



17th Annual BIAZA Research Conference
7th – 8th July 2015

Dublin Zoo

Programme and Abstracts

Programme

Tuesday 7 th July	
8.30	Zoo gates open, registration
8.50	Welcome address: Leo Oosterweghel, Director Dublin Zoo
9.00	Giant footsteps: Dublin Zoo's Asian elephant programme <i>Gerry Creighton</i>
9.15	Asian elephant sleep study <i>Brendan Walsh</i>
9.30	Effects of construction and operation of a novel visitor attraction on the behaviour of two captive Amur tigers (<i>Panthera tigris altaica</i>) <i>Jessica Harley, Jessica Chaisson and Ian Handle</i>
9.45	Welfare of captive chimpanzees with special attention to regurgitation and reingestion <i>Emma K Wallace, Bridget Waller and Katie Slocombe</i>
10.00	Improving the lives of captive thornback rays (<i>Raja clavata</i>) <i>Gavan M Cooke, Eleanor Greenway and Katherine Jones</i>
10.15	The effect of lighting and shading on the pulsation rate of the soft coral <i>Xenia elongata</i> <i>Ryan Hills, Tom Bennett and Sue Dow</i>
10.25	The effects of a simulated lunar cycle on amphibian behaviour <i>Lucy Ward, Holly Farmer, Mike Bungard, Sam Lomax, Wayne Edwards and Andrew E. Bowkett</i>
10.35	Evaluating long-term activity patterns and enclosure usage in captive flamingos; management and welfare implications <i>James Brereton, Darren Croft, Mark Roberts, Rebecca Lee, Fionnuala McCully and Paul Rose</i>
10.45	Tea/Coffee
11.10	Comparison of cardiac structure and function between captive zoo and sanctuary chimpanzees (<i>Pan troglodytes</i>) <i>Aimee Drane, Yedra Feltrer, Tai Strike, Steve Unwin and Rob Shave</i>
11.25	What can we learn from agricultural research? And what can they learn from us? <i>Samantha Ward</i>
11.40	Happiness means welfare: ratings of welfare and subjective well-being correlate highly in brown capuchins (<i>Sapajus apella</i>) <i>Lauren M Robinson, E Londsorf, A Paukner, S Brosnan, I Handel, VAD Wilson, FB Morton, MC Leach, NK Waran and A Weiss</i>
11.55	Using positive reinforcement training to reduce stress associated with veterinary care <i>Elizabeth Durkin and Anne Pullen</i>
12.10	Changes in behaviour before and during treatment for degenerative joint disease in a captive, geriatric European brown bear (<i>Ursus arctos</i>) <i>Clare Ellis, Nick Jackson and Jan Chapman</i>
12.20	A comparative study of digestibility and diets for red titi monkeys (<i>Callicebus cupreus cupreus</i>) at three UK zoos <i>Freisha Patel</i>
12.30	Digesting the indigestible: how do insect-eating mammals cope with consuming chitin? <i>Lizzie Randall and Amy Plowman</i>
12.40	An investigation into the diet variation and suitability of captive green sea turtles (<i>Chelonia mydas</i>) worldwide <i>Alexandra Pulfer, Emma Skirrow, Paul Rose and Kerry Hunt</i>
12.50	Lunch
Special session: It's all in the poo, and urine too	
1.50	Non-invasive adrenal analysis. How many samples should I collect and what will it tell me? <i>Sue Walker</i>
2.20	Putting sparkle into your freezer! The trials and tribulations of faecal sampling <i>Louise Bell</i>
2.35	The whole animal approach: why careful application of endocrinology can be instrumental in animal behaviour studies <i>Lisa Holmes</i>

2.50	Welfare monitoring of an African elephant <i>Paul Perrins, Kirsten Pullen and Holly Farmer</i>
3.00	General discussion on the challenges and benefits of adrenal monitoring
3.15	Tea/Coffee
3.40	Aquariums as restorative environments and the influence of exhibit content <i>Deborah Cracknell, Mathew White, Sabine Pahl and Michael Depledge</i>
3.55	Evaluation of the effectiveness of zoo information signs for education <i>Sarah Spooner</i>
4.10	Can the presentation of captive amphibians in zoological collections be modified to maximise feelings of empathy, engagement and interest from teenage visitors? <i>Steve Nash</i>
4.25	Managing the genetics of a captive species <i>Raja undulata</i> <i>Jean-Denis Hibbitt</i>
4.40	Reintroduction projects involving captive-bred animals: zoo and aquaria involvement and project management factors contributing to success <i>Rachel Gardner</i>
4.55	A global geographic analysis of WAZA member in situ research project site locations <i>Thomas Underdown and Andrew R. Marshall</i>
5.05	Developing a Baseline for the Holistic Measurement of Conservation Success <i>Matthew Durrant, Hayley Blackwell, Freddie Sutton, and Andrew R Marshall</i>
5.15	Evaluating energy consumption and the use of heat sources in animal exhibits to help inform collection planning in a more sustainable way: a case study at Newquay zoo <i>Nicole Fenton Howarth</i>
5.25	The visitor experience at Newquay Zoo: utilising GPS technology and observation to inform collection planning and site management <i>Michelle Gurney</i>
5.35	Poster Session
6.35	Tour of Dublin Zoo, followed by food platters at the Nancy Hands (10 mins walk from zoo)

Wednesday 8th July	
8.45	Zoo gates open
9.00	Effect of three forms of intrinsic enrichment on the behaviour of Sumatran tigers (<i>Panthera tigris sumatrae</i>) and cheetahs (<i>Acinonyx jubatus</i>) in captivity. <i>Juliana Damasceno, Gelson Genaro, Shannen McCarthy, Ruth O’Riordan, Thomas Quirke and Sean McKeown</i>
9.15	The long weekend: do zoo-housed mammals avoid giving birth when the zoo is crowded? <i>Geoff Hosey, Sonya Hill and Samantha Ward</i>
9.30	Factors influencing interactions in zoos: animal-keeper relationship, animal-public interactions and solitary animals groups <i>Giovanni Quintavalle Pastorino, M. Albertini and R. Preziosi</i>
9.45	Nectar pot provision for rainbow lorikeets (<i>Trichoglossus moluccanus</i>) in a walk-through aviary <i>Christopher Dunster, Wanda McCormick and Helen Tedds</i>
9.55	Monitoring behavioural changes during visitor feeds on a group of giraffes at Blackpool zoo <i>Vicky Hoyle</i>
10.05	The effects of environmental enrichment and weather on enclosure use and within-pride conflict in African lions (<i>Panthera leo</i>): study using keeper and researcher data <i>Charlotte Sire, Katie McDonald and Lucy Clark</i>
10.15	A preference test for the common clownfish (<i>Amphiprion percula</i>) for real and artificial anemones <i>Laura Thompson</i>
10.25	Tea/Coffee
10.50	Workshop – ZIMS as a Research Resource
12.30	Lunch

1.15	Long-term research into the breeding ecology of Chilean flamingos in Dublin Zoo <i>Louise McDermott</i>
1.30	Effects of enclosure design on breeding success in flamingos Emily V. Barrington and <i>Andrew R. Marshall</i>
1.40	Breeding behaviour and success of tufted puffins (<i>Fratercula cirrhata</i>): an investigation into the effects of husbandry and social environment Joanna Waterman , <i>Jody Griffin, Lisette Keetman and Holly Farmer</i>
1.50	Reproductive success in hand-reared Java sparrows and early behaviour of their offspring compared to parent-reared conspecifics. Charlotte Leaman , <i>Tom Tooley, Leslie Connor, Holly Farmer, Jo Gregson and Andrew E. Bowkett</i>
2.00	Captive population management: investigating reproductive parameters and the long-term effect of contraception in white-faced saki monkeys (<i>Pithecia pithecia</i>) Emily Thornton , <i>Holly Farmer and Matthew Webb</i>
2.10	A first report on the behaviour and captive breeding of a pair of narrow-striped mongoose, <i>Mungotictis decemlineata</i> Evie Morris and <i>Kathy Baker</i>
2.20	Tea/Coffee
2.45	Assessing Emotional Perception in Chimpanzees Vanessa Wilson and <i>A. Weiss</i>
3.00	Understanding social dynamics and their relevance for breeding success in captive populations <i>Danielle Free</i>
3.15	The behavioural response of a captive population of lion-tailed macaques (<i>Macaca silenus</i>) to changes in social structure over time Rebecca Newman , <i>Leanne Casey, Amy Quinn, Ristead Tobin, Sean McKeown, Thomas Quirke, and Ruth M. O' Riordan</i>
3.30	Behavioural and physiological changes to a captive herd of African elephants <i>Loxodonta africana</i> following the death of an individual. Sarah Armstrong and <i>Heather Young</i>
3.40	The application of Social Network Analysis in guiding management of African lions <i>Panthera leo</i> in captivity Stephanie Willimott and <i>Heather Young</i>
3.50	An evaluation of association patterns, sociality and behavioural characteristics within three captive flamingo flocks Rhianna Worsell , <i>Darren Croft, Heidi Mitchell and Paul Rose</i>
4.00	Do personality differences influence friendships in zoo-housed bonobos? Jonas Verspeek , <i>Nicky Staes and Jeroen MG Stevens</i>
4.10	Summing up and prizes
4.30	Finish

Giant footsteps: Dublin Zoo's Asian elephant programme

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In 2006, Dublin Zoo completely changed the way elephants were managed. The Kaziranga trail was created; a wonderful natural environment with the needs of the elephants in mind. Dublin Zoo switched to protected contact and a training programme was established, tailored to the needs of each elephant. The elephant herd comprises of related females and a bull elephant and the herd is gradually growing with five elephants born here since 2007. This presentation aims to give an overview of the Asian Elephant programme in Dublin Zoo looking at the creation of their habitat, husbandry and breeding. The Asian elephant programme reflects the ethos of Dublin Zoo and serves as a good introduction to conference hosts.

Asian elephant sleep study

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Asian elephants are the justifiable focus of many welfare projects. It is important for zoos to provide excellent welfare standards for their elephants, day and night. Daytime activities are easily assessable, as staff members are present. The aim of the study is to record the behaviour of all eight elephants at Dublin Zoo when staff are not in the zoo (19:00 to 08:00). All behaviours were recorded from a high definition 20 camera CCTV system, and then observed and analysed the following day. Sleeping was the biggest focus of the study. It is believed that wild elephants sleep on average 4 hours per day. Sleeping is important for proper functioning and is essential for quality of life. The study includes 29 months of continuous data.

The results showed that the adult elephants slept on average 3 hrs 28 minutes nightly, the calves slept for 9 hours. Most sleeping occurred between 00:00 to 05:00. Sleeping distances decreased from 4-6m between elephants to 1-2m during last four months of pregnancy. Calves are the only elephants to actively seek tactile sleeping. Each adult elephant lies down on average four times a night, but this increases to eight in some cows as pregnancy duration increases. Calves lie down on average 20 times per night in their first two months, lowering to 12 times per night after two months of age. Pregnant cows show a preference to lying on their left side, they lay on their left 69% of total sleep time, with the remaining on the right side. Mothers of new born calves did not sleep for at least 48 hours after giving birth. They normally sleep every night. Unlike the adults, the calves sleep for longer as they get older. This is possibly normal for elephants and many other mammals, however further study will assess when they stop to sleep in a positive correlation as they get older, and start to sleep in a negative correlation with age (sleep less as they get older).

This study highlights the importance of housing elephants in related groups, and emphasises the importance of sand floors for a comfortable sleeping environment.

Effects of construction and operation of a novel visitor attraction on the behaviour of two captive Amur tigers (*Panthera tigris altaica*)

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Construction of new enclosures and renovations to existing ones are frequently undertaken in modern zoological parks. In an attempt to increase visitor numbers, zoological parks may also increase the diversity of attractions to include mechanized amusement rides. Animal collections can be subjected to increased levels of auditory and visual stimuli during construction and operation of amusement rides. Such increases in external stimuli and visitor numbers may affect the behaviour of animals in a collection. This study investigated the behaviour of two Amur tigers, at Tayto Park, Co. Meath, Ireland, over four phases of construction and operation of an amusement ride on land adjacent to their enclosure. Phase 1 – Park open to the public and no operation or construction of the ride. Phase 2 - Construction of the ride. Phase 3 - Operation of the ride. Phase 4 - Park closed. We hypothesised that tiger behaviour would be altered during construction and a portion of the operational phase, but would be similar between the pre-construction, latter half of the operational phase and closure phase of the zoo and theme park.

For each of the four phases the following parameters were recorded: behaviour of Amur tigers, cloud cover, ambient temperature, wind speed, sound levels and number of visitors in the immediate vicinity of the enclosure. The behaviour of each tiger was monitored and recorded by one of two observers, using focal animal sampling techniques. The results were explored using time series plots for quantitative behaviour measures and covariates against time, stratified by categorical variables including phase and subject.

The amount of time the tigers spent in their house (i.e. off-show) was significantly higher during phase 2 (Construction). On separate univariable analyses for each tiger, there was no significant difference in absolute activity levels between phases. Using a multivariable model, including environmental covariates, activity levels in both the male and female increased with higher average visitor numbers and sound levels. Stereotypic behaviour was not detected during phases 1-3, or during periods when peak sound and/or visual stimuli were recorded. The Amur tigers responded to increased levels of noise and visual stimuli during phase 2 by spending more time in their house. Increased tiger activity during periods of increased visitor numbers was not attributable to pacing or restless behaviour. The reason for increased activity warrants further investigation. There were no statistically significant differences in behaviour during phases 1, 3 and 4, supporting our hypothesis. We deduced that the tigers reduced their exposure to the novel visitor attraction and increased external stimuli by choosing to spend more time in-house. This allowed them to adapt to the construction and operation of the amusement ride.

In conclusion, construction of a mechanized amusement ride led to the tigers spending more time in-house. Operation of the ride had no influence on the behaviour of the tigers. Amur tigers subjected to increased levels of external stimuli, from construction and initial operation of amusement rides, should be provided the opportunity to choose and control their environment with free access to retreat.

Welfare of captive chimpanzees with special attention to regurgitation and reingestion

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In non-human primates, displacement behaviours, such as self-scratching and yawning, can be used to identify anxiety (Maestriperi et al., 1992) and abnormal behaviours, for example regurgitation and reingestion (R/R), can show underlying mental health issues or suffering (Birkett and Newton-Fisher, 2011). We hope that by studying displacement behaviours we can inform strategies to reduce these behaviours. R/R is frequently seen in captive chimpanzees (Birkett and Newton-Fisher, 2011). It is defined as the voluntary movement of food from the stomach or the oesophagus into the hand, the mouth or a substrate followed by the consumption of the regurgitant (Gould and Bres, 1986a). It is a behaviour that can lead to serious health issues, such as oesophageal strictures, ulcers, reflux, oesophagitis, intestinal obstruction, oesophageal motor disorders and pulmonary aspiration (Wyngaarden et al., 1992). Previous studies of R/R behaviour in captive chimpanzees have suggested that it is linked to boredom, sources of stress, type of food, enjoyment of the taste of regurgitated food and limited opportunities to eat throughout the day (Morgan et al., 1993; Baker and Easey, 1996; Struck et al., 2007).

