. (2016) Catastrophic Decline of World's Largest Primate: 80% Loss of Grauer's Gorilla *(Gorilla beringei graueri)* Population Justifies Critically Endangered Status. *PLoS ONE,* 11(10): e0162697

Figure 3: Results of occupancy analysis (cooler colours indicate high probability of presence). a) Grauer's gorilla and b) eastern chimpanzees



Chester Zoo Conservation Scholars

Population status and conservation of the critically endangered Bermuda skink *Plestiodon longirostris*,

Helena Turner, University of Kent

The One Plan Approach (OPA) to species conservation planning; applying the framework to a species of endangered Ecuador amazon parrot, *Amazona lilacina*

Rebecca Biddle, Manchester Metropolitan University

Additional Research Projects

Assessing spatial movement of Eurasian badgers *(Meles meles)* on the Adlington Estate, Cheshire, Chester Zoo and Wirral & Cheshire Badger Group

Banteng abundance, ecology and spatial relationship with the main predator dhole in Ujung Kulon National Park, Indonesia, Chester Zoo

Monitoring & Surveying of Chester Zoo Nature Reserve, Chester Zoo

Developing methods for genetic analysis of faecal samples of threatened Indonesian deer and pig species to investigate population sizes, small population genetics and hybridization, Chester Zoo and National Museum of Nature History (NMNH) Luxembourg

Ecuador Amazon Parrot Research and Monitoring Programme, Chester Zoo and Fundacion Pro Bosque

Gashaka Biodiversity Project, Chester Zoo

North West Dormouse Partnership, Chester Zoo

Community based monitoring of endangered and endemic okapi, Congo peafowl and great apes in eastern Democratic Republic of Congo, Chester Zoo and Fauna & Flora International

Conserving Kidepo Valley National Park's endangered Rothschild's giraffe through integrated and collaborative conservation research, Chester Zoo and Giraffe Conservation Foundation

Conserving the golden mantella frog: Monitoring forests, ponds and populations for better management, Chester Zoo and Madagasikara Voakajy

Pine Marten Recovery Project, Chester Zoo and Vincent Wildlife Trust

Sichuan Forest Biodiversity Project, Chester Zoo, Sichuan Forest Department, Laojunshan, Mamize, Heizhugou, Ma'anshan and Qincaiping nature reserves and Leshan Normal University.

Survey and monitoring for better conservation of the harlequin mantella frog, Chester Zoo and Madagasikara Voakajy

The survival of endangered species increasingly relies upon the viability of small fragmented populations, including zoo populations. The IUCN Conservation Breeding Specialist Group (CBSG) highlights that to achieve viable populations of species thriving in healthy ecosystems, initiatives must involve integrated species conservation planning. To be efficient, this planning has to consider all populations of the species both inside and outside the natural range under all conditions of management. For this to be successful, we need to maximise population viability and understand the consequences of gene flow within and among captive and wild populations. Investigating factors that could negatively impact on the reproductive viability of populations, then allows us to make informed management decisions to boost the reproductive success of threatened species. To ensure the long-term survival and viability of populations within the zoo, our staff members manage or assist the European Endangered species Programmes (EEPs) through routine assessment of studbook population data and support individual reproductive management through the evaluation of physiological status (endocrinology) and/or efficacy of contraception (EAZA Group on Zoo Animal Contraception www.egzac.org) programmes. We also apply our small population management skills in the field to assist with integrated species management to maximise the success of reintroductions of captive bred individuals to the wild. The knowledge and skills of zoo staff are critical in delivering effective applied population management strategies which will improve overall viability of populations of endangered species.

Identifying refugee populations of Cape mountain zebra

Chester Zoo Conservation Scholar, Jessica Lea, along with Dr Susanne Shultz from the University of Manchester, has been researching the Cape mountain zebra *(Equus zebra zebra),* a sub-species endemic to the Cape of South Africa and listed as Vulnerable on the IUCN Red List. Cape mountain zebra provide an ideal study species to explore how to target management across a meta-population. From fewer than 80 individuals in just three populations in the late 20th century, numbers have increased to over 5,000 individuals today. However, the sub-species is now spread across a large number of sub-populations, some of which have very slow growth rates. Most of the reintroduced populations contain genetic information from just one of the three founding populations. Moreover, the many disconnected populations are found across a wide range of habitat types, ranging from grassland to shrubland to almost desert-like Karoo.

Geographic Information System (GIS) software was used to map vegetation communities to estimate grass availability (the zebra's primary food source) in each reserve. These measures were used to produce a habitat quality score for 21 Cape mountain zebra populations. Census data collated across populations including growth rates, population density, female reproductive rates and adult sex ratios demonstrated a clear relationship between habitat quality and population performance (Figure 4). Finally, faecal glucocorticoid and androgen metabolites were sampled from over 160 individuals across seven populations to assess variation in individual physiological status. Faecal glucocorticoid concentrations were elevated in low quality habitat, and faecal androgens were significantly higher in populations with heavily male-biased sex ratios. This indicates that individuals in populations with low habitat quality show signs of chronic stress, and excess stallions may cause increased male competition. Zebra populations with a low abundance of grass and elevated faecal glucocorticoids had lower growth rates, occurred at lower densities, and had lower female reproductive rates. These results indicate two potential causes of poor population growth: low habitat quality and skewed sex ratios.

Chester Zoo Conservation Scholar Jessica Lea

A Cape mountain zebra 'family group' in Gamkaberg Nature Reserve, consisting of mainly grass-poor fynbos shrubland.

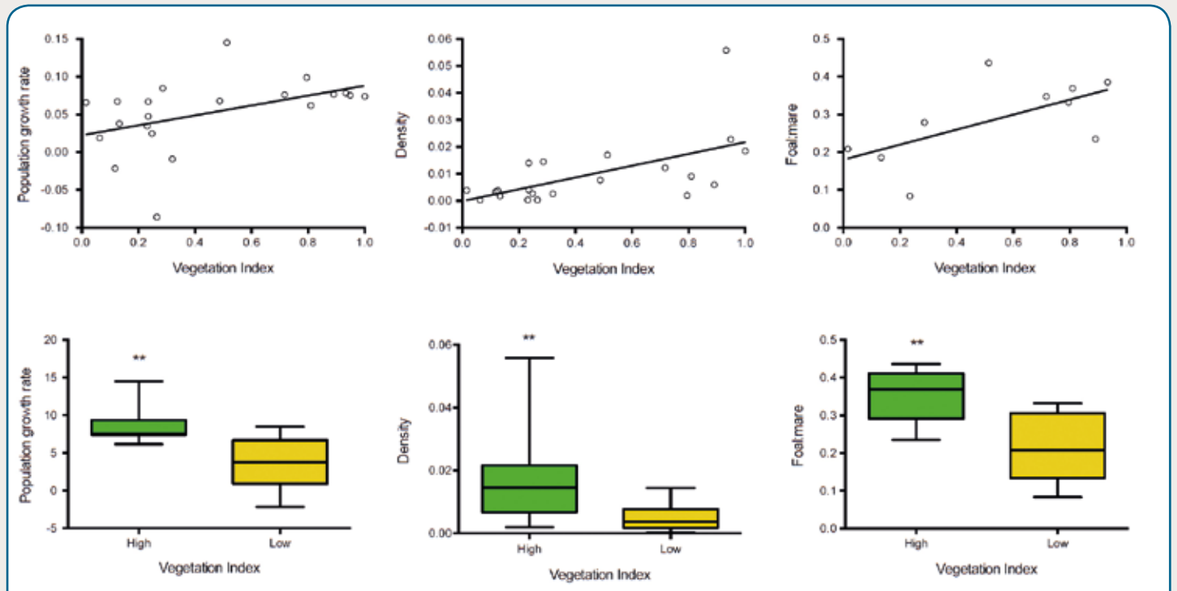


Figure 4: From Lea *et al.* (2016), population growth rate, zebra density (individuals ha-1), and female fecundity (foal:mare ratio) of Cape mountain zebra are all positively associated with habitat quality (Vegetation Index).

This project was the first to use physiological measures over a large scale (termed "macrophysiology") to identify potential causes of poor population growth. In addition, these results were used to assess the on-going management plans and make future recommendations. We recommend that reserve expansions and translocation events should be focused towards areas with high grass availability to maximise population growth. Management should also consider the demographic structure of populations in order to avoid sex-ratio bias in either source or founder populations.

Publications

Lea, J. M. D., Kerley, G. I. H., Hrabar, H., Barry, T. J. & Shultz, S. (2016) Recognition and management of ecological refugees: A case study of the Cape mountain zebra. *Biological Conservation,* 203, 207-215.

Lea, J. M. D., Walker, S. L., Matevich, S. C., Kerley, G. I. H., Jackson, J., & Shultz, S. (Under review) Macrophysiology uncovers relationships between demography, habitat and population performance in a vulnerable species, the Cape mountain zebra, *Functional Ecology*

Chester Zoo Conservation Scholar Ee Phin Wong working in the field with Asian elephants *(Elephas maximus)*

Non-invasive monitoring of 'stress' in wild Asian elephants in Peninsular Malaysia

Asian elephants *(Elephas maximus)* are classified as Endangered by the IUCN. Their main threats are a combination of habitat loss and fragmentation often resulting in human-elephant conflict, due to elephants raiding crops. This conflict is causing economic loss to plantation owners and smallholders in Peninsular Malaysia. Translocation of elephants from sites of conflict to large contiguous forest areas has been extensively used as a strategy for mitigating this issue for over 40 years. However, little is known about the fate of translocated elephants after release.

Chester Zoo Conservation Scholar, Ee Phin Wong, based at the University of Nottingham Malaysia Campus, has been researching the impact of these translocations on the elephants' physiology. Ee Phin, with support from Chester Zoo's Head of Applied Science Dr Sue Walker, tested non-invasive endocrinology methods using faecal samples in tropical field environments. The ability to carry out continuous health monitoring using non-invasive methods in free ranging wildlife is an attractive prospect for wildlife managers. Glucocorticoid is one of many hormones involved in the body's physiological responses towards challenges. Glucocorticoid hormones are important for modulating daily energy usage, facilitating physiological changes to cope with a stimulus or stress event, help the body in recovery from stress and to prepare for the next challenge. Metabolites, when extracted from the dung matter and measured, give an indication of the amount of glucocorticoid circulating in the body. First, an experiment was carried out on 80 dung piles with 685 subsamples to verify the stability of faecal glucocorticoid metabolites in a tropical environment. These faecal glucocorticoid metabolites (a measure of 'stress') in the dung were stable for up for eight hours in a tropical environment. Five translocated elephants were monitored using GPS collars and faecal samples were collected between two-months and a year post-release. These elephants were found to have lower faecal glucocorticoid metabolite levels in comparison to local (non-translocated) elephants. This was in the opposite direction than first expected, a prolonged decrease in adrenal activity rather than an increase. These conditions could have an adverse effect on stress response and health (e.g. adrenal insufficiency, chronic fatigue or post-traumatic stress disorder). This research has highlighted that translocation has long-term consequences on elephant health, which needs to be taken into consideration in human-elephant conflict mitigation.

Publications

Wong, E. P. (2016) Non-invasive monitoring of stress in wild Asian elephants *(Elephas maximus)* in Peninsular Malaysia, PhD thesis, University of Nottingham Malaysia Campus

Wong, E. P., Yon, L., Purcell, R., **Walker, S. L.,** Othman, N., Saaban, S., Campos-Arceiz, A. (2016) Concentrations of faecal glucocorticoid metabolites in Asian elephant dung are stable for up to 8h in a tropical environment. *Conservation Physiology,* 4(1),1-7.

Asian elephants *(Elephas maximus)*, the elephant on the left wears a GPS collar after being translocated

Released large heath butterflies in copulation at Heysham Moss in June 2014

Restoration of the large heath butterfly to Heysham Moss, Lancashire

The large heath *(Coenonympha tullia)* is an internationally endangered butterfly which has suffered a 50% UK decline in the last 30 years. Listed under Section 41 of the Natural Environment and Rural Communities Act (2006), it is also identified as a Priority Species in the UK Biodiversity Action Plan. The main threat faced by this species is loss of habitat; the species relies on wet moorland and boggy areas, which both have undergone huge decline across the country. Prior to 2014 in Lancashire, the large heath was found at only one site: Winmarleigh Moss SSSI. Historically, it was much more widespread, being found throughout the lowland raised bogs of North West England. However, a loss of 98% of this peatland habitat in the UK resulted in a species decline of 49% since the 1970s (Butterfly Conservation Trust, 2015). The large heath butterfly was lost from Heysham Moss in Lancashire in the early 20th Century due to drainage of the area. The overarching aim of this project is to restore a self-sustaining population of butterflies at this site by 2020.

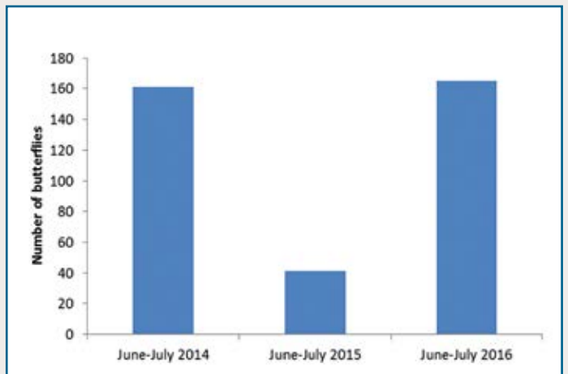


Figure 5: Numbers of large heath butterflies released at Heysham Moss Nature Reserve between 2014 and 2016.

Since 2012, Chester Zoo has worked with Lancashire Wildlife Trust (LWT) to restore the species to Heysham Moss, where it has been locally extinct for over 100 years. After acquisition of the site in 2004, LWT undertook restoration work at the site to ensure the habitat was suitable for the species. They also engaged with the local community to raise awareness, and motivate people to appreciate and protect the fragile bog habitat, and the rare butterfly – Heysham Moss having been damaged by fires twice in the last decade. Over the summer of 2012, hare's-tail cotton grass *(Eriophorum vaginatum)* and cross-leaved heath *(Erica tetralix)* plants, which are important food plants for large heath butterflies at the larval and adult stages respectively, were collected from Chartley Moss and brought back to Chester Zoo. They were then potted and propagated in preparation for the butterfly rearing phase. A zoo-based conservation breeding programme was initiated in 2013, with five gravid female butterflies collected in early July from Winmarleigh Moss SSSI following the advice of experts from Butterfly Conservation and the RSPB, and under license from Natural England. Three purpose-built enclosures were constructed to house the butterflies during their time at the zoo and the butterflies were raised in controlled conditions throughout their life cycle under the care of curatorial staff. This whole process has been repeated three times since the first females were collected in 2013.

In the summers of 2014, 2015 and 2016 pupae were transported to Heysham Moss and released as freshly emerged adult butterflies. Over 350 butterflies have been released at the reintroduction site over the course of the conservation breeding phase of the project (Figure 5). Successes so far include released butterflies observed in copulation immediately after the first release in 2014, and butterflies recorded on site prior to subsequent releases in 2015 and 2016. This demonstrates that the whole life cycle has been completed in the wild at Heysham and confirms that habitat restoration for the butterflies has been successful. From 2016 until 2020, the large heath butterfly populations will be monitored through timed counts and transect walks during the flight period at both Heysham Moss and Winmarleigh Moss. Habitat monitoring will also continue to ensure it remains suitable for the species.

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CONSERVATION BREEDING AND MANAGEMENT

Chester Zoo Conservation Scholars

Can conservation physiology improve the population management of eastern black rhinos?
Nicholas Harvey, University of Manchester

Fencing African elephants in Kenya: landscape and welfare impacts
Jacqui Morrison, Manchester Metropolitan University

Genetics and conservation in the mountain bongo,
Tommaso Sandri, Manchester Metropolitan University

Investigating scent communication in the eastern black rhino *(Diceros bicornis michaeli),*
Rebekah Titchard, University of Liverpool

Keeping fit for the ark: Are zoo-bred reptiles and amphibians ready to go back to the wild?
Luiza Passos, University of Salford

Managing aggression in captive primates,
Veronica Cowl, University of Manchester

Orchid - mycorrhizal fungal interactions; improving propagation methods for chlorophyllous and mycoheterotrophic orchids,
Oliver Hughes, Manchester Metropolitan University

The Pine Marten Recovery Project,
David Bavin, Vincent Wildlife Trust and University of Exeter

Linking ecology and physiology to aid conservation of wild equids
Jessica Leah, University of Manchester

Management strategies of Asian elephant-human conflict in Peninsular Malaysia
Ee Phin Wong, University of Nottingham and MEME

Additional Research Projects

Asian Wild Cattle Project, Chester Zoo and IUCN SSC Asian Wild Cattle Specialist Group

Black Poplar Project, Chester Zoo, RECORD, Cheshire Wildlife Trust and The Mersey Forest

HUTAN Hornbill Conservation Project (HHCP), Chester Zoo and HUTAN

Mountain Chicken Recovery Project, Chester Zoo, Darwin Initiative, Durrell Wildlife Conservation Trust, MALHE, ZSL, Montserrat National Trust, Saving Dominica's crapaud

Preservation of Javan endemic species through conservation breeding and in-situ programmes, in the Cikananga Conservation Breeding Centre (West Java, Indonesia) – Part II, Chester Zoo and Cikananga Conservation Breeding Centre (CCBC)

The translocation and management of the Mauritius Cuckooshrike Coracina typical and the Mauritius Paradise Flycatcher Terpsiphone (bourbonnensis) desolata, Chester Zoo and the Mauritian Wildlife Foundation

Do mixed species aviaries work? Evaluating breeding success of bird species housed within mixed species enclosures within British and European zoological collections, Chester Zoo and Liverpool John Moores University

Environmental impact upon faecal corticosterone metabolite levels in a range of equine species, Chester Zoo and Nottingham Trent University

Patterns of faecal glucocorticoids in Asian elephants at parturition in related and non-related individuals including a comparison of still and live births, Chester Zoo and University of Glasgow

Pregnancy detection in equids using faecal progesterone EIA, Chester Zoo and University of Glasgow

HUMAN-WILDLIFE CONFLICT

Human-wildlife conflict poses a serious, widespread and direct threat to hundreds of endangered species around the world and impacts millions of people's lives. Preventing and mitigating human-wildlife conflict requires not only an understanding of the movements and needs of the species, but also the underlying cultural, political and economic aspects that shape these conflicts. In 2016, we enabled the creation of a global expert advisory group on the topic, the IUCN SSC Task Force on Human-Wildlife Conflict, founded by our Head of Conservation Science, Dr Alexandra Zimmermann. This task force provides advice and guidance for human-wildlife conflicts. Communities that can safely share landscapes with wildlife are paramount for the future of conservation, but achieving this requires an interdisciplinary approach. The Human-Wildlife Conflict Task Force therefore brings together a range of expertise. Members include biologists, social scientists, economists, anthropologists, social psychologists, peacebuilding experts, political ecologists, and many others.