The chance to study the integration of two groups of chimpanzees is rare yet the opportunity arose in 2010 when a group of 11 adult chimpanzees from Beekse Bergen Safari Park (BB) were introduced to the 11 chimpanzees at the Edinburgh Zoo. Within the BB group there were six individuals who frequently engaged in R/R. This integration of the groups provided us the opportunity to study the spread of R/R; the original group had not been observed to engage in R/R prior to the arrival of the BB group. Firstly, we aimed to examine whether the introduction of individuals who exhibit R/R into a population without a history of this behaviour results in the spread of the behaviour. Secondly, we aimed to examine whether R/R, scratching and yawning are influenced by the social dynamics within the group, feeding factors and visitor behaviour or numbers. In order to investigate the factors that may influence the frequency of R/R in the six individuals as well as scratching and yawning in all individuals, we conducted 20 minute focal observations throughout the day. Data was recorded on occurrence of R/R, self-scratching, yawning, the identity of the focal individual's nearest neighbour, if the focal was involved in grooming, if aggression occurred during the focal, the behaviour of visitors and the percentage of windows. Long term data collected since 2010 indicates that despite frequent exposure to BB individuals engaging in R/R, none of the Edinburgh individuals have adopted the behaviour. We will present data to show whether proximity to dominants or friends, aggression, grooming, certain foods, not eating for long periods of time or visitor behaviour, such as banging on windows, has an effect on R/R, self-scratching and yawning. We hope our findings will lead to suggestions for interventions that would aim to reduce R/R and/or anxiety behaviours in this population.

Improving the lives of captive thornback rays (*Raja clavata*)

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Currently zoos and public aquaria alike are expanding and competing to have the best interactive experience to attract more visitors. The displays may compromise the welfare of captive animals and is an issue of increasing concern. Research has shown that 90% of public aquaria in the UK house animals that exhibit stereotypical behaviour. The presence of stereotypies in captivity shows that we do not fully understand welfare needs of the animals. Elasmobranchs are of particular interest in aquatic animal welfare studies as there is little research available and they are known to exhibit stereotypic behaviours in captivity. The thornback ray (*Raja clavata*) is a common feature in public aquaria and is the focal species in this study. We investigated substrate preferences and group interactions with 13 captive bred (from a local public aquaria) thornback rays. We also investigated food preferences. Providing strongly desired food at key times may reduce stress in captivity, if used as a treat it can be a very effective husbandry tool, for example, when moving or handling rays, rewarding or coercion using preferred food can relax the animals. Lastly we measured motivation for reward treats. Measuring motivation for enrichment is a nascent field in animal welfare and can provide invaluable information regarding what animals really want and not what we think they want. We found significant substrate preferences, group size preferences, preferred food choices and provide an ethogram of stereotypic behaviours.

The effect of lighting and shading on the pulsation rate of the soft coral *Xenia elongata*

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Pulsation is a behaviour unique to soft corals of the Xenidiidae family where the polyp tentacles are rhythmically extended and flexed. The behaviour is thought to have evolved to enhance photosynthesis in the symbiotic algae in the coral cells. Pulsation increases the surface area of the polyp exposed to light and the motion of water around the polyp. The latter effect increases efflux of oxygen away resulting in an increase in the photosynthesis-photorespiration ratio. This study measured pulsation rates under different aquarium lighting and shading.

Three colonies of *Xenia elongata* were placed in individual aquarium tanks, each with a different lighting system above the tank. Pulsation rates were recorded by selecting an individual polyp and counting the number of pulses over a one minute period. This was repeated ten times for each experimental condition. After two weeks the coral colonies were moved to a tank with a different light source. The tested light types tested were fluorescent T5, LED and metal halide, which are frequently used for corals in aquaria. The light intensity was recorded for each light at the level of the water surface (with and without shading) and the top and bottom of the coral colonies. The LED lights had the highest light intensity and light intensity decreased with water depth. It was not practicable to adjust the height of the lamps above the experimental tanks.

There were no significant differences in pulsation rates between the colonies under a particular light but polyps pulsed at a lower frequency under T5 than LED or halide. These differences were attributed to the lower light intensity, although it was not possible to control for differences in the light spectrum from the different lights. The LED light had a higher intensity at the water surface but greater attenuation through the water. Polyps located at the top of the colonies pulsed at a higher frequency than those at the bottom. In the shading experiment the base rate of pulsation was recorded, shading was introduced for either 15 or 60 minutes and the pulsation rates recorded. Pulsation was significantly reduced under shading suggesting that pulsation rate is influenced by photosynthesis. Polyps returned to the baseline pulsation rate over a 30 minute period after the shading was removed.

Despite the restriction of the experimental set up, there is evidence that LED lighting is a suitable alternative to traditional aquarium lighting, at least for small tanks, proving an energy efficient alternative without compromising the welfare of the corals.

The effects of a simulated lunar cycle on amphibian behaviour

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Amphibians are experiencing a rapid decline in population numbers and the IUCN currently estimates 41% of amphibians are threatened with extinction. As greater numbers of amphibian species are being kept in captivity, research is needed into husbandry requirements in order to maintain stable and healthy populations. A largely overlooked factor in captive environmental parameters is the replication of moonlight. The majority of amphibians are nocturnal and they mainly use vision for hunting, therefore moonlight may be vital for natural behavioural repertoires. In addition, moonlight intensity and duration changes predictably during the 29.5 day lunar cycle, creating a reliable cue for synchronised behaviour, e.g. mass reproduction events common in amphibian species. Higher levels of moonlight may inhibit typically nocturnal behaviour and encourage diurnal behaviour. This study aims to determine the different behavioural effects of simulated moonlight for a nocturnal and a diurnal amphibian species.

The study concerned two amphibian species; the diurnal golden mantella (*Mantella aurantiaca*), listed as Critically Endangered by the IUCN and endemic to Madagascar, and the nocturnal red-eyed tree frog (*Agalychnis callidryas*) native to neotropical rainforests. Four study tanks were set up for each species; two experimental tanks, where moonlight cycles were simulated, and two control tanks which had no light at night, (golden mantella n=6/tank, red-eyed tree frogs n=3/tank). In the experimental tanks, moonlight was simulated using a single white LED at the top of each tank; light intensity and duration were changed over the course of the 30 day experiment to mimic a lunar cycle. Video cameras were located at the top of each tank and scan sampling was conducted at 30 minute intervals between 1800 and 0600 hours every night, to record the number of frogs visible and moving. Temperature and humidity readings were taken every 30 minutes.

We found a significant effect of simulated moonlight on the activity of both species; a higher number of golden mantella were visible and recorded moving under moonlit conditions compared to periods of no moonlight, with more movement during periods of higher moonlight intensity. The red-eyed tree frogs showed a similar pattern in activity, with increased movement during moonlight periods but no consistent effect of intensity. As the majority of captive amphibians are unlikely to be exposed to natural nocturnal lighting patterns this research highlights a novel and important consideration for best practice guidelines.

Evaluating long-term activity patterns and enclosure usage in captive flamingos; management and welfare implications

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Evidence-based practice suggests that enclosures should mirror key facets of the wild environment of the species contained within. The features present in an enclosure will have an impact on the behaviour patterns of the inhabitants and can affect the range of activities performed. Insight into preferences, measured as occupation of key areas or use of resources, of the animals housed helps determine suitability of provision for that species. Post-occupancy evaluation allows for modification and alteration of key enclosure features after occupation by a specific species, based on data collected on behaviour patterns. Enclosure usage studies have been used on a wide range of zoo species, however birds do not seem to be as prominently investigated as more enigmatic mammalian species. Flamingos (Phoenicopteridae) are one of the most popular of zoo-housed birds and as such, data on captive birds have a wide application around the world's zoos. Despite their popularity, the "ideal" flamingo enclosure may still be undetermined. According to current ISIS and EAZA records, there are likely to be well over 16,000 individual flamingos maintained in around 340+ zoos globally. Flamingos are therefore ideal taxa for long-term behavioural research with the goal of widespread advancement of husbandry.

The Flamingo Behaviour & Welfare Project at the University of Exeter was established in 2012. Part of this project has been an assessment of enclosure usage for all six species of flamingo housed in captivity. This talk covers data collected for four flamingo species (greater, *Phoenicopus roseus*; Caribbean, *P. ruber*; lesser, *Phoeniconaias minor*; and Andean, *Phoenicoparrus andinus*) at WWT Slimbridge Wetland Centre over a three year period. Flock sizes ranged from 22 to over 200 birds, providing comparison against the stated minimum number (20 birds) in current husbandry guidelines to larger flocks replicating wild systems. During this time period, three of these flocks moved exhibits. Behaviour patterns of these three flocks are compared to one flock that remained in the same enclosure and whose activity budget can be used in comparison to those that experienced change to their immediate surroundings.

Using the modified Spread of Participation Index to record zone occupancy, birds were instantaneously scanned at three time intervals during winter opening and four time intervals during summer opening over a period commencing spring 2012 through to winter 2014. Behavioural data were also noted (in generic categories of active and inactive) for each flock to provide an overall understanding of changes in whole flock activity patterns. Preliminary results suggest strong preferences for biologically-relevant areas (foraging, nesting and loafing grounds). Behaviour patterns also appear to mimic those data from wild birds, with preening and resting making

up a large proportion of the flock's day. Preferences for areas that can include all birds within the group appear specifically important, demonstrating a future avenue of research into how social structure influences zone occupancy. Observations spanning over several years have allowed cross-comparison of behaviour and enclosure use during different seasons (breeding and non-breeding), as well as showing changes in activity patterns across different times of the day. Based on these findings, long term enclosure-use studies can help determine yearly activity patterns and zone preferences that may help ameliorate foot health issues, encourage beneficial location of nesting sites and help reduce aggression over favoured resources. As this research is still on-going, this is a snapshot of the usefulness of such results to the wider area of zoo animal welfare, and the specific area of flamingo management practice.

Comparison of cardiac structure and function between captive zoo and sanctuary chimpanzees (*Pan troglodytes*)

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Whilst cardiac disease related to interstitial myocardial fibrosis (IMF) has been suggested as the leading cause of sudden cardiac death (SCD) among captive chimpanzees (1), this is not the case in wild chimpanzees. In the wild population trauma and infectious disease are the primary cause of death (2) with few animals showing evidence of IMF. The exact reasons for the differences between wild and zoo chimpanzee populations in relation to SCD and IMF are unknown. However, stress, diet and physical (in)activity all could be involved. Echocardiography is a non-invasive tool widely used to assess cardiac structure and function. At present data regarding standard echocardiographic reference intervals for chimpanzees are limited (4). However, we have previously generated echocardiographic reference intervals from a population of adult wild-born sanctuary chimpanzees (females $n=64$, 20 ± 5 years; males $n=38$, 20 ± 6 years), living in large enclosures with access to range habitat and food (5). The purpose of the present study was to compare echocardiographic indices of cardiac structure and function collected from zoo animals with the sanctuary reference intervals.

For the purpose of routine health checks 24 adult chimpanzees (females $n=10$, 31 ± 10 years; males $n=14$, 24 ± 11 years) were anaesthetised at two UK zoos. Three different anaesthetic protocols were used: Medetomidine (0.03 mg/kg) and Ketamine (3 mg/kg) ($n = 4$), Tiletamine-Zolazepam (2 mg/kg) and Medetomidine (0.03 mg/kg) ($n=8$), Medetomidine (0.03 mg/kg) and Ketamine (3 mg/kg) maintained on 0.5-2% of isoflurane ($n=12$). As part of the health assessment a comprehensive transthoracic echocardiogram was completed according to published guidelines (6). Measures of cardiac structure (e.g. aortic diameters, cavity dimensions, wall thicknesses), systolic function (ejection fraction) and diastolic function (early and late trans-mitral blood flow velocities) were assessed. These data were compared with the sanctuary data previously reported (5), and the number of animals falling outside of these reference intervals noted for each parameter.

The mean value for the majority of cardiac structural variables in zoo animals fell within the previously reported reference intervals. However, these mean scores were typically at the higher end of the sanctuary range (Table 1) and a number of animals presented with data outside of the sanctuary reference intervals (Table 1). It is important to note that the age of the male zoo animals was comparable to that of the sanctuary population but females were considerably older. Therefore, while age may be a confounding variable in the female comparison it does not explain the differences in males. Increased cavity dimensions, wall thicknesses or reduced function may occur in response to underlying pathology such as hypertension, valvular disease or cardiomyopathy. It could also be related to the previously described IMF caused by an as of yet unknown aetiology. However, longitudinal studies including histopathology and genetic analysis are required to better understand the progression of cardiac pathology in chimpanzees, and would assist future management decisions to improve chimpanzee health in UK zoos.

Table 1. Comparison of echocardiographic measures of cardiac structure and function between adult chimpanzees living in two UK zoological collections with reference intervals calculated from a large wild-born sanctuary population. LV=left ventricular, d=diastole, s=systole, mid=mid wall.

	Sanctuary 5 th -95 th Percentile Range		Zoo mean \pm SD (Range)		Number (%) zoo animals outside the sanctuary intervals	
	Males (n=38)	Females (n=64)	Males (n=14)	Females (n=10)	Males (n=14)	Females (n=10)
LV Structure						
Aortic Diameter (cm)	2.27-3.38	2.10-2.86	2.76 \pm 0.24 (2.47-3.30)	2.67 \pm 0.12 (2.50-2.83)	0	0
LV outflow (cm)	1.60-2.16	1.42-1.96	2.0 \pm 0.13 (1.90-2.33)	1.93 \pm 0.13 (1.70-2.13)	5 (36)	3 (30)
Septal diameter (d) (cm)	0.62-1.00	0.50-0.90	0.97 \pm 0.12 (0.80-1.20)	0.83 \pm 0.20 (0.60-1.20)	4 (29)	2 (20)
Left ventricle (d) (cm)	4.10-5.71	3.53-4.70	4.58 \pm 0.49 (3.8-5.4)	4.76 \pm 0.57 (4.10-5.80)	0	4 (40)
Posterior wall (d) (cm)	0.60-1.11	0.50-0.90	0.92 \pm 0.14 (0.7-1.2)	0.89 \pm 0.17 (0.70-1.20)	1 (7)	4 (40)
Relative Wall Thickness	0.24-0.48	0.23-0.43	0.40 \pm 0.06 (0.32-0.55)	0.37 \pm 0.06 (0.30-0.48)	2 (14)	2 (20)
LV Systolic Function						
Ejection Fraction (%)	43-66	46-67	56 \pm 11 (40-71)	54 \pm 11 (43-70)	4 (29)	1 (10)
LV Diastolic Function						
Trans-mitral E (m/s)	0.55-1.2	0.59-1.1	0.74 \pm 0.2 (0.53-1.17)	0.71 \pm 0.08 (0.60-0.83)	1 (7)	0
Trans-mitral A (m/s)	0.21-0.62	0.2-0.8	0.31 \pm 0.1 (0.2-0.6)	0.31 \pm 0.10 (0.20-0.50)	0	
E/A Ratio	0.81-3.48	1.10-3.87	2.62 \pm 1.2 (1.25-4.89)	2.61 \pm 0.30 (1.24-4.21)	2 (14)	1 (10)

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What can we learn from agricultural research? And what can they learn from us?