Andean bear conservation project

Dr Ximena Velez-Liendo, Chester Zoo Conservation Fellow

"I am a conservation biologist with fifteen years of experience in Andean bear *(Tremarctos ornatus)* ecology and conservation in Bolivia. My research interests lie in large carnivore conservation, human-carnivore conflict, and GIS. Much of my research work has been to produce basic information to assess the conservation status of the Andean bear in Bolivia, and across South America. For my PhD at the Ecology and Evolution Lab at the University of Antwerp, Belgium I produced the first and still, the only national-level habitat suitability assessment for Andean bears in South America. This study covered more than 100,000km2 of bear habitat in Bolivia and assessed potential distribution, diet, and conservation priorities.

After finishing my PhD, I joined an inter-disciplinary team formed by scientists from the EU, Brazil, Mexico and Bolivia to carry out community-based conservation initiatives. For nearly three years, I worked alongside indigenous T'simane communities in Pilon Lajas Biosphere Reserve in Bolivia where I learnt that coexistence with large carnivores is possible when conservation efforts are initiated and owned by the local people."

Conserving large carnivores is a pressing issue worldwide. The ecological and conservation roles of bears, as keystone and umbrella species, and even the cultural importance of this group addressed by the scientific community, is rarely reflected at the local level where communities can suffer considerable losses of livestock and crops. This is a joint project of Chester Zoo, WildCRU, and the Bolivian NGO Prometa, that aims to assess human-bear conflict and to estimate local population

Dr Ximena Velez-Liendo is among the 2017 applicants for the prestigious Whitley Awards, often referred to as the Green Oscars.

abundance in the Inter-Andean Dry Forests of Tarija, Bolivia, an ecosystem already identified as a priority for Andean bear conservation.

Whilst currently considered Vulnerable by the IUCN this categorisation is based only on inferred trends of their population, habitat models and reported human-bear conflict. Thus, this project will generate the first population estimates for the study area, quantify levels of human-bear conflict, and develop measures to reduce conflict in partnership with local communities.

This conservation initiative is the first of its kind in Bolivia and has so far received a positive response from local authorities who, after the first meeting, declared their desire to include the Andean bear in the municipality emblem if their presence in the local forest areas is confirmed with camera traps.

Regional population abundance will initially be assessed using an occupancy framework based on data from camera traps. An initial success of this project has been to garner the support of local communities by training local field assistants in the operation of the cameras and in asking for their help in selecting the best places to locate them. Cameras must be very carefully located in order to satisfy the protocols of a robust experimental procedure but must also be placed in areas where bears are likely to be found. Locally reported sightings are being used as focal points for this network of cameras. The cameras have been in place since August 2016 and have recently provided the first ever photograph of an Andean bear in the Inter-Andean Dry Forests of Tarija (Figure 6) along with other more common species that inhabit this threatened ecosystem including pumas (Figure 7).

The project will continue in 2017 with questionnaire surveys designed to assess local perceptions and attitudes towards bears together with collecting data on incidences of livestock depredation and crop damage. This data will ultimately be used to develop mitigation measures designed to reduce these losses and the resulting retaliatory persecution of bears by people.

Figure 6: First camera trap image of an Andean bear *(Tremarctos ornatus)* in the Inter-Andean Dry Forests

Figure 7: Camera trap images from the Andean Bear Conservation Project. a) pampas fox *(Lycalopex gymnocercus),* b) pumas *(Puma concolor),* c) Geoffroy's cat *(Leopardus geoffroyi),* d) Molina's hog-nosed skunk *(Conepatus chinga).*

Celebrating conservation success in Assam

In 2004 the Assam Haathi Project (AHP) was conceived in collaboration between Chester Zoo and the Assamese NGO EcoSystems India. The purpose of this project was to facilitate the conservation of elephants by mitigating human-elephant conflict in Assam. The initial success of the project was driven by the communities themselves who, with the support of Chester Zoo, invested a lot of time, effort and often their own finances in developing and testing deterrent methods and sharing their experience and knowledge with neighbouring villages. The Assam Haathi Project has since received £350,000 in funding from the Darwin Initiative that has facilitated research leading to three peer-reviewed publications.

At the end of 2016, the details of more than 3,000 incidents of crop raiding and damage to property had been recorded. The villages and communities where the project began have been constantly monitored for more than 10 years. This research has produced an enviable, long-term dataset that is vital for identifying sustainable methods of conflict mitigation and to facilitate the coexistence between people and elephants. To date, the project has focussed on diversifying livelihoods, documenting patterns of conflict, evaluating mitigation methods and protecting people from the damage that elephants can cause to property and crops. However, a critical component of this conservation initiative is also to promote the viability of Assam's elephant populations. There is currently little knowledge of the movements of elephants through this landscape, how the

The Assam Haathi Project is working towards mitigating human-wildlife conflict involving Asian elephants *(Elephas maximus)*

intervention methods have affected their behaviour and ecology, or even what the population trends are.

Next steps

The next phase of the AHP will address some of these issues. It is hoped that further funding awards in 2018 will enable PhD students and post-doctoral researchers to focus on the ecological and behavioural aspects of elephants in Assam. For example, there is a concern that by employing deterrent methods in project villages that the elephants simply change their behaviour accordingly, therefore reducing conflict in one area may in fact result in increased incidents in neighbouring villages. It is therefore anticipated that by adopting a landscape approach to conflict mitigation a more sustainable solution can be identified which may include for example, the community-led regeneration of forest patches, and/or the creation of corridors

Human-wildlife conflict

Local communities are also involved in alternative livelihoods such as craft making

to enable elephants to move through the landscape without persecution. Focussing efforts on the ecology, behaviour, reproductive success and migration patterns of Indian elephants in Assam will contribute to appropriate long-term conservation planning to ensure coexistence of elephants and people.

Field Programmes Coordinator, Valerie de Liedekerke, and Dr Kay Farmer, Conservation Impact Officer, during their visit to the local communities in May 2016

The Chester Zoo Conservation Science team visited Assam in November 2016 to meet with local partners, EcoSystems India in order to discuss site-selection for the next phase of this project. It is hoped that a landscape-scale approach to improving coexistence can be developed by learning more about elephant herd structure, numbers, and behaviour along with hotspots of conflict, deforestation and community forest regeneration projects. Accordingly, the team also met with influential stakeholders representing local governments, forest departments, student unions, and autonomous councils to gauge their support. During these meetings, the challenges of human-elephant conflict and potential mitigation strategies at a district scale were discussed. Participants in these meetings were broadly supportive of the initiative and a research proposal is currently being drafted in collaboration with our national partners.

Additional Research Projects

Mauritius Fruit Bat Project, Chester Zoo and The Mauritian Wildlife Foundation

Livelihoods and Sustainable Development

Communities that live alongside wildlife or close to protected areas need to receive some benefits from conservation to be able to support it. This is particularly true for poor and marginalised communities in developing countries, where conservation can seem like a luxury in relation to the circumstances in which some people survive. In many cases sustainable livelihoods and development initiatives are essential and must be integrated into conservation strategies if they are to succeed. Many of our field projects are built around this concept, working to find culturally acceptable, equitable and economically viable solutions for communities to benefit from conservation efforts around the world.

Living with Tigers

In 2016, Chester Zoo in partnership with Green Governance Nepal launched the Living with Tigers project, funded by the Darwin Initiative. The main objectives of the project are to design and implement practical interventions to reduce the risk to people and livestock from tiger and leopard attacks. Furthermore, the project also intends to address poverty issues and improve wellbeing, to study the underlying pressures which drive social norms, and the dynamics of conflict using both ecological and social research techniques.

According to the World Bank, 25% of the population of Nepal live below the national poverty line. Many of these people inhabit the Terai lowlands where subsistence livelihoods are closely associated with the regions' protected areas. Over the past 20 years the Terai's human population has increased by 81%, significantly intensifying the pressure on forest resources. Meanwhile, tiger populations in the Terai are reported to have recovered by as much as 63% as a result of rigorous anti-poaching activities (GON 2013). Consequently, encounters between people and tigers have increased and reports of human-tiger conflicts are rising, particularly in the buffer zone forest areas around Chitwan and Bardia National Parks (Dunghana et al. 2016). These areas are vital for most households because 75% of the country's energy supply (as firewood) and 37% of the nation's livestock fodder for livestock is collected from them (Acharya *et al.* 2016).

The Living with Tigers project focusses on conflict hotspot areas within the buffer zones of Chitwan National Park (CNP) and Bardia National Park (BNP) and works with two carefully selected communities in each national park. We expect to work with 400-600 households across each of the National Parks. In these areas we are developing safer practices for communities that use buffer zone forests, while also reducing the need to harvest natural resources by installing fuel efficient cooking

The installation of bio-gas plants and predator proof livestock pens are two main strategies implemented to reduce human-wildlife conflicts in Nepal. ©Prakash Chapagain

stoves. We are also working towards enhancing the protection and husbandry of livestock through improved veterinary care and installation of predator proof livestock pens. With the help of our national partners we are developing ideas with the communities to explore alternative livelihood solutions such as agriculture, artisanal handicrafts and micro-finance opportunities. The project has plans to fund village homestay businesses to support local tourism within the communities, and facilitate the acquisition of equipment and materials for small scale industries such as essential oil distillation and rope making.

This project will address the underlying social causes of human-tiger conflict in the Terai. We hope that by using a social marketing strategy to implement behaviour change, we will create a lasting impact that benefits marginalised communities around Chitwan and Bardia National Parks.

The long-term success of tiger conservation in Nepal is determined ultimately by how socially acceptable and economically sustainable their presence is for the local communities affected. The project will have a lasting positive impact on both poverty and conservation through building capacity and empowering communities to take a sustainable, adaptive and long-term approach to securing and improving their well-being and consequently, improving local tiger habitat and fostering tolerance for tigers.

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An investigation into the knowledge and use of sustainable palm oil in Chester's hospitality industry

Palm oil is an edible vegetable oil that comes from the fruit of oil palm trees. As the highest yielding (Vijay *et al.* 2016, Corley 2009), most efficient and versatile vegetable oil crop (World Bank 2010), palm oil is the world's most widely used edible oil and global consumption is rising (Vijay *et al.* 2016). It is found in 50% of supermarket products, from foods to cosmetics, cleaning products and animal feed (World Bank 2010). The rapid and unregulated expansion of unsustainable plantations, particularly in South East Asia, has resulted in extensive deforestation, loss of biodiversity and increase in greenhouse gas emissions (Vijay et al. 2016, Gaveau *et al.* 2016). Transforming the palm oil market to a sustainable and traceable supply is the most responsible path and the first step to ensuring that the palm oil industry impacts as little as possible on the biodiversity of the regions it is grown in. The Roundtable for Sustainable Palm Oil (RSPO) is the most recognised certification scheme globally, however currently only 20% of palm oil produced is certified, with a focus on manufacturers of products sold in supermarkets (RSPO, 2017). Knowledge of sustainable palm oil in the UK catering industry is unknown and perceived to be more limited.

Our research aimed to identify existing knowledge and current procurement procedures in restaurants around the city of Chester. Part of this research aimed to identify the perceived benefits and barriers to adopting sustainable palm oil procurement in restaurants in Chester and tested acceptance levels for interventions. We found that 80% of respondents had no knowledge of palm oil as an environmental issue and around 40% were unsure whether palm oil was found in their products or not. Some respondents listed multiple barriers preventing them from using sustainable palm oil within their restaurants. From these, it is clear that respondents believe the biggest barriers to be cost, availability and knowledge. Despite the lack of knowledge and unknown use of palm oil, there was a high willingness to engage with us on the topic from local restaurants. A restaurant toolkit was developed to include practical tips to help businesses make and deliver their sustainable choices. Our first sustainable palm oil restaurant partner was The Lowry,

The Green Gold Conspiracy is an interactive game around palm oil issues served over a three-course meal. © Museum of Science and Industry. Sebastian Matthes, Mannox

Salford, and we are currently working with Chez Jules, Chester. Next steps in the project will include communication with survey participants to increase knowledge of sustainable palm oil and encourage uptake in the restaurant toolkit which is available to download from the Chester Zoo website (www.actforwildlife.org.uk/palmoil).

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Chester Zoo Conservation Scholars

Assessing practical interventions for reducing human-large felid conflict in Nepal,
Amy Fitzmaurice, University of Oxford

VISITOR AND COMMUNITY ENGAGEMENT

With over 1.6 million visits a year, Chester Zoo is ideally placed to engage visitors and communities on conservation. Through our many varied learning programmes, a large part of our role as a zoo is to raise awareness and educate the public on ways they can maximise their contribution to conservation. In order to assess the effectiveness of these programmes, we conduct research that allows us to understand the impact of our work, provide evidence-based recommendations for improvements, as well as gaining insight into the value of zoos in connecting people with wildlife.

Measuring the impact of Chester Zoo's in-school education programme

Many zoos have claimed that they have a strong educational impact, but evidence to support this is lacking. Chester Zoo's Safari Ranger programme involves staff from our Discovery and Learning team visiting schools to deliver zoo-related workshops. In order to assess the impact of this approach, a repeated measures survey was conducted before and after students took part in a pilot of a new Safari Ranger programme. The programme ran over the autumn term and consisted of four sessions delivered in the classrooms of UK Key Stage 2 students (ages 7-11). The first three sessions covered three different aspects of conservation, and the final session was a practical craft session.

Before the programme began, the students were given a survey in the style of a worksheet to fill out so that their knowledge of and attitudes towards zoos and conservation could be assessed. The sheet included open-ended questions to test their knowledge of conservation and conservation actions, attitude statements measured on a five point Likert-type scale and a space for the students to draw actions that may help to prevent extinction of wildlife. The students were given the same worksheet after the completion of all four sessions, and we used repeated-measures linear mixed models to look for differences in the students' attitudes and knowledge.

The open ended questions and drawing were numerically coded, with the level of knowledge and understanding displayed increasing with the value assigned. The answers were coded manually, and a sample of them was also coded by a second coder to ensure fair coding. Conservation understanding, knowledge of pro-conservation behaviour and drawing scores showed a significant increase after the sessions. The overall proportion of students who could demonstrate some level of conservation understanding increased from 4.5% to 79.8%.

Safari Ranger delivering an activity in a local school

We also found significant changes in two of the four attitude statements we assessed using Likert-type scales. Students agreed with the statement, "It is wrong for animals to be kept in zoos," significantly less after the sessions. There was a significant increase in agreement with the statement, "Zoos are for saving animals from dying out ('extinction')."

Overall, the results of this study have shown that there is a significant increase in knowledge, as well as changes in attitude statements in students in correlation with their participation in a zoo-run education programme.

Publications

Moss A., Littlehales C., Moon A., Smith C., & Sainsbury C. (2017) Measuring the impact of an in-school zoo education programme. *Journal of Zoo and Aquarium Research,* 5 (1), 33-37

The impact of a zoo-based biodiversity campaign

In 2014, the global biodiversity campaign 'Biodiversity is Us' was launched by WAZA. The campaign was zoo-based, and took place across twenty institutions. Graphics panels were designed to improve visitor understanding of the concept of biodiversity, while a mobile phone application was created in order to suggest actions that visitors could take to protect biodiversity. Short films were produced which focussed on both of these aims. These objectives align with the Aichi Biodiversity Target stating that by 2020, people should have a greater awareness of the value of biodiversity and how to protect it.

In order to assess whether this campaign was an effective way of working towards this target, we carried out repeated measures surveys of visitors in 2014/15 as they entered and left various zoos and aquariums. Before and after the visit, we asked a series of open questions to assess their level of biodiversity understanding. We asked participants to list what they thought of when presented with the word 'biodiversity', and we asked them to suggest ways in which they could help to conserve animal species.

We found a greater understanding of biodiversity was present after the zoo visit, with a proportional increase of 8.9% in the number of visitors who were able to display some form of biodiversity understanding (Figure 8). We also found that visitors who could recall seeing some of the 'Biodiversity is Us' campaign showed a significantly greater increase in knowledge than those who did not. In addition, we discovered a 22.3% increase in the number of visitors who were able to suggest an action that could help to conserve species that is feasible at an individual level (Figure 8).

Based on these findings, we recommend that zoos and aquariums take advantage of their position as educational institutions and display more targeted biodiversity materials to increase understanding and contribute towards meeting Aichi Target 1.

Visitors at Chester Zoo

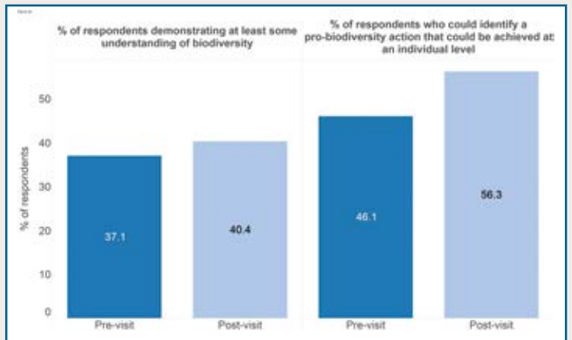


Figure 8. Overall comparison before and after a visit to a zoo or aquarium for the two dependent variables – biodiversity understanding (n = 2743) and knowledge of actions to help protect biodiversity (n = 2585) – in the 2014–2015 survey.

Publication

Moss, A., Jensen, E & Gusset, M. (2017) Impact of a global biodiversity education campaign on zoo and aquarium visitors, *Frontiers in Ecology and the Environment,* 15 (5), 243-247. doi:10.1002/fee.1493

Additional Research Projects

Evaluating the longer-term impact of being a Chester Zoo volunteer, Chester Zoo

Measuring the educational impact of Chester Zoo's in-zoo taught education ('Discovery') programme, Chester Zoo

Measuring visitor engagement with interpretation: Evaluating the success of the site-wide redesign of Chester Zoo interpretation, Chester Zoo

Observing the social interaction of families at Chester Zoo to inform planning for the 2017 investment in PLAY! Chester Zoo

Persons as animals, University of Leeds and Chester Zoo
The impact of a zoo-based biodiversity campaign, Chester Zoo, WAZA and The University of Warwick

What impact does exhibit design have on conservation, education and visitor experience? Chester Zoo and Queens University Belfast

Developing and improving the education and eco-tourism value of terrestrial biodiversity conservation sites in Mauritius, Chester Zoo and Mauritian Wildlife Foundation

Mkomazi Rafiki wa Faru, Chester Zoo and George Adamson Wildlife Preservation Trust


Monsoon Forest at Chester Zoo's *Islands*

The many research projects we conduct at Chester Zoo are designed to address and inform on matters that may impact on the health and wellbeing of our living collection. We regularly evaluate our husbandry techniques, the enclosures and environmental enrichment using a range of methods to provide evidence-based recommendations for the care of the species. We also investigate potential causes and treatments for diseases to benefit both the animals at the zoo and their species in the wild.