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Farm animal welfare has moved from strength to strength since the days of the Brambell Report (1965) which initiated the five freedoms for animals being kept under intensive livestock husbandry systems. The general principles of which have now been incorporated within the Animal Welfare Act (2006) and UK zoo licencing (Secretary States Standards for Modern Zoo Practice; Defra, 2012). With farm animal welfare funding being a high priority, research into housing, breeding, husbandry, nutrition, social requirements and euthanasia spanning numerous domestic species is vast. Therefore, there is a wealth of experience and technological advances which as zoo biologists we should be tapping into. So, what can we learn from current farm animal research?

In addition to this, for years animal scientists have dismissed zoo animal research due to small samples sizes and the 'individual animal' research approach. However, with additional pressure from the 3R's (Replace, Reduce, Refine) there is now a shift in the movement of farm animal research and they too now recognise that animals are individuals within a group system and are starting to explore individual preferences and welfare concerns, rather than animals as a group. They call it 'precision farming research', however this is what we have been doing all along. So, what can they learn from us?

With expertise and knowledge on both sides, is it time to start discussing how we can help each other?

Happiness means welfare: ratings of welfare and subjective well-being correlate highly in brown capuchins (*Sapajus apella*)

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Is it possible to have all your needs met but still be unhappy? It's a common concept in human literature and one that has begun to creep into animal welfare, with some authors suggesting that an animal with high welfare is capable of being unhappy. Questionnaires filled out by staff familiar with animals may provide an additional method of measuring welfare and addressing this question. In this study we attempted to answer whether welfare can be reliably measured with a questionnaire and if happiness and welfare are measuring the same construct. We administered two questionnaires to three research facilities housing a total of 66 brown capuchins. The first questionnaire was a novel 12-item welfare questionnaire based on work by FD McMillan and D Broom. Raters used a five-point Likert scale to answer 12 questions related to welfare indicators, including, but not limited to, physical health, frequency and ability to cope with stress, the ability to control their environment, and behavioural manifestations of positive and negative welfare. The second questionnaire was the Subjective Well-Being questionnaire, a previously validated four-item measure of 'happiness' utilising a seven-point Likert scale. Each capuchin was rated by an average of 3.48 members of staff on welfare. The interrater reliability of the welfare questionnaire ranged from 0.51 to 0.86. A principal component analysis revealed that all of the welfare questions defined a single dimension, which was strongly correlated with the four Subjective Well-Being items ($r=0.79-0.88$, all $p<0.01$), suggesting that animals who are rated by observers as being 'happier' were also rated higher on the welfare items. Due to these high correlations we conducted a second principal component analysis, this time including the 12 welfare questions and the 4 Subjective Well-Being items. Consistent with the previous results, all 16 items had high loadings on a single component reinforcing that they are measuring the same construct. These results show that the welfare measures and the Subjective Well-Being indicators appear to define a single dimension in captive brown capuchins. It is concluded that through using questionnaires, we can reliably utilize the experience of animal caretakers in assessing individual animal welfare.

Using positive reinforcement training to reduce stress associated with veterinary care

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Zoo-housed species are exposed to various stressors within the captive environment, this includes veterinary care, which can cause behavioural and physiological stress responses, which may impact upon their wellbeing. The evolution of animal training methods, such as positive reinforcement training (PRT), has been extrapolated from training behaviours for anthropogenic purposes, such as entertainment, to training for voluntary cooperation with restraint and veterinary care in order to reduce stress. This investigation examined current scientific and zoological literature, regarding behavioural and physiological measures of stress when using traditional aversive methods of restraint and veterinary care, compared to voluntary cooperation, to establish whether a quantitative basis for the use of PRT existed.

Evaluation of the literature suggested that behavioural parameters of stress, including escape responses, fear vocalisations and aggressive behaviours exist. Additionally, physiological parameters of stress, including heart rate, respiratory rate and stress hormones, such as glucocorticoids are evident in response to involuntary restraint and veterinary procedures. When these behavioural and physiological responses of stress were compared to PRT literature, it was apparent that these parameters of stress were reduced as a result of voluntary cooperation with veterinary care, thus providing a quantitative basis in support of PRT effectively reducing the stress of veterinary care, consequently improving animal wellbeing. Despite the success of PRT to alleviate veterinary stress, species and individual differences and elements of PRT methodology can influence the success of reducing stress through training voluntary cooperation with veterinary behaviours. Differences may include; trainer awareness of body language and effects on the animal, and ethical concerns of PRT including motivational levels, nutritional and anticipatory concerns. These areas have been highlighted as recommendations for prospective research to enhance the success and positive nature of PRT in the future.

Changes in behaviour before and during treatment for degenerative joint disease in a captive, geriatric European brown bear (*Ursus arctos*)

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The data presented were collected as part of a wider study that utilised behavioural and physiological measures of welfare to develop husbandry routines for three female European brown bears (*Ursus arctos*) at the Welsh Mountain Zoo. The bear in this study was undergoing diagnosis for arthritis (degenerative joint disease DJD) during the first year of behavioural observations and so observations prior to onset of medication (PM) and during treatment (DT) with Carprive, were possible. Non-invasive CCTV cameras (CnM secure H. 264) were used to collect data and 342 hours of footage over 18 days, across two years (2011-2012) were analysed for enclosure usage and activity patterns. Additionally, faecal samples were collected during 2012 observations and analysed for corticosterone metabolite levels. Factors affecting behaviour and changes in daily behaviour patterns, morphology of observed behaviour and enclosure usage prior to and during treatment for DJD are discussed.

Higher humidity was shown to decrease time spent active ($r = -0.58$, $p = 0.012$,) and increase time spent engaged in stereotypical behaviour ($r=0.60$; $p=0.008$). Precipitation also caused an increase in the time the bear spent engaged in stereotypical behaviour ($r=0.49$; $p=0.038$). Stereotypical behaviour was reduced from 16% (PM) to 8% (DT) of total time on camera, however this was not found to be significant ($p=0.089$). The amount of time spent performing stereotypical behaviour during the afternoon was halved in 2012 (from 4 hrs 56mins and 9secs PM to 1hr 50mins and 57 secs DT). Time spent on concrete substrate decreased from 90% to 82% in the second study year, however this was not found to be statistically significant ($p>0.05$). Average daily stress hormone levels were 11.59 ng/g (\pm SD 5.54), which was higher than that of the younger two bears in the wider study (6.10ng/g SD 5.28; 8.10ng/g SD 5.28) but not significantly so (Kruskal-Wallis, $p=0.051$). Stress hormone levels were not found to

correlate with any behaviours, climatic or husbandry factors, however the highest measurement coincided with an exceptionally wet day (28mm precipitation). Additional discussion is provided to highlight key changes made by keeping staff to improve welfare for the bear. It is hoped that the findings will help zoo keepers, managers and vets to identify behavioural indicators of this degenerative joint condition in bears so that medication can be administered early and husbandry changes can be implemented to enhance welfare.

Data were collected as part of Ellis' MSc research project undertaken at Manchester Metropolitan University, part funded by the ABWAK Research Fund and the National Zoo of Wales Research Fund.

A comparative study of digestibility and diets for red titi Monkeys (*Callicebus cupreus cupreus*) at three UK Zoos

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There are many challenges and factors to consider when formulating a captive diet to provide optimum health and well-being, especially for non-human primates which have varying digestive strategies. There is growing concern for the prevalence of obesity and nutrition related health problems in zoo housed primates, thought to be caused by high energy diets and low activity levels. These high energy diets have been proposed to be partly caused by the feeding of cultivated fruit for captive primates, due to their high sugar and digestible carbohydrate content, compared to wild counterparts. This study aimed to propose an optimum captive diet for the red titi monkey (*Callicebus cupreus cupreus*) through reviewing the diets provided to eight individuals held at three UK zoos (Bristol Zoo Gardens, Twycross Zoo and Blackpool Zoo), in terms of adequacy, digestibility and possible implications of the diet. This was conducted through five day intake studies, faecal analysis and diet nutrient analysis at each institution. Digestibility was determined through faecal analysis for dry matter (DM), crude protein (CP), digestible energy (DE) and inorganic matter (IO). Diet nutrient compositions were analysed through Zootrition™ software, and daily average nutrients were statistically compared with recommendations provided by the National Research Council (NRC) for non-human primates, where available.

Digestibility was found to be relatively high for all nutrients at each institution however, it was lower with increased fruit quantities in the diet. Results of diet analysis showed a diet with a high fruit content was energy dense, as anticipated, however a diet with a high proportion of vegetables including starchy root vegetables was also of high energy density. This questions whether eradicating fruit is necessary if it is to be replaced with vegetables of similar nutrient composition. Due to limitations and the need for further study an optimum diet was not proposed however recommendations were made based on the findings of this study. Further research is needed regarding this species to aid the determination of an optimum captive diet, this study has also raised questions regarding the feeding of cultivated fruit and vegetables which would be beneficial to expand on for the health and wellbeing of the captive frugivorous primate population.

Digesting the indigestible: how do insect-eating mammals cope with consuming chitin?

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Replicating the nutrients an animal might obtain from their wild diet in a captive environment can prove to be a huge challenge, and the difficulty of this extends even further when considering animals with very specific feeding strategies, such as insectivores. Different species display varying levels of insectivory, ranging from the entirely myrmecophagic animals (purely ant and termite diet) to primates which may supplement their frugivorous feeding with insects. If the way an animal utilizes nutrients from food can be determined, then more accurate dietary husbandry guidelines can be formulated. The aim of this study was to investigate the capacity of five insectivorous species to digest chitin, the polysaccharide component of insect exoskeletons. It is unclear how many species possess the chitinolytic enzymes necessary to breakdown this source of dietary fibre, or whether hydrolysis may occur through bacterial fermentation by microbes in the gut. By determining the apparent digestibility of chitin, the extent to which an animal uses the chitin it ingests as a source of energy or nutrients can hopefully be revealed.

The animals investigated in this study were the ring-tailed coati, common cusimanse, emperor tamarin, pygmy slow loris, and short-beaked echidna, species which span a wide range of insect-eating habits. Each species was fed one of three different insect species of known chitin content (mg/kg); mealworms (55.7 mg/kg), locusts (67.6 mg/kg) and waxmoth larvae (38.1 mg/kg) for 7 days, and faeces were collected for 5 days after a two day adaptation period for each insect species. This continued, with an intake study continuously being carried out, until at least 100g of dry faeces were collected for each diet. Faeces were also collected for a 'normal diet' control. The faecal samples are to be analysed to determine the Acid Detergent Fibre (ADF) fraction, and then compared to the ADF value of each treatment diet, which will give an indication as to how much fibre (chitin) is digested. It could be expected that the insects with the highest chitin content would be the least easily digested, but this would depend on an individual species' ability to cope with dietary fibre. The degree of sclerotization (cross-linking of chitin with proteins) in the exoskeleton could also have an effect on apparent digestibility. Protein and calcium evaluations of faecal samples will also take place to determine digestibility of these important nutrients and the impact, if any, of dietary chitin.

An investigation into the variation and suitability of diets for captive green sea turtles (*Chelonia mydas*) worldwide

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Green sea turtles are widely accepted as herbivores, however omnivorous feeding behaviour in the wild has been recorded. Therefore, the aim of this study was to investigate the suitability of nine captive green sea turtle diets through comparisons based on wild diets found from external research. Proximate analysis methods were utilised to determine the nutritional content of individual dietary items, which were then used to construct an average nutritional value for turtle diets per collection. Where food items were absent due to availability nutritional information was obtained through Zootrition.

Significant differences were found between captive diets for concentrations of protein ($p < 0.001$), ether extract ($p < 0.001$), phosphorous ($p = 0.002$) and calcium ($p < 0.001$). However, the phosphorous content between the individual diet items was not significantly different ($p = 0.74$) therefore it could be assumed that any increase or decrease in overall diet phosphorous content stems from quantities and combinations of foods given. Median nutrient values of the captive diets significantly differed from the wild diet average ($p = 0.004$) suggesting areas for further investigation, and improvement of captive sea turtle diets. Comparison with data on wild dietary contents highlighted that many of the analysed diets were significantly different in protein ($p = 0.004$), phosphorous ($p = 0.004$) and ether extract ($p = 0.004$). One collection fed on average only 11.06g of protein per turtle daily compared to average wild diet figure of 45.71g protein. Both calcium and fibre (measured as ADF) content did not

show a difference between median values per collection and wild data, however these values did vary significantly between collections ($p < 0.001$). Four collections fed diets that had higher phosphorus levels than calcium; this imbalance from accepted ratio of 2:1 Ca:P is of particular concern due an increased risk of developing metabolic bone disease, and it is recommended that such diets be reviewed to see how this balance can be redressed.

This study serves to highlight the disparity in the nutrients being fed between collections, as well as the variation between wild and captive diets. Use of wild data should be considered by those keeping green sea turtles in captivity to ensure a more suitable feeding regime is provided.

Non-invasive adrenal hormone analysis: How many samples should I collect and what will it tell me?

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Measuring adrenal hormones non-invasively, in faeces or urine, although commonly used is still a relatively new science; we have a lot to learn regarding its potential and its limitations. Stress physiology, which involves the hypothalamic pituitary adrenal axis (HPA), is a complex process and is influenced mainly at the level of the brain by a multitude of factors including, but not limited to, age, sex, experience, environment, reproductive state and other biological states. HPA activity can be assessed at many levels ranging from changes in pulsatility, circadian rhythms and average daily concentrations. In addition to these changes, assessing acute changes in HPA activity, such as peak height and duration following a challenging situation is informative. It is important to recognize that non-invasive adrenal monitoring is limited in its assessment and mainly focuses on pooled daily concentrations.

There are also technical challenges of measuring adrenal activity non-invasively. Hormone analysis itself generally involves two stages of sample preparation (e.g. extraction and concentration) and assay analysis (e.g. EIA or RIA). Unlike blood, which targets mainly the native biologically active hormone, faecal and urine steroid analysis targets metabolites of these native hormones and tend to require extraction prior to analysis. Also, the assay of choice must be biochemically and biologically validated to ensure it is appropriate to measure relevant metabolites. Sample metabolism can vary between and within species; therefore, in some cases the decision to use faeces or urine may also have to be addressed. Furthermore there is the added challenge of sample identification and sample decay.