Evaluating *Islands* at Chester Zoo

In 2015 Chester Zoo opened *Islands,* the largest development in UK zoo history. The area covers 15 acres, contains over 600 individual animals and aims to replicate the habitats of six South East Asian islands. This development offered the unique opportunity to study the impact of re-housing animals and to evaluate the design of the new enclosures. The majority of animals that moved to *Islands* came from exhibits within the core zoo and enabled us to assess animal behaviour and welfare both pre and post move within the same individuals. A multi-disciplinary approach was used to assess, not just the animals, but also the visitors, in order to evaluate the success of the development. A combination of animal behaviour, endocrinology and social science techniques were used.

Data collection first began in 2013 and has, to date, involved over a dozen students working across five main focal species plus smaller studies on other Islands species. Over 2,000 hours have been spent collecting data on Sumatran tigers *(Panthera tigris sumatrae),* Sulawesi macaques *(Macaca nigra),* Sumatran orangutans *(Pongo abelli),* southern cassowaries (Casuarius casuarius) and rhinoceros hornbills *(Buceros rhinoceros).* In addition to behavioural observations, faecal samples were also collected from the Sulawesi macaques and southern cassowaries to monitor glucocorticoid and reproductive hormone activity, which was linked to the behavioural data.

To assess how visitors responded to Islands three main approaches (observations, surveys and focus groups) were used to identify differences in visitor behaviour and attitudes at enclosures both before and after species were moved. An extremely low prevalence of conversations related to conservation were found at pre-move exhibits, however visitor attitudes were positive towards the role of zoos in saving species from extinction. This study is now being repeated to explore any differences in visitor response between *Islands* and the previous exhibits. As part of a post-doctoral project with the University of Leeds ('Persons as Animals'), focus groups of zoo visitors gave almost unanimous positive feedback regarding Islands. In particular, participants reported feeling as if they were in closer contact with the animals, and that they could almost imagine that they were seeing them in their natural habitats in South East Asia.

Results from the animal behaviour data collected have revealed that animal visibility has increased for four of the five main focal species. In addition, there has been a marked increase in positive social interaction behaviours in the Sumatran orangutan group (Figure 9). The Sulawesi macaque social networks have been maintained despite the introduction of a new male (Figure 10) and three macaques have successfully produced offspring since their move. Furthermore, faecal hormone analysis suggested that both cassowaries were exhibiting reproductive cycles (Figure 11) and began to show breeding behaviours for the first time. These individuals have now been brought together in the same enclosure.

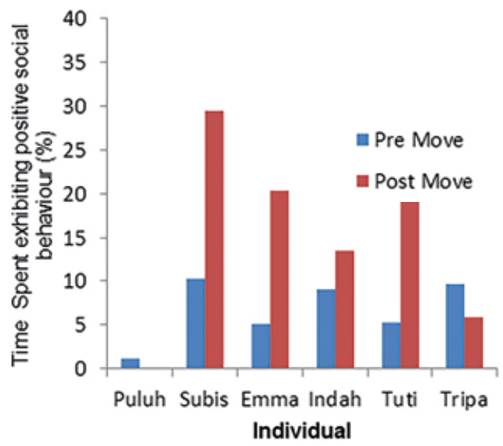


Figure 9. Positive social behaviour in Sumatran orangutans *(Pongo abelli)* at Chester Zoo significantly increased after their move to Monsoon Forest in *Islands.*

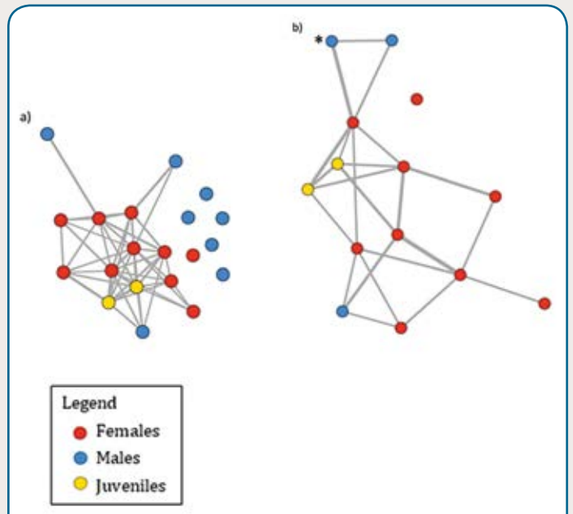


Figure 10. Social network *(Macaca nigra)* diagrams for proximity networks in a) the monkey house, and b) the breeding group in *Islands*. Line thickness is a proxy for the frequency of interactions, with thicker lines indicating that individuals spent more time, on average together. The networks indicate that social relationships remained relatively stable throughout their move to *Islands,* and that the new male (* in Figure 10b) integrated quickly into the already established social group.

The next phase of Islands is being developed in 2017 and will involve the move of more species. Data collection has begun on two focal species which will be moving to new enclosures, the Malayan tapirs (Tapirus indicus) and Malayan sun bears (Helcarctos malayanus). Behavioural observations will continue into 2017 for the current Islands species. This project has revealed that by combining methodologies we can provide vital information required for evidence-based management of captive species. Final results will provide evidence of the success of Islands in relation to both zoo animal welfare and visitor-related outcomes and it is hoped that the final analysis of this research will provide recommendations for future exhibit design.

Monsoon Forest at Chester Zoo's *Islands*

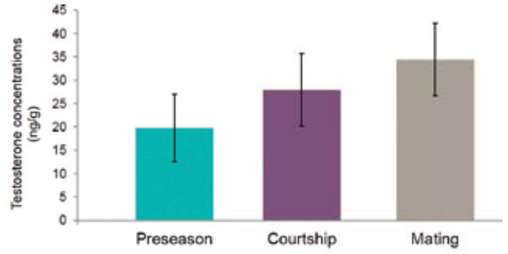


Figure 11. Faecal hormone analysis of a male Southern cassowary *(Casuarius casuarius)* shows an increase in testosterone throughout the breeding season

WILDLIFE HEALTH AND WELLBEING

Mountain chicken frog *(Leptodactyus fallax)* being scanned for a microchip during fieldwork

Tackling disease in mountain chicken frogs

Over 40% of all amphibian species are currently at risk of extinction and emerging infectious diseases are perhaps the most pressing threats that they face. Chytridiomycosis, caused by the fungus *Batrachochytrium dendrobatidis (Bd)*, is known to cause population declines and mass mortalities both in the wild and in zoos. Chester Zoo, along with partners has been documenting the impacts of the disease and conducting ground breaking research in developing treatments both in the field and ex-situ.

The Mountain Chicken Recovery Programme was established in 2002 with the aim of saving the Critically Endangered mountain chicken frog *(Leptodactyus fallax)*. The mountain chicken is a large frog endemic to the East Caribbean, and is now confined to two islands, Montserrat and Dominica after being driven to near extinction by introduced predators, over-hunting for food and the emergence of Bd. Along with partners from the Institute of Zoology (IoZ), Durrell Institute of Conservation and Ecology (DICE), other academic institutions and in-country partners, researchers at Chester Zoo provided one of the first full species assessments for chytridiomycosis by tracking the population before, during and after the emergence of the disease. This research revealed a species decline representing one of the fastest ever recorded, with a loss of over 85% of the population on Dominica and nearly 100% in Montserrat over a period of 18 months (Hudson et al. 2016a).

There is a pressing need to mitigate the effects of this disease in mountain chicken frogs and Chester Zoo staff members are involved in research to find a treatment. Using capture-mark-recapture methods a proportion of captured frogs were treated with itraconazole. Results of the study revealed that frogs were unable to develop an immune response to the disease, but that treatment increased survival and recovery rate in the short-term. This veterinary approach could be important for short-term measurements to help with conservation actions, and improve population survival during periods of high disease risk (Hudson et al. 2016b).

The captive colonies (quarantine and non-quarantine) of mountain chicken frogs are still playing a vital role for the future of the species in the wild. It is critical to design a strategy that clarifies the roles for this species programme, managed by Chester Zoo, which assesses the current status of the population, determines future management strategies, and creates individual breeding recommendations for all frogs. After a workshop hosted at Chester Zoo with all partners of the ex-situ programme in the European Association of Zoos and Aquaira (EAZA), the mountain chicken frog programme developed a 5-year Long-Term Population Management Plan (LTMP).

This document establishes the baseline for the recommendations for all specimens and institutions holding the species. This means that the status and trends of the captive population need to be monitored at regular intervals as a basis for the formulation of management measures.

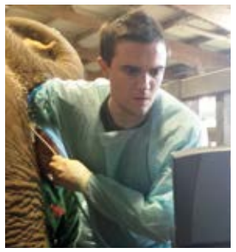
Publications

Garcia, G. & Schad, K. (2016). *Long-Term Management Plan for the Mountain Chicken Frog* (Leptodactylus Fallax) European Studbook (ESB) Chester Zoo & EAZA.

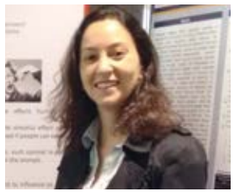
Hudson, M. A., Young, R. P., D'urban Jackson, J. D., Orozco-Terwengel, P., Martin, L., James, A., Sulton, M., **Garcia, G.,** Griffiths, R. A., Thomas, R., Magin, C., Bruford, M. W. & Cunningham, A. A. (2016). Dynamics and genetics of a disease-driven species decline to near extinction: Lessons for conservation. *Nature Scientific Reports*, 6, 30772.

Hudson, M. A., Young, R. P., **Lopez, J.,** Martin, L., Fenton, C., Mccrea, R., Griffiths, R. A., Adams, S., Gray, G. & **Garcia, G.** (2016). In-situ itraconazole treatment improves survival rate during an amphibian chytridiomycosis epidemic. *Biological Conservation,* 195, 37-45.

Chester Zoo Conservation Scholars



Exploring the innate and adaptive immunity of Asian elephants that may confer protection from elephant endotheliotropic herpesviruses haemorrahagic disease (EEHV-HD),
Johnathan Haycock, University of Surrey & Animal and Plant Health Agency



How does sound produced by the zoo-going public affect zoo mammals?
Marina Bonde de Queiroz, University of Salford

Proximate mediators of competitive behaviour in cooperatively breeding mammals,
Rhiannon Bolton, University of Liverpool

The significance of the social welfare of captive Asian elephants *(Elephas maximus),*
Rutendo Wazara, University of Liverpool

Additional Research Projects

An investigation into the activity budgets of the breeding group of African painted dogs at Chester Zoo, Chester Zoo and University of Manchester

Establishing a standardised method of measuring Komodo dragon *(Varanus kmodoensis)* body temperature, Chester Zoo and Manchester Metropolitan University

Evaluating the diets of captive black rhinos in European zoos, with particular emphasis in iron and copper content, Chester Zoo and University of Manchester

Interaction between slender-tailed meerkats *(Suricata suricatta)* and cape porcupines *(Hystrix africaeaustralis),* Chester Zoo and Harper Adams University

Improving gut loading practices for the enhancement of feeder insects fed to reptiles and amphibians in Chester Zoo, Chester Zoo and University of Manchester

Investigating the behavioural impact of carcass feeding on a pride of Asiatic lions at Chester Zoo, Chester Zoo

Investigating the effects of keeper presence on begging behaviour in captive Asian Short Clawed Otters *(Aonyx cinereus),* Chester Zoo and Nottingham Trent University

SCIENCE COMMUNICATION

A large part of our scientific work includes disseminating our findings both nationally and internationally to our peers, but also to the wider public. We achieve this through publications in scientific journals, presenting our work at scientific conferences, providing seminars, lectures and technical training, and delivering a number of scientific events.

Symposia

International Commercial & Conservation Breeding Symposium

In partnership with Marketing Cheshire, Chester Zoo organised and delivered a successful international symposium focussed on conservation breeding. The Commercial and Conservation Breeding Symposium was part of the 'Britain is Great' campaign and brought together animal breeders from industry and conservation. Over 100 delegates shared ideas and techniques and met potential collaborators. For our science to be useful, successful techniques and results must be translated into animal management by communicating with academics, animal managers, wild population managers, funders and the wider public to have a positive real-world impact on species conservation.

Dr Sue Walker, Head of Applied Science, at the International Commercial and Conservation Breeding Symposium, Chester, March 2016

Conservation Symposium 2016: Join the Dots

Chester Zoo hosted its annual Conservation Symposium in October, which this year focused on connecting wildlife, habitats and people. The sell-out event proved exceptionally popular attracting an audience of more than 150 attendees. Speakers from research and conservation organisations including the RSPB, World Land Trust and Borneo Nature Foundation delivered a range of entertaining and inspiring talks on themes of connectivity both in terms of habitat and the relationships between humans and the natural world. The event was chaired by Act for Wildlife patron, TV vet and wildlife presenter, Steve Leonard.

Speakers and Chester Zoo staff at the 'Join the Dots' 2016 Conservation Symposium

Science Festivals

Members of Chester Zoo staff also attended a number of science outreach events in 2016 including the EuroScience Open Forum in July 2016. The largest interdisciplinary science meeting in Europe hosted a total of 4,500 professionals from around the world who gathered to share the latest knowledge in cutting-edge science. Dr Sue Walker was a speaker at the conference and delivered a presentation on how to use science to be more effective in conservation breeding and improve the conservation status of wildlife. Our exhibit at the conference gave us an opportunity to disseminate our science to the wider scientific community and attracted attention from a variety of people of all disciplines interested in our work.

Across five public science festivals, we engaged with over 2,500 members of the public at activities held both in the zoo and at venues in the city of Manchester. As part of the Cheshire-wide 'Amazed by Science' festival in May, Chester Zoo hosted two afternoons of interactive science activities to engage families with the six Conservation and Science Specialisms. In July, we ran an event in the Manchester Cathedral as part of the EuroScience Open Forum public event schedule, 'Science in the City'. Created around the idea of 'Using Science to Save Species', we focused on our work with Asian elephants both in the zoo and in the field. In September, Chester Zoo staff once again took part in the 'Science Uncovered' event as part of the European Researchers Night at the Manchester Museum and showcased their conservation and science work to members of the public. We organised two events as part of the world–renowned Manchester Science Festival, the first of which was held at the Museum of Science and Industry along with our partners, the Vincent Wildlife Trust and the Lancashire Wildlife Trust. We engaged visitors in the type of science we use to help save native species but also showcased what they can do at home as part of our 'Wildlife Connections' campaign. Visitors had the opportunity to build a bug house, practice with radio-tracking equipment, and learn how we measure hormones. Finally, we attended the University of Manchester's 'Science Spectacular' at the Manchester Museum where we gave some of our Conservation Scholars the opportunity to engage with families and talk more about their research.

Children taking part in activities at 'Amazed by Science' at Chester Zoo

Engaging the public at 'Amazed by Science' at Chester Zoo

Science Education, Training and Conference Participation

Chester Zoo staff members regularly participate in international and national conferences to share ideas and scientific achievements with both the academic and the zoo community. Staff delivered over 70 presentations at conferences and symposia in 2016, including the BIAZA Research Conference held in the Yorkshire Wildlife Park where one of Chester Zoo's industrial placement students was awarded a prize for their poster.

Chester Zoo staff also deliver lectures, technical training sessions and provide project supervision for University students at both undergraduate and postgraduate levels. Last year, we hosted six students participating in industrial placements as part of their undergraduate qualifications, and one PhD student as part of her Doctoral Training. Chester Zoo acts as well as a training facility for undergraduate students conducting projects on animal behaviour. A total of 50 projects were approved in 2016 facilitated by the Discovery & Learning division of the zoo and a full list of these projects can be found on p36-37. Within the zoo, staff lead programmes such as the Junior Members summer school and Zoo Intern Workshops which provide the opportunity for future Conservation Scientists to learn more about the work of Chester Zoo. We also host a number of successful internal seminars and regularly invite leading experts and academics to give talks and discuss potential collaborations.

COLLABORATING INSTITUTIONS

Animal and Plant Health Agency
BIAZA
Cheshire Wildlife Trust
Cikananga Integrated Conservation Foundation
Darwin Initiative
Durrell Institute of Conservation and Ecology (DICE)
EAZA
EcoSystems India
Explore Gaia Enterprise
Fauna & Flora International
Free The Bears
Fundacion Pro Bosque
George Adamson Wildlife Preservation Trust
Giraffe Conservation Foundation
Green Governance Nepal
Harper Adams University
HUTAN
Institute Congolais pour la Conservation de la Nature
Instituto de Conservação de Animais Silvestres
Instituto de Pesquisas Ecológicas
IUCN SSC Asian Wild Cattle Specialist Group
Katala Foundation Inc.
Komodo Survival Programme
Lancashire Wildlife Trust
Liverpool John Moores University
Lowland Tapir Conservation Initiative
Madagasikara Voakajy
Manchester Metropolitan University
Mauritian Wildlife Foundation
Morelia University
National Museum of Nature History Luxembourg
Natural Resources Wales
Nottingham Trent University
Okapi Conservation Project
Orangutan Veterinary Advisory Group
Philippines Biodiversity Conservation Foundation Inc.
Queens University Belfast
RECORD
Royal Zoological Society of Scotland
Sichuan Forest Biodiversity Project
University of Birmingham
University of Canterbury
University of Chester
University of Exeter
University of Glasgow
University of Kent
University of Leeds
University of Liverpool
University of Manchester
University of Oxford
University of Salford
University of Surrey
University of Warwick
Vincent Wildlife Trust
WAZA
Wildlife Conservation Society
Wirral & Cheshire Badger Group
Zoological Society of London

SUPPORTED PROJECTS

In addition to actively undertaking research projects, we support a wide range of scientific activities. We provide funding and assistance to global conservation projects, biological samples and data from our animal and plant collection for research and we provide training opportunities for undergraduate students.