Unlike reproductive steroids where there are often clearer biological patterns (such as oestrus cycling, pregnancy, seasonality) interpretation of adrenal metabolite concentrations tends to be difficult on their own. Understanding what might predict elevated adrenal activity is a commonly asked question. This can be successfully addressed through the correlation of longitudinal endocrine profiling in combination factors thought to influence adrenal activity (e.g. individual, age, sex, behaviour, management practices or season). Analysis of several factors alongside frequent and substantial sample collection will give a good indication of factors related to adrenal activity. However, elevated adrenal activity is not only a normal and biologically necessary response, it can occur for a variety of reasons and therefore the observation of elevated HPA activity should not be deemed as stressful. Therefore, to suggest that elevated adrenal activity may be harmful, other down-stream measures of stress such as, but not limited to, poor body condition, reproductive health, immune function and fitness should be measured alongside longitudinal endocrine profiling.

Measuring hormones associated with the stress response is a useful tool for conservation biologists and animal managers and can help us understand biological mechanisms associated with species decline and animal welfare.

Putting sparkle into your freezer! The trials and tribulation of faecal sampling

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Monitoring stress of zoo-housed animals is an important part of assessing welfare standards to determine the extent a specific captive stressor may have upon the individual. The collection of faecal samples from target individuals therefore, allows researchers to observe trends in stress hormones over a selected time period. Once analysed these can be used to consider the extent if any that the stressor may have impacted upon the individuals physiology and behaviour. Used alongside behavioural observations faecal sampling can therefore, provide a non-invasive and scientific means of assessing an individual's welfare. To date, 697 faecal samples from three *Panthera* species comprising of 15 individuals have been collected as part of a long term study monitoring specific stressors across EAZA collections. Coordinating the movement of these individuals to allow for the collection of 'fresh' faecal samples is not an easy task, factors to ensure the reliability of the findings from the initial collection through to storage and laboratory analysis must be considered. This study aims to consider the factors influencing the success of faecal sampling as a non-invasive welfare indicator whilst considering *in situ* effects upon the validity of the samples. Case studies using Amur tiger and Amur leopard will be discussed to show how variable data collection can be and thus, how influential these factors can be for the success of research.

The whole animal approach: why careful application of endocrinology can be instrumental in animal behaviour studies

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There are a number of factors that can influence the behaviour and welfare of animals involved in research, whether domesticated, captive exotic or laboratory species. Husbandry techniques, environmental effects and even developmental conditions can all influence individual behaviour and physiological responses at various stages throughout life, which ultimately impacts on animal health and wellbeing.

Endocrinology can help to complete the picture when subtle or rarely occurring behaviours may fail to explain why social groups are incompatible or reproductive attempts result in failure. By quantifying the levels of steroid hormones and urinary proteins in some species, researchers can measure the physiological responses of individuals following a known or observed event, as well as identify patterns such as reproductive cycling. In addition physiological data can also be used as a tool in captive husbandry to accurately time reproductive events or to predict the level of anticipated competition between individuals in social groups.

The combination of physiological, behavioural and environmental data in statistical models enables a more rigorous assessment of potential influences on animal health and welfare, however it is important that researchers take the potential limitations of physiological measures into account. Individual tolerance and health status must be considered and regular samples must be taken in order to identify potential factors that can influence the strength of an endocrine response. Using findings from experimental research with wild house mice and other published case studies, I will demonstrate the value of combining physiological and behavioural data, using systematic sampling methods and rigorous statistical models to interpret findings. Future plans for zoo research incorporating endocrinology will also be discussed.

Welfare monitoring for an African elephant

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Paignton Zoo Environmental Park holds a single, elderly African elephant, Duchess, who has been housed alone since her long-time companion, Asian elephant Gay, died in March 2010. Since then Duchess' welfare has been a prime concern for the keeper team and we have used a variety of methods to attempt to monitor this on a continuous basis. As would be expected in an elderly animal Duchess has had a number of health issues, including the loss of her right eye in 2011. She then also developed cataracts in her left eye resulting in severe, or possibly complete, loss of vision. She underwent an operation to remove the lens of her left eye in September 2012. It was particularly important for us to understand the impact on her welfare of the condition itself and the medical interventions at this time. We collected daily faecal samples pre- and post-operation for measurement of corticosterone metabolites and intensified our regular behavioural observations. Unfortunately, despite these efforts to provide evidence of her welfare condition over this period the results are difficult to interpret and do not allow us a clear understanding of the impact of the many potentially stressful events that occurred. However, the behavioural results do allow us to infer that following the operation her vision was restored to a functional level.

Aquariums as restorative environments and the influence of exhibit content

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Research on environments that promote human health and well-being finds that exposure to natural environments, even highly 'managed' settings, such as botanical gardens, can have calming and stress-reducing effects. However, research on urban parks has shown that people's psychological responses differ depending on the numbers of species present. These studies have found that greater well-being tends to be experienced in settings perceived to contain higher species richness. Using the simple but common method of asking people to rate photographic images, we systematically explored reactions to different exhibit types, categorised by climatic region (tropical/temperate), species richness (high/low) and abundance of individuals (high/low). We also explored responses to a sub-category of 'charismatic' and 'less charismatic' animals. Photos were rated on four dimensions (aesthetic, behavioural, emotional and perceived restorativeness). We found that exhibit content influenced responses, with participants generally expressing a greater preference for tropical exhibits, particularly those containing high species richness and/or abundance, and charismatic animals. These exhibits were also perceived to be more restorative. This research has a number of practical and policy implications. Exploring optimal stocking conditions may be important for the use of aquaria in stressful environments such as healthcare settings and the workplace. Aquariums may also provide an alternative setting for potentially restorative experiences that may be especially valuable for people unable to access natural environments. Furthermore, as marine ecosystems can be adversely impacted by visitors, the ability to connect people to natural environments by proxy, for example through aquariums, could be extremely important: helping urban populations connect with the marine environment and its species may lead to greater understanding of the benefits of natural ecosystems and an increased willingness and motivation to conserve and protect them.

Evaluation of the effectiveness of zoo information signs for education

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Zoos claim they play a crucial role in public education about animals and that the use of information signs is the primary way of imparting this knowledge. However, few studies examine the effectiveness of zoos as an educational institution and even fewer look at the success of animal information boards. This presentation examines how successful signs are at increasing public understanding a) about animal facts and b) conservation. Our study surveyed 234 visitors; 118 having read animal signs (read) and 116 acting as a non-reading (unread) comparison group. Of these respondents 72 (43 read and 29 unread) also completed an email questionnaire 6 months post-visit, to test knowledge retention. In-visit and 6 month post-visit questionnaires both investigated knowledge of animal facts based on the 1st, 10th and end line of each sign. Questions were also asked about 'did you know?' fact signs, the animals' habitat, appearance and threat status. Responses were coded as correct (1) or incorrect (0) and binomial GLMs were used to compare the responses between reading and non-reading groups. We demonstrate how the probability of answering animal knowledge questions correctly was shown to increase after reading the sign. Reading was found to be a key predictor in understanding both animal threat status and habitat, key areas for conservation awareness. Data collected 6 months post-visit indicated that the probability of correctly answering animal questions falls over time but is higher than baseline (unread group) knowledge. The non-reading (unread) group showed an increase in knowledge 6 months post-visit. As 66% of the unread group stated that they read signs after our interview, it is proposed that sign reading could explain the knowledge increase. We propose zoo information signs are important in increasing public awareness of animals, in particular, for developing awareness of threat status and animal habitat.

Can the presentation of captive amphibians in zoological collections be modified to maximise feelings of empathy, engagement and interest from teenage visitors

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Amphibians represent the most threatened class of vertebrates and the continued survival of many wild populations is affected by a multitude of factors including habitat loss, pollution, invasive pathogens and over harvesting. With global amphibian populations in steep decline there is a clear need for a multi-faceted approach to their conservation. The viability of many species in the wild has been severely compromised and captive breeding in zoos has been identified as an essential component for the short-term survival of many endangered taxa. Educating the visiting public about amphibians is an essential role for zoos, however due to their secretive nature and passive behaviour, amphibians are considered to be challenging animals to exhibit. A consequence of this is an indifferent attitude towards them and a lack of engagement by the visiting public, both of which hinder delivery of the conservation message. There is a clear need for zoos to promote amphibian conservation more effectively and to focus their efforts on developing exhibits that maximise opportunities for visitor engagement and empathy. Prior research on other taxa reveals a number of physical and behavioural attributes that may enhance visitor interest and also identifies an impact due to the arrangement of the display itself, with naturalistic enclosures widely perceived to be more interesting. This research uses a mixed methods approach (comprising questionnaires, slide shows and group discussions) to determine the impact of species attributes and enclosure design on the attitude of 102 teenage zoo visitors towards amphibians in a captive collection. By investigating attitudes towards amphibians as a group and identifying those features that promoted interest and engagement it was revealed that many of the features that enhance visitor interest in other taxa can be applied equally to amphibians. Brightly coloured, active animals in naturalistic displays fostered the most positive opinions whilst simplistic displays caused visitors to question welfare and husbandry. Individual visitor perceptions of 'natural' were also influential in determining the level of interest in both species and exhibit. Although generally viewed in a positive or indifferent light, there was a significant difference ($p < 0.001$) in the extent to which respondents were concerned or interested in amphibians in comparison to other animals.

A targeted approach to amphibian display is needed if zoos are to effectively engage their visitors with their animals and with the messages they wish to promote. Gaining a better understanding of how visitors perceive and think about amphibians and identifying those aspects of their captive display that may enhance engagement, is essential for this to occur. If interest in an unfamiliar topic (amphibian conservation) can be enhanced by exposure to particular animals displayed in a certain way then this allows an institution to maximise the potential for further interest and learning.

Managing the genetics of a captive species *Raja undulata*

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Over a number of years, UK aquaria have been collaborating in a managed breeding program for the endangered and commercially protected undulate ray, *Raja undulata*. To further enhance this program, recent and ongoing genetic research is being undertaken for the first time on this species of skate. This presentation will explain the work, through collaboration between SEA LIFE and Manchester University, to establish the genetic primers and microsatellites needed to allow the development of a concise pedigree and family tree of the existing population. The benefits that this information will bring in the strategic mating of animals will be discussed while highlighting how this research could aid *in-situ* conservation and fisheries management of the species.

Reintroduction projects involving captive-bred animals: zoo and aquaria involvement and project management factors contributing to success

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Reintroduction aims to re-establish a viable population of a species within its indigenous range from which it has disappeared. The reintroduction field is fast-growing and methodology and favourable practices have been continually evolving over recent decades. Along with intensification, focus is now set to shift in the face of climate change and increasingly human-dominated environments. It is therefore crucial that ongoing efforts are recorded and reviewed regularly in order to learn from approaches and to progress. Zoo and aquaria involvement in reintroduction is lacking thorough quantification; this is a shortcoming in the light of this practice being an emphasised contribution by these institutions to *in situ* conservation efforts and an outcome of captive-breeding programs. This research focuses on the contribution by European Association of Zoos and Aquaria (EAZA) member institutions to reintroduction projects involving captive-bred animals.

EAZA institutions are found to be contributing to a greater extent than previously documented. They are focusing attention on threatened species and the resources they are providing extend beyond animals, to high levels of staff, expertise and funding. The research then addresses the project management factors that are contributing to the level of project success. Level of success is assigned according to a combination of both a subjective and objective measure. Success is found to be predicted by a number of project management factors. This highlights that the decisions practitioners make are influencing the projects they are undertaking and therefore that success has the potential of being optimised; it is not only due to factors such as animal biology, that are beyond practitioner control. The results also show that a more focused approach is required in many areas of the reintroduction process, as opposed to thinly spreading resources across every potentially applicable management component. Where breadth of awareness of considerations is essential, outcome can be optimised by then concentrating resources in accordance with the specifics of the project in hand. It is hoped that the conclusions of this study will aid future reintroduction initiatives and that it will provide a foundation for extension and development in further review efforts.

A global geographic analysis of WAZA member *in situ* research project site locations

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Under inspiration from the World Zoo and Aquarium Conservation Strategy, all modern zoos now contribute in some way to *in situ* conservation. However, the aims and objectives of these conservation intervention efforts are wide in their approaches and scale, often varying greatly between institutions. In the absence of existing measures of conservation success for the zoo community's field conservation efforts we here gather evidence from the published zoo conservation science literature to evaluate these efforts.

There have previously been a small number of studies which have analysed various WAZA-branded *in situ* conservation site locations. Our study goes beyond these previous efforts in order to provide a wide ranging and more comprehensive summary and analysis of *in situ* sites which have a scientific output. The CIRCLE team has compiled a database of 16,111 publications authored by WAZA institutional members. The database comprised published papers from a Web of Science search with authorship by a WAZA member-based author verified by checking each paper. Details for the continent, country and GPS coordinate locations of the project sites were collated from the papers listed in the database. We assessed geographic information of field project sites detailed in these publications and compared them to known hotspots of biodiversity. Outputs from the work included a global map of *in situ* field project sites, which showed that zoo field conservation research extends across all continents and most countries. The disparity in publication numbers between institution members is striking, with the majority of publications from a handful of research-intensive members. Other results included the number of studies per country where the studies were conducted, as well as the location of sites in relation to protected areas globally. The work is intended to provide a baseline for planning future zoo conservation research work. While zoo research is clearly global in extent, many are not engaging fully with scientific research. There is also potential for greater inter-institution collaboration between zoos working in close proximity, particularly regarding data-sharing and selection of field sites for research.

Developing a baseline for the holistic measurement of conservation success

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Holistic assessments of conservation projects are essential to our understanding of them. They should draw on all ecological and socio-economic aspects, from biodiversity to threats. Commonly, field conservation projects, especially zoo funded ones, lack a holistic approach. We aim to review conservation success using a developed set of holistic indicators and focus upon tropical forests due to their noted intrinsic biodiversity value. Our study uses a zoo-led conservation project in Magombera forest in Tanzania. A Holistic Indicator Selection Protocol (HISP) was used to develop 43 indicators, categorised into ecological, social and interactive. These indicators have been analysed since 2007. Annual data are incorporated into a Holistic Ecosystem Health Index (HEHI). Among the indicators assessed to date, our data show mixed success of the forest conservation work. No significant change in forest biomass or relative growth rate to trees is recorded. However, an increase in rare tree species has demonstrated improving biodiversity. The abundance of three forest-dependent diurnal primate species has declined significantly from 2007-2013. This suggests a lag response to forest loss occurring 30 years prior to the study period. Positively, Udzungwa red colobus groups have stabilised from 2013-2014 in line with decreasing incidences of logging and tree-cutting. Usage of fuel-efficient stoves has increased in nearby villages alongside improvements in the number of students reached by environmental education. This suggests that awareness of the importance of forest conservation is increasing. Furthermore, the compliance of village committees with agreed conservation actions emphasises a positive impact on local management and governance. Currently, HEHI has not indicated overall conservation success during the study period, highlighting some weaknesses in forest patrols and socio-economic development. Therefore, monitoring will continue as we hone our holistic measurements of conservation success.