Conservation Funding

Africa

African Wild Dog Breeding, Veterinary and Reintroduction Programme, George Adamson Wildlife Preservation Trust

Combating rhino poaching across Kenyan private- and community-owned conservancies, Association of Private Land Rhino Sanctuaries

Improving patrol coverage of the black rhino population in the Chyulu Hills, Kenya, Big Life Foundation

Upgrading the peripheral fence line of the Mkomazi Rhino Sanctuary to enhance security through the reconfiguration of the fence line, George Adamson Wildlife Preservation Trust

Nigerian Montane Forest Project, University of Canterbury

Okapi EEP, Okapi Conservation Project

Latin America

Conservation and reintroduction of goodeids, Morelia University

Giant Armadillo Conservation Program, Instituto de Conservação de Animais Silvestres

Lowland Tapir Conservation Initiative (LTCI): Pantanal & Cerrado Tapir Programmes, Instituto de Pesquisas Ecológicas

Socio-ecology and conservation of spider monkeys in Mesoamerica, Liverpool John Moores University

Why, when and how giant anteaters cross roads? Understanding impacts and effects of roads on giant anteater populations, Instituto de Conservação de Animais Silvestres

Madagascar and Mascarenes

Long-term conservation management of the Echo Parakeet Psittacula eques. Restoring the species and developing management techniques, Mauritian Wildlife Foundation

Long-term conservation management of the Pink Pigeon Nesoenas mayeri. Restoring the species and developing management techniques, Mauritian Wildlife Foundation

Monitoring, behavioural observations and youth conservation initiatives in Mangabe Protected Area, Madagasikara Voakajy

Propagation and conservation of critically endangered plant species of Mauritius, Mauritian Wildlife Foundation

Restoration and reforestation of the Grande Montagne Nature Reserve (Rodrigues) with native plants to recreate the upland forest community, Mauritian Wildlife Foundation

Survey and monitoring of the Rodrigues Fruit Bat Pteropus rodricensis population. Sensitisation of the Rodriguan population on fruit bats. Assessment of bat-related fruit damage in Rodrigues, Mauritian Wildlife Foundation

South Asia

Blue-crowned laughingthrush conservation programme, Forestry Bureau of Wuyuan County

South East Asia

Assessment of the status and distribution of Komodo dragon populations on the island of Flores, Indonesia (Year 2), Komodo Survival Programme

Community-based conservation of the Philippine Cockatoo *Cacatua haematuropygia* and its habitats (Philippine Cockatoo Conservation Programme; PCCP) [13th phase], Katala Foundation Inc.

Monitoring program for translocated Palawan Forest Turtles in Palawan, Katala Foundation Inc.

Southern Cebu Biodiversity Conservation Programme, Philippine Biodiversity Conservation Foundation Inc.

The ecology of Bornean hornbills, Ravinder Kaur

West Visayan Threatened Endemic Species Conservation Programme, Philippine Biodiversity Conservation Foundation Inc.

Palawan Deer Research and Conservation Program, Katala Foundation

Other

Partula field programme consortium, ZSL

SUPPORTED RESEARCH PROJECTS

Biological & Data Sample Requests

Adenovirus structure in apes, University of Lincoln, External Professional Researcher

An Ark for Bears or a bare Ark? Hormonal assessment of the reproductive potential of rescued female sun bears *(Helarctos malayanus)* in Cambodia, Free The Bears, External Professional Researcher

An investigation into social relationships and social structure in European zoo elephant herds, Nottingham Trent University, PhD

Assessment of genetic variability in captive and wild populations of the critically endangered blue-throated macaw, New Mexico State University, External Professional Researcher

Body condition scores in European zoo elephants- a cross-sectional and longitudinal evaluation regarding status quo, historical development and influencing factors, University of Zurich, PhD

Donations to the National Poo Museum, Isle of Wight

Environmental impact upon faecal corticosterone metabolite levels in a range of equine species, Nottingham Trent University, External Professional Researcher

Quantifying body shape and locomotor anatomy in birds, crocodilians and lizards, University of Liverpool, PhD

Examining travel routes in captive Sumatran orangutans *(Pongo abelii),* University of Birmingham, PhD

Expression of the 2D:4D ratio across the Primate Order, University of Kent, PhD

Flexibility of bat wing bones: within-element variability in stiffness quantified using nano-indentation and micro-CT, University of Manchester, External Professional Researcher

Genetic diversity of the giant anteater Myrmecophaga tridactyla, Cantebury Christ Church University, External Professional Researcher

Genetic sampling and pelage scores of captive Scottish Wildcats to remove hybrids and build a more robust population, EEP Genetics Research

Histoplasmosis at the human-wildlife interface in Kenya, University of Liverpool, External Professional Researcher

Laterality of hand use in chimpanzees: Is hand use stable, heritable and related to personality and social networks? University of Chester, PhD

Preliminary investigation into the diversity and distribution of nematodes infecting primates at Chester Zoo, Liverpool John Moores University, PhD

Proteomic and Genomic Comparison of Montserrat Tarantulas with Near Relatives, Canterbury Christ Church University, External Professional Researcher

Quantifying Light Spectrum and Temperature within Amphibian Enclosures, Manchester Metropolitan University, MSc

Red Panda EEP Genetics Research

Reproductive Endocrinology of the European Badger *(Meles meles)*: Effects on Reproduction, Behaviour and Survival Strategies, University of Oxford, PhD

To investigate the relationship between the diversity of major histocompatibility complex (MHC) and Toll-Like-Receptor genes (TLRs) and Elephant endotheliotropic virus (EEHV) exposure status in captive Asian elephants *(Elephas maximus)*, Copenhagen Zoo, External Professional Reseacher

Unraveling iron storage disease in black rhinoceros diceros bicornis, MSc, Ghent University

Why do giraffes hum at night? University of Cambridge, BSc

Undergraduate training projects

University of Chester

An investigation of the visibility and enclosure use of captive radiated tortoises

Comparing the diurnal activity budgets of the Bucerotiformes within Chester Zoo

Does the behaviour of the male Asian elephant at Chester Zoo vary due to enclosure utilisation?

Do zoo visitors affect the ethology of Sumatran tigers in differing captive collections?

Enclosure design and space utilisation on captive Malayan Sun Bears at Chester Zoo

Enclosure use of Bactrian camels in mixed species exhibits

Evaluating the enclosure usage and the behaviours performed of captive Rothschild giraffes at Chester Zoo

Exploring the effect of visitor presence on animal behaviour

High and low visitor density effects on captive chimpanzees' behaviour; does this affect enclosure space utilisation?

Hierarchy in a chimpanzee troop

How does age affect the behaviour in Asian elephants at Chester Zoo?

How visitor numbers affect and influence the behaviour of Sumatran orangutans in a captive environment

How visitors affect Humboldt penguins specifically looking at visitor quantity and noise levels

Impact of zoo visitors on the behaviour and enclosure use of the Sumatran Orangutans at Chester Zoo

Investigating the effect of visitor density on enclosure utilisation of a captive male Sumatran orangutan

Inter-species interaction in the Tsavo Aviary at Chester Zoo

Limb laterality during feeding in a group of captive Sumatran orangutans at Chester Zoo

Sex differences in sociality amongst captive chimpanzees

Space use as an indicator of enclosure appropriateness in various captive monitor lizard species Varanus

The effects of visitors on the behaviour of Meerkats

The effect of time of day on the number and types of vocalisation expressed in captive Humboldt penguins

The influence of social structure of captive giraffes

The influence of weather patterns on the activity budget of captive Sumatran tigers

The influence of zoo visitors on captive chimpanzees' behaviour at Chester Zoo

Testing survey methods on species of captive birds

What factors influence enclosure usage of Jaguars?

Liverpool John Moores University

Analyse and compare behavioural differences between wild and captive lion/cheetah

Asian elephants' behaviour and use of enclosure

Comparative study on social networking in Sumatran and Bornean Orangutans

Difference and similarities in the social interactions of old world monkeys, chimpanzees, Bornean orangutan, Sumatran orangutan and Sulawesi macaque

Does dominance affect space utilization and enrichment use in captive chimpanzees?

Do crested macaque offspring benefit from social bonds?

Personality traits in infant Asian elephants at different times of ay and compared to their mother/father, a captive study

Social encounters and preference of the Rothschild's Giraffe at Chester Zoo

The short term effects post social and mutual grooming bouts within Chimpanzees focusing on anxiety levels for the groomer

Temporal variation in daily scratching rates in Columbian Spider Monkeys

Askham Byran College

Enclosure design and enrichment regimes and the affect this has on Asian elephants at Chester Zoo

Edge Hill University

Does crowd size affect the behaviour of Asiatic Lions and Sumatran Tigers in captivity?

Falmouth University

The Bali Starling and Endangered Species

Glyndwr University

An investigation into the behaviour of captive cheetahs

How enclosure design affects the behaviour of captive Asian elephants

The use of the captive environment by giraffes housed at Chester Zoo

Manchester Metropolitan University

Animal Movements Studies for Performance Arts

Merristwood College, Guildford, Surrey

An increase in juvenile Bornean orangutans will increase the activity of the females more that it does the males within the group

University of East Anglia

Orangutans: Is there a correlation between their solitude and habitat both in-situ and ex-situ?

University of Manchester

Post conflict behaviour in primates x 4

University of South Wales

Markers of social dominance and hierarchy in Pan troglodytes

Warwickshire College

A comparative investigation into the behaviour of Lemur catta in captivity and in the wild

PUBLICATIONS

Peer-reviewed publications

Baines, F., Chattell, J., Dale, J., Garrick, D., Gill, I., Goetz, M., Skelton, T. & **Swatman, M.** (2016). How much UV-B does my reptile need? The UV-Tool, a guide to the selection of UV lighting for reptiles and amphibians in captivity. *Journal of Zoo and Aquarium Research,* 4**,** 42.

Edwards, K. L., Trotter, J., Jones, M., Brown, J. L., Steinmetz, H. W., & **Walker, S. L.** (2016). Investigating temporary acyclicity in a captive group of Asian elephants (*Elephas maximus*): Relationship between management, adrenal activity and social factors. *General and comparative endocrinology*, *225*, 104-116.

Esson, M. & **Moss, A.** (2016). The challenges of evaluating conservation education across cultures. *International Zoo Yearbook,* 50**,** 61-67.