Evaluating energy consumption and the use of heat sources in animal exhibits to help inform collection planning in a more sustainable way: a case study at Newquay zoo

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One of the challenges facing modern zoos is balancing their conservation activities with maintaining a viable operating business. Zoos aim to keep living collections of endangered animals for a variety of purposes including conservation and research but also have commitments to both local and global sustainability. To be more active advocates of sustainability zoos must be more sustainable in their own practices and there is a growing need for the results of energy audits and monitoring to be used in a more effective way for activities such as collection planning. The aim of the current study is to evaluate the energy usage of enclosures to inform collection planning in a more sustainable way. This is being carried out using three case studies at Newquay zoo: a Phillipine exhibit which houses Visayan warty pigs (*Sus cebifrons*) and Phillipine spotted deer (*Rusa alfredi*), a tortoise exhibit which houses leopard tortoise (*tigmochelys pardalis*) and radiated tortoise (*Astrochelys radiate*), and a waxbill aviary which houses six bird species, red eared waxbill (*Estrilda troglodytes*), purple grenadier (*Uraeginthus ianthinogaster*), white-eye (*Zosterops senegalensis*), goldbreast (*Amandava subflava*), Cape dove (*Oena capensis*) and chestnut-back mannikin (*Lonchura castaneothorax*). The overall energy consumption of the enclosures is being monitored using the Hanwell environmental monitoring system. The animals' use of indoor heat sources such as heat lamps is being recorded using camera traps. Cameras were set to take a photograph and record the animals' location and proximity to the heat source, and temperature every half an hour, over a 5 day period. Three heat zones were identified to mark whether the animals were using the entire heat source or only partially using it. Using one of our case studies we will demonstrate firstly whether the species in the current study are actually using the heat sources provided to them and if using systems such as automatic timers or sensors on heat lamps we could reduce the energy consumption of the exhibits. Secondly we aim to show how the data we have collated can be used alongside other variables such as cost of feed, food miles etc, to give each exhibit a 'sustainability' rating. This will then be fed into the WWCT's existing collection planning tool which takes into account other factors such as conservation status and exhibit value (in terms of visitor experience) to establish a traffic light system of grading animals in collection plans.

The visitor experience at Newquay Zoo: utilising GPS technology and observation to inform collection planning and site management

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Passive GPS tracking, interviews, and observational survey methods were utilised to characterise visitor behaviour and experiences at Newquay Zoo in the context of animal popularity (attracting power and holding time), engagement, social interaction, dwell time and use of the Zoo site. Low-cost GPS data loggers returned highly accurate spatial and temporal data for 87 participant groups, and analysis of GPS tracks using mapping software – alongside interview responses - highlighted areas for improvement with reference to signage, visitor orientation, and sustained interest in different elements (actual vs anecdotal). Observational data enabled further detailed analysis of the contribution made to the zoo experience by individual species or non-animal elements, informing the assessment of exhibit appearance, signage, interpretation, and levels of visitor engagement. Although the majority of visitors recognised the potential of zoos to educate and conserve, most came to the Zoo to enjoy time with their social group, regardless of stated motivations or expectations, generally reflecting on the day's experience as 'enjoyable family time'. Individual animals made a lasting impression on visitors, and were still found to be the primary component of an enjoyable visit to the Zoo, with many citing specific animals or animal behaviour as the most memorable aspect of their experience. However, findings indicate that improved signage could encourage visitors to discover more of the Zoos' animals, while increased opportunities for social fun, engagement and education built around the animal exhibits could have a positive effect on the typical visitor experience, potentially improving dwell time, emotional connection to animals, and perceptions of value for money.

Effect of three forms of intrinsic enrichment on the behaviour of Sumatran Tigers (*Panthera tigris sumatrae*) and Cheetahs (*Acinonyx jubatus*) in captivity

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The stimulation of natural and relevant behaviours is necessary to ensure the welfare of captive animals. This is the central goal of environmental enrichment techniques. Environmental enrichment classified as intrinsic, functions as intrinsic reinforcements, whereby the performance of a behaviour increases the chances that the behaviour will be performed again. Exploration is an example; the addition of new objects or new scents to the environment, which take little time to implement, can act as intrinsic enrichment and reinforce the performance of behaviours such as exploration. This study investigated the effect of three forms of intrinsic enrichment (a new object in the environment and two new scents) on the behaviour of two Sumatran tigers (*Panthera tigris sumatrae*) and eight cheetahs (*Acinonyx jubatus*) in captivity, at Fota Wildlife Park, Cork, Ireland. The new object consisted of a ball made of hay, about 20cm in diameter, tied by natural string, which was used as a substrate for subsequent application of scents. The odours utilised were the herb *Nepeta cataria* (catnip), and the spice *Cinnamomum zeylanicum* (cinnamon). Both scents were used in liquid form (5mL), sprayed into the hay ball. The behaviours were recorded directly through focal sampling with continuous recording for an hour, seven consecutive days for each enrichment. The experimental design consisted of seven days of baseline observation without introducing enrichment, followed by seven days of application of the hay ball (no scent), with subsequent applications of catnip and cinnamon, with seven-day intervals between each treatment (hay ball, catnip and cinnamon). The study of the behaviour of both species, elucidates the effectiveness of these enrichments for the two species in question. Studies focusing on the improvement of environmental enrichment techniques, as well as reinforcement are fundamental to the improvement of the welfare of captive animals.

The long weekend: do zoo-housed mammals avoid giving birth when the zoo is crowded?

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Two laboratories have reported evidence that birth events in their captive primate colonies (cotton-top tamarins and chimpanzees) might be skewed towards periods when there are fewer people present, and have postulated that the animals suppress some components of the parturition process in order to delay births until quieter periods. If this is a widespread phenomenon among mammals, and occurs among zoo-housed mammals, then clearly this would be a potential welfare concern. Here we test the hypothesis that the timing of births in zoo-housed mammals is influenced by the number of people in the zoo. Birth records were analysed for 15 different mammalian species representing four orders (Artiodactyla, Perissodactyla, Primates, Carnivora) housed in two zoos. Birth data were obtained from ZIMS records, and average daily visitor numbers were calculated from gate records. A significant negative correlation between number of births and average daily gate numbers was found only in red lechwe; no correlation was found in any of the other species. Significant temporal variation in birth number between days of the week was found in three species (chimpanzee, nilgau and blackbuck), but this was not associated with mean gate numbers for those days in any of them. No housing or husbandry variables could be identified which might account for the birth timings observed in the lechwe. It was concluded that the evidence does not support the hypothesis that zoo-housed mammals avoid giving birth when the zoo is busy.

Factors influencing interactions in zoos: animal-keeper relationship, animal-public interactions and solitary animals groups

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Interactions that animals experience can be a significant influence on their health and welfare. These interactions can occur between animals themselves, but also between animals and keepers, and animals and the public. This project proposes a permanent monitoring scheme to record animal-human interactions and animal-animal interactions. This will be accompanied by a survey of animal personality for welfare, husbandry, breeding programmes and reintroduction purposes. The pilot project is currently based on direct monitoring of animal behaviour, use of time lapse cameras and animal personality questionnaires completed by experienced keepers. The goal of this project is to create a network between zoos to explore the aforementioned interactions to produce husbandry protocols and explore personality and behavioural traits in multiple species. We present provisional data regarding polar bear (Fasano Zoosafari, Italy), Sumatran tiger, Amur tiger and Asiatic lion (ZSL London and Whipsnade zoos) interactions with humans and conspecifics. These data are collected across a broad range of environmental conditions and we outline the monitoring protocols developed to collect this data. The first year data show the great adaptability of these species to *ex situ* environments, low or absent negative impact of visitors' presence and the relevance of individual personality in these interactions.

Nectar pot provision for rainbow lorikeets (*Trichoglossus moluccanus*) in a walk-through aviary

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'Walk-through' enclosures have become increasingly popular in zoos over the last few years as they enhance the visitor experience by allowing them to get up close and interact with animals. Due to their brightly coloured plumage and natural curiosity, rainbow lorikeets (*Trichoglossus moluccanus*) are becoming more frequently used in these types of walk-through enclosures, whereby visitors can buy small pots of nectar to feed the birds. A number of studies have been carried out on how these types of enclosures impact on the behaviour of their residents, mainly lemurs, with conflicting results showing both positive and negative behaviours displayed as a consequence of visitors entering the enclosures. This, coupled with a large amount of research into the potential impacts of general captivity on psittacine behaviour, highlights a need for an exploration into whether there is an impact on lorikeet behaviour in walk-through enclosures. Factors such as the varying levels of nectar pots offered and visitor numbers within the enclosure could impact on the natural behaviours of the birds. Behaviour observations were carried out in the 'Lorikeet Landing' walk-through aviary exhibit housing rainbow lorikeets (n=37) at Twycross Zoo, East Midlands, with scan samples taken at 30 minute intervals between 1100hrs and 1600hrs over a period of five weeks. The number of visitors within the enclosure and nectar pots offered to the birds was also recorded at each data collection point. Results showed a positive correlation ($p < 0.05$) between the number of nectar pots provided and number of birds drinking during weekdays (Mon-Fri), but no correlation during weekends (Sat-Sun). Both social and independent behaviours were affected, noticeably levels of aggression increased after nectar pot provision during weekdays ($p = 0.004$) but not at weekends ($p = 0.625$), possibly due to a perceived competition for nectar when there were less visitors entering the enclosure. Allo-preening also increased during weekdays ($p = 0.002$) but not at weekends ($p = 0.782$), potentially as a means of rebuilding social bonds affected by the increased levels of aggression. These results suggest that captive lorikeets may resort back to natural feeding strategies seen in the wild by taking advantage of available food when they perceive sources to be unreliable. As a result it is recommended that procedures are in place to monitor the number of visitors and nectar pots provided at any one time, and also where the nectar pots are located within the enclosure. Also, further research is needed into the effects of nectar pot provision at different times of year to investigate if other variables impact on behaviour. This will aid in improving captive bird welfare and also help continue to provide a positive experience for zoo visitors.

Monitoring behavioural changes during visitor feeds on a group of giraffes at Blackpool Zoo

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Human-animal interaction experiences have become very popular within the zoo industry to enable extra revenue and to help provide knowledge to the visitors thus helping conservation strategies. As the animals are gaining personal and close contact with the visitors it is important to determine whether these interactions are having a positive effect on the individuals and not interfering with good welfare standards. A case study was conducted at Blackpool Zoo where two hybrid giraffe (*Giraffa camelopardalis*) Kiera and O'Grady were observed during the Easter and summer holidays 2014. Behavioural observations were carried out pre-, during and post-visitor feeds to determine whether an observed difference could be seen between conditions. Significant differences were found in 'natural' behaviours, such as feeding behaviour, by O'Grady increasing with higher visitors numbers participating in the visitor feed ($p < 0.05$). Kiera's behaviour of resting/standing showed a significant difference with the number of child visitors at the feeds ($p < 0.05$). 'Out of sight' was significantly different for O'Grady and Kiera suggesting that the giraffes did move away from the platform at times throughout the feed ($p < 0.05$). This could be interpreted as a need to ensure the giraffe can choose to access space away from close proximity to visitors thus helping formulate a positive experience for the giraffe. As no significant difference between observed abnormal behaviours prior to and following the feed was found we could conclude that the visitor interactions are a positive experience for the giraffes at Blackpool Zoo.

The effects of environmental enrichment and weather on enclosure use and within-pride conflict in African lions (*Panthera leo*): study using keeper and researcher data.

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This study assessed the enclosure use of a pride of captive African lions at West Midlands Safari Park in the recently developed 'Kingdom of the Lions' reserve, considering the influence of (a) weather and (b) provision of enrichment. The effect of enrichment on the duration of behaviours for focal members of the pride was also assessed, to examine what could be done to minimise the amount of conflict between the pride and a semi-excluded member. Data on pride enclosure use began to be collected daily by instantaneous scan sampling (one hour AM, one hour PM) as part of the patrol keeper routine in the autumn of 2014 and this programme is continuing. Our study is the first analysis of the keeper collected data and combines it with researcher collected data which focused on the behaviour of two focal cats (the dominant member of the pride - and the semi-excluded member) using continuous recording.

Analysis found that pride enclosure use was affected by both weather, and the type of enrichment present. The overall use of the enclosure was compared to the previous year pilot study results and significant differences were found. Furthermore, changes in the behaviour of the focal cats due to different types of enrichment were also seen. Outcomes of data analysis are periodically fed back to the keepers who collect the pride data in order that they see the benefits of their efforts and can assist in the interpretation of results. The findings may be beneficial to ensuring cohesion within the pride, and in avoiding any future conflict.

A preference test for the common clownfish (*Amphiprion percula*) for real and artificial anemones

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The trade of marine ornamentals has been expanding significantly over the last two decades, with 45 countries removing and exporting between 14 and 30 million fish and other marine ornamentals such as sea anemones. However, they are still using and relying on some unsustainable practices to collect the fish, for example cyanide fishing. These unsustainable practices are having detrimental effects on coral reefs, which support over 4000 species of fish, 800 species of reef building coral and several thousands of other reef invertebrates. Two species that live on coral reefs and have symbiotic relationships from which both species benefit are anemone fish and sea anemones. Increased demand for clownfish as a commonly traded anemone fish, has in turn increased the demand for sea anemones, because of their symbiotic relationship. Sea anemones have slow growth and reproduction rates so may be susceptible to overharvesting in the future. This study therefore, aimed to determine whether clownfish can live in artificial anemones just as well as real ones, to encourage artificial ones to be used over real ones without affecting the welfare of clownfish. Common clownfish (n=6) were put through a preference test to determine when given the choice if they preferred real or artificial anemones. No significant difference was found between preening time for real and artificial ($p>0.05$) anemones although the clownfish showed more complex preening behaviours towards the real anemone and showed a higher mean frequency for hiding in the real anemones tentacles, although not significantly so ($p>0.05$). Results suggest that clownfish do in fact prefer real anemones.

Long-term research into the breeding ecology of Chilean flamingos in Dublin Zoo

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This presentation will be based on data collected on the Chilean flamingo flock in Dublin Zoo. This flock currently numbers 82 birds, 12 of which hatched last year. All flamingos have large leg rings so each can be individually identified. Observational data of the flock has been collected since 2003 during the breeding seasons. Over the years, a picture of the flock has been built up allowing Dublin Zoo to understand the breeding ecology of this species better. This research has revealed which birds are successful breeders and which do not fare so well. It also looks at how pairs change from year to year depending on how successful each pair is.

This research has also shaped how Dublin Zoo manages the flamingo flock. Data revealing high numbers of eggs which do not hatch lead onto research looking into egg fertility. Eggs are now artificially incubated until they internally pip and then they are placed back on the nest where a dummy egg had been placed. If the parents have abandoned the nest, the fertile egg can be given to another pair which is chosen based on data collected on pairs. Thus, this research has helped to improve breeding success of the group each year. Other research on the flamingo flock includes using biometrics to determine the sex of Chilean flamingos. Currently, additional research is being undertaken on flamingo feet using photographs collected over several years.

Effects of enclosure design on breeding success in flamingos

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Zoo enclosures must fulfil their inhabitants' biological requirements if the animals are to thrive and breed. Successful breeding of zoo animals is also an indication that animals have good welfare. This study evaluates enclosure design for flamingo species, as evidence-based research in this area is limited. Breeding success data (eggs laid female⁻¹, proportion of eggs hatched and proportion of survivors) and enclosure and husbandry parameters were obtained from 26 flamingo flocks at 20 UK institutions using questionnaires. Regression models were used to identify the parameters that best predicted breeding success. Egg-laying was positively related to pool size relative to enclosure size, distance of feeding area from public viewing area, flock size and presence of other species in the enclosure. Increasing enclosure area and soaking of nest areas with water negatively influenced egg laying. Hatching success was positively predicted by enclosure area, but negatively predicted by presence of other species in the enclosure and pool size relative to enclosure size. Survivorship was positively influenced by flock size, indoor pool size relative to indoor enclosure size and pool size relative to enclosure size. Use of enrichments to encourage breeding had a negative influence on survivorship as did the area of the indoor enclosure. The results suggest that flamingos breed most successfully when their enclosure allows them to exhibit natural behaviours, such as spending extended periods of time in water in large flocks, with little disturbance from the public.

Breeding behaviour and success of tufted puffins (*Fratercula cirrhata*): an investigation into the effects of husbandry and social environment

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Since Living Coasts opened in 2003, the tufted puffin (*Fratercula cirrhata*) population has experienced limited breeding success. As Living Coasts houses the only population of tufted puffins in Europe, it is important for the birds to breed to maintain a self-sustaining population. Previous behavioural studies determined that keeper disturbance during daily husbandry led to evacuation of nest boxes during key incubation periods in the breeding season. Our study continued to monitor the behaviour of the puffins in the non-breeding and breeding seasons and in addition, aimed to determine the effect of enclosure modifications on nest box use. Five sets of behavioural observations were conducted during the study; three prior to breeding season, one during the onset of breeding and one during the breeding season. Activity budgets were recorded by carrying out instantaneous focal follows on each of the puffins (n=13), focusing on aggression, pairing and nesting behaviours. We found that husbandry continues to influence behaviour during the breeding season, particularly when it involves keepers entering the exhibit. Enclosure use did not change in response to exhibit changes and the birds did not use the upper nest boxes this year. During the study it was also observed that the feet of the puffins were pale in colour compared to previous years and particularly wild counterparts. On analysis of the provisioned diet, it was suggested that specific carotenoids may be deficient in the puffins current diet (astaxanthin, lutein, zeaxanthin and β -carotene). Of particular interest is astaxanthin, which is also found in puffin egg yolks. In response, the effect of carotenoid supplements on leg colouration has been monitored during the breeding season. Colouration analysis will contribute to improving dietary provision for the species and feed directly into the management of puffins housed at Living Coasts. The project is part on an ongoing long-term study to determine best practice in the husbandry of the species, with the ultimate aim of increasing breeding success.

Reproductive success in hand-reared Java sparrows and early behaviour of their offspring compared to parent-reared conspecifics

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Java sparrows *Lonchura oryzivora* are members of the Estrildidae family and are native to the islands of Java and Bali in Indonesia. The species is currently listed as Vulnerable on the IUCN Red List due to intense trapping for the local and international cage-bird trade. There is a well-established captive population of Java sparrows at Paignton Zoo Environmental Park with an estimated 60 mature birds in January 2015. In 2013, the zoo began developing a hand-rearing protocol for Java sparrows and studying their post-fledging behaviours and interactions with parent-reared conspecifics. Java sparrows breed well in captivity and as relatively large seed-eating finches they make a potentially useful model species for the development of hand-rearing protocols. During 2014/15 the project has expanded to include the study of breeding behaviour and success. Ultimately, this project aims to develop a hand-rearing protocol to inform the intensive management of threatened Estrildidae populations in the wild.

Nesting behavioural data were collected on the hand-reared (HR) 2013/14 project birds and parent-reared (PR) Java sparrows in Reptile Tropics, a large tropical mixed-species aviary. Each nesting pair (n = 11) was observed for 20 minute periods once a day opportunistically across 142 days, during this time specific courtship and nesting behaviours were recorded using all occurrence sampling. Nesting and breeding success were compared by recording the presence of nest material, number of eggs, number of viable eggs and number of chicks every week for all accessible nest sites (n = 17). Data was also collected on the post-fledging behaviour of birds that have been hand-reared or fledged naturally this breeding season (2014/15).

Four out of nine hand-reared birds established nest sites in their first breeding season (aged 9-12 months) which, given the approximate ratio of hand-reared to parent-reared birds at the start of the breeding season, would indicate there was no effect of rearing on mate preference. Two pairs involving a hand-reared bird (HRPR) are known to have produced viable eggs and fledged 17 chicks in five broods between them. Although parent-reared pairs (PRPR) had a higher average clutch size than HRPR pairs, HRPR pairs had higher average egg fertility. Hatching and fledging rates were similar for both types of parent pair. There were significant differences between HRPR and PRPR pairs in the rates of courtship and defensive behaviours, although the effect of rearing may be confounded by age and fledging events respectively. Preliminary results also indicate that hand-rearing does not affect fledging behaviour or ability to integrate within a breeding group of mixed-aged conspecifics. Results will be discussed within the context of the developmental stress hypothesis, hand-rearing protocols and the project's limited sample size.

Captive population management: investigating reproductive parameters and the long-term effect of contraception in white-faced saki monkeys (*Pithecia pithecia*)

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Captive breeding programmes provide important reserve populations for endangered and vulnerable species. In Europe, many species are managed as European Endangered Species Programmes (EEP), which involve maintaining records on demographic and genetic information and providing recommendations for breeding, with the aim of maintaining high genetic diversity within the population. The EEP for the white-faced saki monkey (*Pithecia pithecia*) is managed by Paignton Zoo Environmental Park. The breeding rate of *P. pithecia* has been high in recent years which has led to a surplus of individuals and as a result, management strategies have now been implemented to reduce population growth. Investigating demographic factors and trends in population growth can help to support studbook decisions and there is little known about the long-term effect of management strategies. We explored the demographics of the captive *P. pithecia* population since 2000, from

540 births in zoos participating in the European captive breeding programme. As saki monkeys do not show external signs of oestrus, observations were conducted to determine potential behavioural indicators of oestrus to provide scientific evidence for the timing of management recommendations. Finally, the long-term behavioural effects of two contraceptive methods performed on adult males (vasectomy and the Deslorelin implant) were monitored at two UK zoos to identify changes in group social behaviour as a result of breeding cessation. From studbook analysis, the age of females at first birth was found to be around four years of age, younger than that of wild counterparts, thus supporting the requirement of active management strategies to reduce breeding and overpopulation. There is also a male sex-ratio bias in births, which is contributing to the surplus male problem. By observing adult sexual behaviour at Paignton Zoo each month, a small increase in olfactory communication was determined around the time the adults were seen mating, which may be indicative of the female being in oestrus. Further behavioural observations in relation to contraception found that the vasectomy affected social and sexual behaviours for several months following surgery; however, these behaviours returned to pre-contraception levels one year later. After Deslorelin implantation, time spent engaged in group social and affiliative behaviours increased over time, perhaps due to the suppression of testosterone. Findings will contribute directly to future management plans for the *P. pithecia* EEP, providing a scientific basis for recommendations in contraceptive practice for the species.

**A first report on the behaviour and captive breeding of a pair of narrow-striped mongoose,
*Mungotictis decemlineata***

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The narrow-striped mongoose, *Mungotictis decemlineata*, is a small Malagasy carnivore that is listed as 'Vulnerable' by the IUCN Red List. The world's captive population of this species consists of 16 individuals held in 4 EAZA institutions. It is therefore desirable that all individuals breed in order to establish a viable self-sustaining captive population. The pair of narrow-striped mongoose housed at Newquay Zoo (WWCT) have bred successfully in the past; however the offspring have not survived past one month of age due to (suspected) maternal infanticide. Infanticide is not an uncommon phenomenon among captive populations of mongoose species; however its causes are not well understood. In particular, infanticide perpetrated by related individuals is complicated to explain; especially considering most data from wild populations regards infanticide as a form of sexual competition. Infanticide rates in captive animals are however, reported to be higher than wild rates. An initial study aiming to quantify the instances of infanticide in all mongoose species held in European zoos revealed that, of the responses, 37% of institutions reported an occurrence of infanticide. Anecdotally, disturbance or lack of space is most often cited by keepers as the most likely cause, however there is limited evidence supporting either theory.

The aim of the current study was to monitor the pair of narrow-striped mongoose at Newquay zoo in order to i) identify any behavioural indicators of stages in the breeding season, such as oestrus or birth of offspring and ii) if infanticide occurs, evaluate any potential environmental/husbandry triggers for this behaviour. Data collection was conducted from Jan – May 2015. Data was collected from video cameras installed in the indoor, off-show enclosure and paired where possible with outdoor observations by the first author. Two 15min focal follows were conducted for each individual on each observation day, during which behaviour was recorded at 30 second intervals. Observations were counterbalanced across the working day. In addition, 24 hour sections of video (0000hr to 2359hr) were chosen weekly to be watched in their entirety and scan sample data of both individuals taken every 15 minutes.

As yet there have been no offspring born and thus no infanticide events during the duration of the study, therefore we are unable to make any further suggestions regarding causes of infanticide in this pair. Behavioural data are still being collected but we have observed copulation in this pair. We aim to present this data in conjunction with any trends in behaviour identified, that may help predict oestrus and copulation and therefore inform husbandry practice and management.

Assessing Emotional Perception in Chimpanzees

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Research in chimpanzees has found that they are able to understand knowledge and intent in others. This ability is termed Theory of Mind, and has previously been thought to be unique to humans. Whilst this research highlights that chimpanzees share many of our human abilities of perception, there has been limited assessment of how chimpanzees perceive emotions in conspecifics, possibly because testing emotional perception is methodologically more difficult. Understanding to what extent chimpanzees demonstrate empathic behaviours and emotional perspective taking is especially important when addressing captive welfare, given that being empathic may lead to social stress. We aimed to assess emotional perception in 18 adult chimpanzees housed at Edinburgh Zoo. Here we present preliminary findings for chimpanzee response on a video task of social scenarios. Each subject was shown a conflict scenario involving non-familiar chimpanzees. The scenario consisted of three clips edited together to tell a “story”. This scenario was played three times, followed by one of two outcomes. One scene showed an ‘expected’ outcome of the conflict. The other scene showed an ‘unexpected’ outcome of the conflict. The order in which the outcomes were presented was randomised across chimpanzees. We predicted that if subjects could understand the emotional context of the scenes, then the unexpected outcome would violate their expectations, and they would thus look longer at this scene. Our findings were contrary to our predictions. Subjects looked longer at the expected outcome ($t_{[14]} = 2.56$, $p = 0.023$). These results suggest that the subjects’ responses reflected their interest in the emotional valence of the outcomes, and do not necessarily reflect perspective taking. We discuss these findings in light of the methodological approach used, and explore suggestions for improving assessment of emotional perception in chimpanzees, especially with regard to limitations on invasive research in apes.

Understanding social dynamics and their relevance for breeding success in captive populations

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With the increasing loss of biodiversity, cooperative captive breeding programmes are becoming a vital means for saving individual species from extinction. These breeding programmes, however, frequently suffer from poor reproductive success, as has been recorded with the Hartmann’s mountain zebra (*Equus zebra hartmannae*). Poor reproductive success in captivity may be related to environmental conditions, genetics, health or behavioural issues. Social dynamic behaviours are one of the most important factors that affect the reproductive success of group-living species, yet their effect on the breeding success of captive species has been subject to little research. Social dynamics have been suggested as a potential cause of reduced reproductive success in captive Hartmann’s mountain zebra because of the noticeable difference between the social organisation of this species and other equid species, such as the Grevy’s zebra (*Equus grevyi*), who are breeding well in captivity. In the wild, Hartmann’s mountain zebra stallions maintain small, stable harems, whilst Grevy’s zebra stallions hold territories, mating with any females that enter them. The low reproductive success exhibited by Hartmann’s mountain zebra in captivity may reflect the greater dissimilarity between the captive environment and the environment in which the species evolved, than that experienced by other equid species. This study aimed to investigate the importance of this.

Life history data for a sample of 57 male and 111 female Hartmann’s mountain zebra, who had resided in at least one of 16 European Endangered species Programme (EEP) zoos, were extracted from the species’ studbook. These data were supplemented and clarified with information obtained from a questionnaire sent to these same EEP zoos. In addition, information from a second questionnaire regarding husbandry and management techniques, which had been sent to EEP zoos in 2007, was also utilised. Results confirm that breeding success varies between individuals, the two sexes and zoos. The effect of a range of variables on reproductive success for

both male and female Hartmann's mountain zebra was tested using a Generalized Linear Mixed Model (GLMM). The results of the model indicated that breeding success in captivity can be affected by social dynamics. The primary associations revealed were between breeding success and: current age/age at death; the total number of moves between zoos; length of time spent at a zoo; inbreeding coefficient; whether the stallion was able to see females when stabled separately; enclosure space and whether it was shared with other species; whether the harem stallion changed and the age that a male left the natal group. In addition, group size, whether a male spent time in a bachelor group, whether females were able to see one another when stabled separately and whether the stallion was able to see another breeding age male, all appear to be unrelated to breeding success. The breeding success of the HMZ captive population would benefit from changes to the husbandry and management regime based on the results of this study. In addition, increased record keeping regarding social behaviour and husbandry and management techniques by zoo staff would greatly assist future research.

The behavioural response of a captive population of lion-tailed macaques (*Macaca silenus*) to changes in social structure over time

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Lion-tailed macaques are one of the most endangered primate species due to human disturbance in its habitat, the Western Ghats in India. Populations in captivity are generally small with little breeding success. Fota Wildlife Park in Ireland is a member of the European Endangered Species Programme (EEP) for the lion-tailed macaque and has one of the largest and most successful captive populations in the EEP. This group has been the focus of a number of studies, which have primarily investigated the behavioural responses in the group to changes in social dynamics. This paper examines the group over an eight year period, tracking the changes in behaviour as a result of the death of a dominant male, the introduction of a new male and the eventual growth of the group. Using data from instantaneous scan and focal samples, behaviours were grouped into four categories: active, feeding, social and restful, in addition to vigilance for the dominant male. The results showed that the shifts in social structure had a statistically significant effect on the behaviour of the group, with decreased levels of feeding, active and social behaviours following the loss of individuals, and the return of normal behaviour patterns as the group became more stable. Furthermore, the results showed that as vigilant behaviours decreased in the newly introduced dominant male, social interactions increased. These results show that alterations to the group structure of a captive group can have significant effects on the behaviours exhibited. These findings reinforce the concept that group size could be a major influence on captive breeding success as could group stability. Captive lion-tailed macaque populations are now being viewed as models for fragmented populations in the wild, as the same constraints are applied to both groups. These types of behavioural studies provide us with valuable information, for improving not only captive populations, but could now also help us to manage fragmented populations in the wild.