Fu, Y., Chen, B., **Dowell, S.** D. & Zhang, Z. (2016). Nest predators, nest-site selection and nest success of the Emei Shan Liocichla (*Liocichla omeiensis*), a vulnerable babbler endemic to southwestern China. *Avian Research,* 7**,** 18.

Hosey, G., Melfi, V., Formella, I., Ward, S. J., Tokarski, M., Brunger, D. & **Hill, S. P.** (2016). Is wounding aggression in zoo-housed chimpanzees and ring-tailed lemurs related to zoo visitor numbers?. *Zoo biology*, 35 (3), 205-20a9

Hudson, M. A., Young, R. P., D'urban Jackson, J. D., Orozco-Terwengel, P., Martin, L., James, A., Sulton, M., **Garcia, G.**, Griffiths, R. A., Thomas, R., Magin, C., Bruford, M. W. & Cunningham, A. A. (2016). Dynamics and genetics of a disease-driven species decline to near extinction: lessons for conservation. *Nature Scientific Reports,* 6**,** 30772.

Hudson, M. A., Young, R. P., **Lopez, J.,** Martin, L., Fenton, C., Mccrea, R., Griffiths, R. A., Adams, S., Gray, G. & **Garcia, G.** (2016). In-situ itraconazole treatment improves survival rate during an amphibian chytridiomycosis epidemic. *Biological Conservation,* 195**,** 37-45.

Inskip, C., Carter, N., Riley, S., Roberts, T., & MacMillan, D. (2016). Toward Human-Carnivore Coexistence: Understanding Tolerance for Tigers in Bangladesh. *PloS one*, *11*(1), e0145913.

Lea, J. M., Kerley, G. I., Hrabar, H., Barry, T. J., & Shultz, S. (2016). Recognition and management of ecological refugees: A case study of the Cape mountain zebra. *Biological Conservation*, *203*, 207-215.

Lopez, J., Barbon, A. R., Smithyman, J., Goetz, M., Marschang, R. E., Dastjerdi, A. & Stidworthy, M. F. (2016). High prevalence of intestinal adenocarcinoma in a captive populatio of Amazon milk frog (*Trachycephalus resinifictrix*). *Journal of Zoo and Wildlife Medicine,* 47**,** 1061-1068.

Moss, A. (2016). Can conservation education learn anything from 'Big Data'? *International Zoo Yearbook,* 50**,** 23-33.

Plumptre, A. J., **Nixon, S.**, Kujirakwinja, D. K., Vieilledent, G., Critchlow, R., Williamson, E. A., Nishuli, R., Kirkby, A. E. & Hall, J. S. (2016). Catastrophic Decline of World's Largest Primate: 80% Loss of Grauer's Gorilla (*Gorilla beringei graueri*) Population Justifies Critically Endangered Status. *PLoS ONE,* 11**,** e0162697.

Plumptre, A., & **Nixon, S**. (2016). New survey reveals dramatic decline of Grauer's gorilla. *Oryx*, *50*(2), 203.

Rademaker, R., Meijaard, E., Semiadi, G., Blokland, S., Neilson, E. W. & **Rode-Margono, E. J.** (2016). First Ecological Study of the Bawean Warty Pig (*Sus blouchi*), One of the Rarest Pigs on Earth. *PLoS ONE,* 11**,** e0151732.

Sauer, C., Hammer, C., Bertelsen, M. F., Tuken, T., Clauss, M. & Hammer, S. (2016). Quantitative macroscopic digestive tract anatomy of the beira (*Dorcatragus megalotis*). *Journal of Zoo and Aquarium Research,* 4**,** 174-179.

Schuiteman, A., **Ryan, C.**, Nut, M., Nay, S. & Att, S. (2016). New records of Orchidaceae from Cambodia II. *Cambodian Journal of Natural History,* 2016**,** 7-14.

Wong, E. P., Yon, L., **Purcell, R.**, **Walker, S. L.**, Othman, N., Saaban, S. & Campos-Arceiz, A. (2016). Concentrations of faecal glucocorticoid metabolites in Asian elephant's dung are stable for up to 8 h in a tropical environment. *Conservation Physiology,* 4.

Yarnell, K., **Purcell, R. S.** & **Walker, S. L.** (2016). Fecal Glucocorticoid Analysis: Non-invasive Adrenal Monitoring in Equids. *Journal of Vizualised Experiments,* 110

Conference Presentations

Ashpole, I. A. (2016). The successful treatment of a giant anteater with clinical orthopoxvirus ('cowpox') infection [Oral Presentation]. *British Veterinary Zoological Society, 11-13 March.* Chester.

Ashpole, I. A. (2016). The successful treatment of a giant anteater with clinical orthopoxvirus ('cowpox') infection [Oral Presentation]. *BIAZA Pangolin, Aardvark and Xenarthra working group conference, 11 September.* ZSL London Zoo.

Barton, C. (2016). Influencing the palm oil sector through collaborations and effective partnerships [Oral Presentation]. *EAZA Conservation Forum, 9-13 May.* Fuengirola, Spain.

Barton, C. (2016). Palm oil use in cosmetics: Sustainable palm oil from a conservationists perspective [Oral Presentation]. *Society for Cosmetic Scientists, 15 November.* Coventry, UK.

Bazley, S. (2016). Investigating the impact of interactive touch tables on visitors at Chester Zoo [Oral Presentation]. *23rd Biennial Conference of International Zoo Educators Association, 18-22 October.* Buenos Aires, Argentina.

Biddle, R. & **Pilgrim, M.** (2016). Blue-throated Macaw, *Ara glaucocularis*, EEP Update for Annual TAG Meeting [Oral Presentation]. *EAZA Annual Conference, 20-24 September.* Belfast, Northern Ireland.

Biddle, R. & **Pilgrim, M.** (2016). Eastern Black rhino EEP Update for annual TAG & EEP meetings [Oral Presentation]. *EAZA Annual Conference 20-24 September.* Belfast, Northern Ireland.

Biddle, R. & **Pilgrim, M.** (2016). Ecuador Amazon Parrot, *Amazona lilacina*, EEP Update for Annual TAG Meeting [Oral Presentation]. *EAZA Annual Conference, 20-24 September.* Belfast, Northern Ireland.

Biddle, R. & **Pilgrim, M.** (2016). Fighting for survival: Conserving the Ecuador Amazon parrot (*Amazona lilacina*) [Poster Presentation]. *EAZA Annual Conference, 20-24 September.* Belfast, Northern Ireland.

Biddle, R. & **Pilgrim, M.** (2016). Fighting for survival: Conserving the Ecuador Amazon parrot (*Amazona lilacina*) [Poster Presentation]. *International Conservation and Commercial Breeding Symposium, 8-9 March 2016.* Chester.

Biddle, R. & **Pilgrim, M.** (2016). Jaguar, *Panthera onca*, EEP Update for Annual EEP & TAG Meetings [Oral Presentation]. *EAZA Annual Conference, 20-24 September.* Belfast, Northern Ireland.

Cowl, V. (2016)a. Contraception in prosimians - Prosimian TAG [Oral Presentation]. *EAZA Annual Conference, 20-24 September.* Belfast, Northern Ireland.

Cowl, V. (2016). Contraceptive research in callitrichids - Callitrichid TAG [Oral Presentation]. *EAZA Annual Conference, 20-24 September.* Belfast, Northern Ireland.

Cowl, V. (2016). EGZAC EAZA update 2016 - veterinary committee [Oral Presntation]. *EAZA Annual Conference, 20-24 September* Belfast, Northern Ireland.

Cowl, V. (2016). EGZAC: The use of contraception in wildlife management [Workshop]. *EAZA Annual Conference, 20-24 September.* Belfast, Northern Ireland.

Cowl, V. (2016). Reproductive management in EAZA breeding programmes - EPMAG committee [Oral Presentation]. *EAZA Annual Conference, 20-24 September 2016.* Belfast, Northern Ireland.

Cowl, V. (2016). Reproductive management in EAZA zoos - Joint TAG/EEP/ESB coordinators meeting [Oral Presentation]. *EAZA Annual Conference, 20-24 September.* Belfast, Northern Ireland.

Cunningham, E., **Unwin, S.** & Setchell, J. M. (2016). Can we make wild primate capture safer? [Oral Presentation]. *Joint meeting of the International Primatological Society and the American Society of Primatologists, 21-27 August.* Chicago, Illinois.

Cunningham, E., **Unwin, S.** & Setchell, J. M. (2016). Improving the way we Dart: reviewing trends in darting wild primates [Poster Presentation]. *Joint AAZV/ EAZWV/ IZW Conference, 18-22 July.* Atlanta, Georgia.

Davis, N. (2016). Promoting natural behvaiours at Chester Zoo- everyone's a winner! [Oral Presentation]. *Learning from the Wild, 23-24 April.* Chester Zoo.

Evans, G. (2016). Ecuador Amazon – Ecology, conservation, captive management and breeding [Oral Presentation]. *BIAZA Bird Working Group, 26-27 October.* Chester Zoo.

Evision, E. (2016). Sleeping behaviour in Asian elephants [Oral Presentation]. *15th International Elephant & Rhino Conservation and Research Symposium, 14-18 November.* Singapore Zoo.

Finch, K., Parry, C., Lenihan, A., Davis, N., Rowlands, T. & **Holmes, L.** (2016). Ready for an Island life? Assessing the impact of moving Sumatran orangutans (*Pongo abelli*) [Oral Presentation]. *18th BIAZA Research Conference, 28-29 June.* Yorkshire Wildlife Park, Doncaster.

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Grevy's zebra *(Equus grevyi)*

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