Behavioural and physiological changes to a captive herd of African elephants *Loxodonta africana* following the death of an individual

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African elephants are highly social and demonstrate altruistic behaviours including co-operative care of young, group defence, group foraging and resource gain. Elephants in captivity have been observed to exhibit many similar behaviours to their wild conspecifics and can therefore be highly sensitive to changes in herd structure, particularly following the death of an individual. This study aimed to analyse behavioural and physiological changes observed in a herd of captive African savannah elephants (*Loxodonta Africana*, n=5) following the loss of the herds' bull elephant, Nissim. Observed data pre-Nissim's death were compared to post, in order to highlight any physiological and behavioural changes to individuals, as well as the overall behavioural state of the herd. Weight recordings and daily temporal gland secretion trends were compared to reveal physiological changes, with social and maintenance behaviours also being monitored and compared in order to determine differences to each individual as well as the herd dynamics as a whole.

Different individuals showed varying responses associated with bereavement, with the matriarch of the herd, Juba, displaying the most marked differences. Nala, the youngest member of the herd spent significantly more time with her mother Tana than beforehand, as well as all but one of the elephants showing marked increases in the occurrence of tactile behaviour initiated towards one another. Through sudden alterations within the highly structured nature of elephant society, captive elephants' habituation to daily routines alongside their atypical herd size and composition, some variables changed (with individual variation) in response to the level of stress associated with the event. The cumulative effects observed in each individual elephant revealed the overall response of the herd to the event and the resulting uncertainty associated with the loss of a conspecific. These changes highlight the importance for in-depth health and behavioural monitoring of all captive species to detect subtle changes following significant events and may have some considerations for the study of grief in wild African elephants.

The application of Social Network Analysis in guiding management of African lions *Panthera leo* in captivity

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Social Network Analysis (SNA) in animal behaviour research is an expanding field and is most commonly used to understand the social dynamics of wild populations. SNA can be transferred to model disease transmission and learning information. Few studies have reported its use in comparing the effect of different environments. This study aimed to determine the social network of a captive African lion pride (n=11) and the effect of being housed in two different enclosure conditions. Three different behaviour matrices were recorded in each enclosure; affiliative, aggressive and proximity. Data were collected across 50 hours using point sampling in one hour observation periods.

All three behaviours showed significantly different social network structures when compared with random structures and between enclosures. Affiliative relationships were weaker in the larger enclosure; this may have been caused by an increase in choice of associates. The increase in aggressive behaviour and proximity in the smaller enclosure may have been caused by a reduction in choice owing to decreased availability of space and therefore lower tolerance. Additionally three lionesses were shown to exhibit large changes in social structure position between the two enclosures; personality traits may have caused this distinct difference. As a result of this research, management practices including extending the smaller enclosure and using Social Network Analysis as an ongoing tool for measuring welfare and social structures would be beneficial for the African lion pride.

An evaluation of association patterns, sociality and behavioural characteristics within three captive flamingo flocks

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Social network analysis (SNA) can be used to determine association patterns formed between individuals within groups. Such network approaches are useful to the study of social species to determine the relevance and importance of social bonds to both the individual and the group. SNA can be used in conjunction with behavioural analysis to investigate specific characteristics of the individuals that are associating, and hence provide an understanding of why bonds may be present. For captive animals, aggression rate, group dynamic and behavioural measures of welfare can be factored into SNA models to see any effect of husbandry on behaviour. The highly social nature of flamingos (*Phoenicopteridae*) makes them ideal model species for asking questions into the function of, and maintenance of, non-random association patterns in such a managed environment.

SNA for three flocks of flamingos was used to assess the presence of preferential bonds between individuals. Populations of greater flamingos (*Phoenicopterus roseus*) at Marwell Wildlife, Caribbean flamingos (*P. ruber*) at WWT Llanelli Wetland Centre, and Chilean flamingos (*P. chilensis*) at Dublin Zoo were used in this research. Alongside of this, direct behavioural observations of activity patterns and aggression rates were collected on the greater flamingo flock to categorise specific personality types of these flamingos. Data for Dublin Zoo were provided by keepers and volunteers for the period from April 2013 to May 2014, and data from Llanelli were provided by the education department and volunteers from September 2012 to October 2013. Data from Marwell Wildlife were recorded between July 2014 and November 2014. The same training was given to all those collecting data using a standardised methodology applied to all three flocks. Birds were deemed to be associating if they were within one neck length of each other and not acting aggressively, or if birds were mirroring the same behaviour pattern. Flamingos included in the analyses were identifiable from unique leg rings. It was noted whether birds were aggregating around a specific resource and this was factored into the SNA output. Networks for each flock were drawn in Netdraw with (half-weight) association indices calculated in Socprog. These data were collected as part of an on-going project investigating the relationships between individual flamingos within captive flocks across a number of institutions.

Preferential associations are seen in all three flocks however some random grouping can be seen in the Caribbean and Chilean flocks. Overall there were more preferred relationships in each of the flocks than there were avoided relationships. There was also a notable presence of same-sex pairings occurring in some flocks, which may have implications for future breeding attempts. Agonistic behaviours in the Marwell flock were recorded in relation to whether age and gender affected rates of aggression. There was no correlation between age and gender but the overall number of aggressive encounters recorded decreased as time went on, and the most aggressive individuals within the flock were the most strongly bonded to other particular birds. This may suggest that seasonal changes in behaviour, as well as the association choices made by the birds have an impact on the overall content and patterning of aggression seen at different times of the year.

SNA has provided information on association patterns within captive groups of flamingos, and used alongside behavioural analysis, gives an indication into the characteristics of the flocks. Strong associations within social groups may be formed not only for breeding, but also to control more resources. Behavioural observations may also indicate dominance within the flock where strongly-bonded flamingos are more aggressive in an attempt to maintain a chosen, specific, relationship.

Do personality differences influence friendships in zoo-housed bonobos?

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Recent evidence suggests homophily in friendships in captive chimpanzees, capuchin monkeys and wild baboons, meaning that individuals with similar phenotypes have stronger friendships. Personality has been suggested as a phenotypic trait influencing friendships. In chimpanzees individuals with similar sociability scores were found to sit more in contact with each other, and this effect was stronger for maternal kin. Our aim is to study potential influences of personality similarity on friendship in captive bonobos, who are closely related to chimpanzees, but differ in some socio-ecological contexts. We use behavioural observations on 41 adult and adolescent bonobos (15 males, 26 females; aged between 6 and 63 years) housed in 5 European zoos (Frankfurt; Planckendael; Stuttgart; Twycross; Wuppertal). Mean focal time per individual was 17 hours. We used Factor Analysis and Parallel Analysis on individual behavioural scores to construct a multidimensional personality profile for each individual, resulting in three personality factors that were labelled “sociability”, “positive affect” and “anxiety”. We then used Principal Component analyses and Parallel Analysis on dyadic behavioural scores to construct a model for relationship quality and in line with our previous research could discriminate between two components of relationship quality, named “relationship value” and “relationship compatibility”. Using ‘contact sitting’ as a conventional measure of friendship, we found that individuals of similar sociability scores spend more time sitting together, in line with the published results for chimpanzees. Using the composite measure of relationship quality, we found that individuals of similar sociability scores had higher relationship value, but not relationship compatibility. When interactions with maternal kinship were included in the model, we found that relationship value was higher only in related dyads with more similar sociability, positive affect and anxiety, but not for unrelated individuals. However, the number of related dyads in our sample was small (n=11) and this category included kinship relations that may be functionally very different, such as 1 mother-daughter pair, 7 mother-son pairs and 3 pairs of maternal brothers. Literature has shown that mother son relationships have a crucial role in bonobo sociality for bonobos while friendship is less important for maternal brothers. Including these different relations in one category may have driven the kinship effects we found in our study. In general we find a relationship between similar personality traits and friendship in zoo-housed bonobos. These results help us better understand the nature of friendships in captive bonobo groups, contributing to the evolution of social relationships in primates.

Assessing the effect of different light conditions on crayfish welfare using a dark-light preference maze

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Noble crayfish (*Astacus astacus*) are freshwater crustaceans of European streams, rivers and lakes that frequently hide in dark places and naturally explore new environments. In a study by Fossat et al. (2015) a paradigm was validated to assess stress by using a subaquatic dark-light plus maze placing red swamp crayfish (*Procambarus clarkii*) in a conflicting situation between its innate curiosity for novel environment and its aversion for light. The experimentally stressed animals showed less explorative behaviour and remained preferentially in the dark arms, a response similar to the anxiety-like behaviour observed in rodents. We used the preference test on noble crayfish that were housed in tanks in different light conditions in order to investigate the welfare consequences. 468 crayfish were housed in social groups of 26 individuals divided over 18 tanks in two different light intensities (weak light: 38 lux; bright light: 761 lux) with 3 different light spectrums (cold white (CCT ≈ 5500K), warm white (CCT ≈ 2600 K) and neutral (CCT ≈ 3800 K)) over a period of six months. The animals had access to shelter places to hide. At night they had fourteen hours of complete darkness. In the plus maze the measured values in the dark/light branches were 21 versus 550 lux. We found that the crayfish kept in low lux conditions spent 7.87% (SD=9.48, p value Mann-Whitney-U test = 0.098) more time in the light arms of the plus maze than those kept under high lux. The spectrum of the light had no effect (p-value Kruskal-Wallis test = 0.715) This suggests that there is a trend in crayfish to show less anxious behaviour when being housed under low light conditions during the day, even when given the possibility to seek cover. The light intensity could be a factor to consider to ameliorate crayfish welfare.

Fossat, P., Bacqué-Cazenave, J., De Deurwaerdère, P., Delbecque, J., Cattaert, D. 2014. Anxiety-like behavior in crayfish is controlled by serotonin. *Science*. 344, 1293.

Effects of visitor feed experiences on the behaviour of ring-tailed lemurs

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Zoological institutions allow visitors close encounters with exotic species through schemes such as 'visitor feed experiences'. Interactive opportunities are reported to improve visitor perceptions towards species, increase conservation support and can be a good source of income for zoos; however, animal welfare is a common concern during such events. We investigated the effects of visitor feed experiences on the behaviour of ring-tailed lemurs (*Lemur catta*, n=9) and crowned lemurs (*Eulemur coronatus*, n=4) housed at Newquay Zoo, UK. Behaviour was recorded in four conditions; 1) during visitor feeds and 2) 30 minutes post-visitor feeds as experimental conditions; 3) during a keeper feed and 4) 30 minutes post-keeper to act as a baseline. *L. catta* were significantly more vigilant, interacted with keepers more and spent less time feeding/foraging and being social during visitor feeds compared to baseline days. The *E. coronatus* spent significantly more time solitary and interacting with keepers and were significantly less aggressive and less time out of sight during visitor feeds compared to baseline. There were no differences in the behaviour for either species in the 30 minutes post-visitor feeds compared to baselines. Our results indicate that while lemurs adapt their behaviour in response to visitor presence, once the visitors leave the enclosure the lemurs return to baseline behaviour quickly, therefore their long-term welfare is not compromised by the experience. Anecdotal evidence suggests that there may be individual differences in responses to visitor presence; therefore, further study into individuality will be important in assessing welfare implications in social groups.

Monitoring the effects of breeding and the coinciding management of cubs on the behaviour of the male and female Amur tigers (*Panthera tigris altaica*) housed at Blackpool Zoo

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Amur tigers (*Panthera tigris altaica*) are generally considered to be a solitary species, with males having large territories overlapping those of multiple females and females thought to be solely responsible for cub-rearing. Although this is typically accepted to be the case, many zoological institutions house tigers in pairs or groups, with the sires often encountering young that they potentially would not encounter in the wild. This study monitored a breeding pair of collectively housed Amur tigers at Blackpool Zoo to determine whether management strategies surrounding the dam and cubs were sufficient and thus group-living being beneficial. The male, Zambar, was monitored over four phases: 'pre-cub', 'separation', 'introduction' and 'post-cub', with the female, Alyona, being monitored during the 'pre' and 'post-cub' phase only. The male tiger was shown to significantly increase resting behaviour ($p < 0.01$) when separated from the female potentially indicating a level of stress at the separation. When comparing 'pre' to 'post-cub', both subjects had significantly decreased levels of pacing ($p < 0.001$) in the 'post-cub' phase with social contact between sire and dam increasing significantly 'post-cub' after being reunited ($p < 0.001$). Findings therefore suggest that captive individuals of this species may be more social than first anticipated and may benefit from group living, going on to show increased distress when separated. Future research revolves around evaluating management strategies within individual collections in order to determine whether modifications are needed for specific individuals.

How do keas (*Nestor notabilis*) react when faced with a novel feeding problem?

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Innovation is a process by which individuals learn to solve novel problems, and can allow individuals to adapt and even thrive in new environments. The effects of innovation can include: access to previously unobtainable resources, invasion success, habitat generalism and the occupation of urban environments. Previous studies (Huber *et al*, 2001; Werdenich and Huber, 2006; Auersperg *et al*, 2010; Brunon *et al*, 2014; Griffin *et al*, 2014) have provided evidence that innovative individuals can problem solve by some understanding of means-end relationships. This study aimed to determine how keas (*Nestor notabilis*) react when faced with a novel feeding puzzle at Blackpool Zoo. Further aims were to ascertain if subjects applied existing behaviours to a novel situation or innovate new responses. Subjects were observed for a total of 22 hours to establish a baseline of normal behaviours. They were then observed for an hour before and after the test device was implemented so as to be able to measure the effect of the treatment. Results from this study indicate that the test device had a significant effect ($p < 0.05$) on some behaviours including: perching, locomotion, flight, grasping with beak, foraging and feeding. However interaction with the device was limited and no new behaviours that had not been previously displayed were seen during the treatment. Furthermore, the female was nesting over the study period which may have impacted on the results. Further study is strongly recommended.

Interactions between zoo visitors, captive animals, education and enrichment

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Animal-visitor interactions in the zoo setting are under-represented in peer-reviewed literature with even less consideration given to the influence of zoo-based education or enrichment on this complex relationship. Zoos, wildlife parks and aquariums commonly claim that education is one of their primary goals; yet, their ability to successfully educate visitors has been challenged. Some studies have shown that zoos are successful educators, especially at improving visitors’ cognitive knowledge gain; yet, it has proven more difficult to establish if zoos affect any change in visitors’ conservation related behaviour or even how to effectively measure if education has occurred. Here, we present an overview of an ongoing PhD project which considers how an educational intervention using environmental enrichment influences child-animal interactions in the zoo. First, to establish a baseline, this study quantified the effect of visitors on the behaviour of free-ranging ring-tailed lemurs (*Lemur catta*) at Fota Wildlife Park and gentoo penguins (*Pygoscelis papua*) at Dingle Aquarium, using instantaneous scan sampling to collect data. Next, we considered, the impact of zoo-based education on primary school children’s knowledge, attitude and behaviour toward the ring-tailed lemurs and gentoo penguins. A controlled experimental design was used with control groups participating in standard zoo or aquarium curriculum, and treatment groups participating in standard curriculum plus a hands-on educational intervention. During the educational intervention, children make enrichment devices for lemurs and penguins, which they then observe the animals using, when they visit the zoo. Previous evidence suggests that visitors learn more from, and prefer to see, active animals that have environmental enrichment in their enclosures. Furthermore, increased animal activity is often associated with enrichment, and enrichment has been used to alleviate negative visitor effects in some zoo-housed animals. Data collection for this part of the project is triangulated; our mixed-method approach uses questionnaires, behavioural observation and conversational content analysis. Additionally, and unique to this project the behaviour of the animals is simultaneously recorded during child-animal viewings using instantaneous scan sampling. The overall aim of the project is to improve children’s learning and behaviour while simultaneously improving the welfare of the lemurs and penguins.

Social interactions amongst three species of primates in the rainforest biome exhibit at ZSL London Zoo

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Scientific research in zoos is vital to understand how the captive environment affects animals and can lead to improvements to their welfare and health management. Due to space availability, management ease and visitor preferences, zoos are increasingly using mixed-species exhibits. Although species coming from a similar wild environment are gathered together, they might not all be used to cohabiting in such proximity with one another and so it is vital to document their interspecific behaviour to highlight and then manage any welfare concerns. Tamarins of genus *Saguinus* are known to form mixed-species groups in the wild, which provides advantages in terms of predator detection and foraging. The aim of this study was to investigate the social behavior of eight individuals of three different species (four Emperor tamarins - three males and one breeding female, two female golden-headed lion tamarins and a pair of red titi monkeys) in the Clore rainforest biome at ZSL London Zoo. In particular we wanted to determine whether dominant behaviour would arise from the Emperor tamarins as this species is known for its intraspecific and interspecific dominance behaviour both in the wild and in captivity. Instantaneous scan sampling for a total of 20 minutes was performed each study day morning to record the feeding behaviour of the primates. After the feeding observations, all eight individuals were then submitted to two focal observation sessions of 10 minutes, one in the morning and one in the afternoon, to record all intraspecific and interspecific interactions. Finally, instantaneous scans were performed every 10 minutes throughout the day in order to assess babysitting of the Emperor tamarin newborn twins. By monopolizing the feeding tray, the Emperor tamarins established a hierarchy for the arrival order of the species at the feeding area.

This dominance of the Emperors was further supported by the social interaction study, where the breeding couple would be mostly seen interacting with individuals of the same species, leaving the interspecific interactions to the younger ones. The most surprising result concerned babysitting. While mostly being carried by members of the same species upon birth, the dynamics changed once the twins started walking on their own. Unlike what would normally happen in the wild, the golden headed lion tamarins took charge of the babysitting of the Emperor tamarin twins.

Welfare focused ethogram for the common European cuttlefish

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The common European cuttlefish (*Sepia officinalis*) is frequently found in public aquaria around the world. These remarkable creatures make fantastic display animals due to their rapid colour/texture/behaviour changes associated with feeding or camouflage. These adaptations evolved to evade predators due to their extremely fragile bodies and soft tissues. In captivity they damage easily when startled or feeling perceived threats. These injuries rarely heal and can cause permanent damage and even death. Knowing the signals before damaging behaviours occur can go a long way to improving their welfare. Another aspect of captive animal welfare is providing enrichment. These cephalopods are very intelligent and require suitable enrichment to prevent stereotypic behaviours and other signals of poor wellbeing. Here, based on hundreds of hours of observations, we provide a very detailed welfare focused ethogram. Cuttlefish are very adept at telling you what they think through their very wide repertoire of signals. The ethogram has all recorded cuttlefish behaviours, including those likely to precede damaging behaviours and those indicating the cuttlefish are enriched. Ethograms like these can be a valuable tool in preventing injuries and assessing wellbeing in captive animals.

Intrinsic versus extrinsic environmental enrichment applied under different temporal conditions to captive ocelots (*Leopardus pardalis*)

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One of the main objectives of environmental enrichment techniques is the stimulation of natural behaviours in captive species. These techniques can be classified according to the value of reinforcement provided as intrinsic or extrinsic. Intrinsic enrichments (IE) are classified as those in which the animal's response to the stimulus determines the chances of the same response occurring again. However, extrinsic enrichments (EE) are those in which the animal's response to the stimulus generates a reward and this determines the chances of this response occurring again. The study hypothesis was based on the predictions, proposed by Tarou and Bashaw (2007), suggesting that extrinsic enrichment techniques promote more effects on the behaviour of animals than intrinsic ones. The present study investigated the behavioural patterns of ocelots (*Leopardus pardalis*) in captivity on the application of environmental enrichment of each type (IE and EE), under two different temporal conditions: consecutive and intermittent. Belonging to two Brazilian conservation institutions, 20 ocelots were used as subjects, being separated into two groups, according to the temporal exposure of the enrichment: consecutive (7 days) and intermittent (1, 2 and 3 days). Enrichments consisted of: IE - 5ml of liquid catnip (*Nepeta cataria*), sprayed on a substrate previously set in the environment; EE - a puzzle feeder built with a wooden box containing holes that allowed the animals to withdraw a food reward with their paws (wet cat food, fish flavour). Both groups received the two types of enrichment and the sets of experiments were repeated twice each with a week's interval between the sets and two weeks between each enrichment type. The behaviours were video-recorded in real-time and the images were analysed later. Research which examines different types of enrichment have greater potential to stimulate behaviours related to cognition and activity, with long-term effects such as the development of effective techniques in improving the welfare of captive species.

Individual behavioural and physiological profiles of three captive, female, European brown bear (*Ursus arctos*) and implications for welfare

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There is increasing interest in exploring individual differences in animals as a means of measuring welfare. Data presented were part of a wider study, investigating behavioural and physiological welfare indicators to inform husbandry routines for three group-housed, female, European brown bears (*Ursus arctos*). Data were collected to measure activity levels (e.g. walking, feeding, exploring etc.), time engaged in stereotypical behaviour, incidence of social conflict and faecal stress hormone levels. Continuous, focal sampling was used to record behaviour and activity patterns using twenty-four hour CCTV cameras of all on-show and off-show areas, except the bears sleeping dens. A total of 162 hours and 53 minutes of 'on camera' footage was obtained of the three bears on 8 observation days during spring and early summer in 2012. Scats were collected for each bear on the day following behaviour observations and samples were analysed for corticosterone metabolite levels. Each bear had a different activity and physiological profile, described herein. Each bear exhibited a different form of stereotypical behaviour and performed these in different locations (near den, off show, near keeper work area) and at different times of day. The highest ranking bear, in terms of social rank, spent the most time on camera (8hrs 7min 42secs: 29262secs \pm SD 7262) and had the lowest average faecal stress hormone level (6.21ng/g SD 2.35 / SE 0.78), however she also exhibited the highest average daily duration of stereotypical behaviour (1hrs 1min 8secs, 3668secs SD \pm 3313). Visitor numbers were correlated with faecal stress hormone levels for one bear ($r=0.8$, $p = 0.04$) but not the other two. Implications for husbandry are discussed and such detailed individual profiles of captive animals are recommended, where feasible, to enable husbandry routines that suit each animals' individual needs.

Data were collected as part of Ellis' MSc research project undertaken at Manchester Metropolitan University and part funded by the ABWAK Research Fund and the National Zoo of Wales Research Fund.

Preferences of red-sided eclectus parrots (*Eclectus roratus polychloros*) for different coloured feeding enrichment devices

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Enrichment devices are often provided to parrots to change an environment, with the goal of increasing opportunities to perform species appropriate behaviours and abilities, therefore enhancing animal welfare. Preferences of two red-sided eclectus parrots (*Eclectus roratus polychloros*) were tested using three differently coloured wooden feeding enrichment devices at Blackpool Zoo. Behavioural observations were conducted for two phases: prior and during enrichment, with visitor dwell times and duration of interaction with the devices also recorded. There was no significant association between gender and colour of device (χ^2 2.49_[2], $p= 0.29$). The enrichment did not have a significant effect on dwell time ($p=0.36$), but a highly significant correlation was found between number of visitors and dwell time ($p < 0.001$). There was also a significant relationship between gender and the performance of active or passive behaviours ($p < 0.001$) with weather affecting the frequency of behaviours. These results will hopefully give a small insight into the captive management of eclectus parrots for the zoo, but more research is needed to determine if preferences are individual or species specific.

How do people feel about the euthanasia of healthy animals at Copenhagen Zoo?

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The euthanasia of a young, healthy giraffe named Marius at Copenhagen Zoo in Denmark last year was highly controversial. The aim of this research was to gain the opinions surrounding this subject of a variety of different people. A literature review was conducted in order to understand better the reasons as to why the zoo decided to undertake the procedure. Opinions of a variety of people were gathered via a questionnaire. The results showed that the majority of respondents (93%) had a negative view of the euthanasia on moral grounds. Only 7% of people seemed to have more of an understanding about the reasons as to why the giraffe euthanasia occurred.

In conclusion, the majority of people had a negative view of the giraffe euthanasia which may have been influenced by how the event was portrayed by the media. As my results show that there was only a small percentage that seemed to agree more with the reasons behind why the event took place. This may suggest that there is not much education of euthanasia in the UK besides what is expressed by the voice of the media. Furthermore, from these findings, I think that it may be suggested that if the practice were to be more commonly used in the UK, it may be necessary to provide more education around animal euthanasia in order to assist in preventing the majority of people perceiving the event in a negative way.

Evaluation of *Ginglymostoma cirratum* L. (nurse shark), *Rhina ancylostoma* L. (bowmouth guitarfish) and *Carcharhinus melanopterus* L. (black tip reef shark) to monitor the movement, behaviour, shark resource usage and the intra-species and inter-species interactions

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Sharks have very complex behavioural patterns and therefore the behaviours may be difficult to interpret without detailed, direct study. If behaviour of sharks in a captive environment are observed then researchers may gain a better understanding of shark behaviours in a wild environment. An instantaneous scan sampling method was undertaken at Blackpool Sealife centre UK to investigate blacktip reef shark (*Carcharhinus melanopterus*, n = 2), nurse shark (*Ginglymostoma cirratum*, n = 2) and bowmouth guitarfish (*Rhina ancylostoma*, n = 2) movement behaviour, resource usage and inter-species and intra-species interactions. The nurse shark showed a significant difference ($p < 0.05$) in being out of sight than the other two species, however the bowmouth and the blacktip species showed a higher cruising behaviour than the nurse sharks displayed. The blacktip reef shark and the bowmouth guitarfish show a higher mean value for the tank glass usage, whereas the nurse shark showed a higher mean value for the tunnel usage and the no resource usage/out of sight. All three species of shark had a higher mean interaction for shark species. All three species tended to stay with their own species members (Intra-species) rather than the other fish. There was an observed difference in the amount of time the bowmouth guitarfish species interacted with interspecies in comparison to the blacktip reef shark and a considerably lower interaction of interspecies seen with the nurse shark species. This study suggests that the behaviours displayed by the three shark species show similar behaviours in a wild environment which in contrast would be beneficial to researchers studying sharks in a wild environment.

Interactions, behaviour and enclosure usage within a group of captive Bornean orangutans (*Pongo pygmaeus*) at Twycross Zoo

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Bornean orangutans (*Pongo pygmaeus*) lead relatively solitary lifestyles *in-situ*. In contrast, captive orangutans are housed in social groups of male and females, differing substantially to their solitary lifestyle. This may allow them to be more social, but also cause undesirable behaviours of dominance/displacement which rarely occur between male and females *in-situ*. Additionally, arboreal behaviour may be lacking due to limited vertical space, leading to welfare implications. Appropriate exhibition of wild-type behaviour is vital, thus, broadening the literature may provide zoos with improvements to welfare and reproductive success of the species. The study aimed to investigate interactions and enclosure usage in a group of captive Bornean orangutans at Twycross zoo, Warwickshire. Investigation focused towards whether orangutans express wild-type behaviour. Individuals were studied for a total of 64 hours over a 10 week period. An ethogram of behaviours was used to collect behavioural data, and the spread of participation index (SPI) was used to study enclosure use. Data was collected using a method of continuous focal sampling, where 15 minutes represented one observation session. Kruskal-wallis and Mann Whitney U tests were used to test for statistical significance.

Data analysis showed a significant difference between the time individuals spent utilising ground and vertical space ($H_3=19.08$, $p<0.001$; $H_3= 8.93$, $p<0.05$ respectively). There was also a significant difference between the percentage of time individuals spent in social and solitary behaviours (Kibriah $H_3=118.4$, $p<0.001$; Batu $H_3=73.52$, $p<0.001$; Maliku $H_3 35.83$, $p<0.001$; Molly $H_3-23.35$, $p<0.001$). Although solitary behaviours were higher, orangutans expressed more social behaviours than seen *in-situ*. Significant differences in displacement/dominance behaviours ($H_2 = 11.26$, $p<0.001$; $H_2= 9.25$, $P<0.05$ respectively) revealed Batu showed higher displacement (2.02%) and dominance (0.57%) towards Kibriah.

Behavioural observations, enclosure use and visibility of Javan rhinoceros hornbill (*Buceros rhinoceros silvestris*) and Southern cassowary (*Casuarius casuarius*)

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Chester Zoo has invested heavily in a new exhibit development, Islands. This 5Ha site, showcasing species from the threatened islands of Southeast Asia, will provide new living areas for a number of Chester Zoo's current species, including Javan rhinoceros hornbill (*Buceros rhinoceros silvestris*, 1:1:0) and Southern cassowary (*Casuarius casuarius*, 1:1:0). This study was conceived as a way of evaluating current behaviour, visibility and enclosure-use of these two species, before they move to Islands. The importance of understanding enclosure use and animal visibility is essential to modern zoos, whose interests lie in both animal welfare and visitor experience. Suitable enclosure design is essential in ensuring quality of life for captive animals and providing an immersive environment for the public, while issues with visibility in, for example, densely planted enclosures can limit visitor interest. Previous research at Chester Zoo found that birds tended to attract the least visitor interest in terms of attracting power and holding time. Given that many of the birds housed at Chester Zoo are kept for an educational purpose, such as to raise awareness of the threats the species face in the wild, it is important to take measures to increase visitor interest so that this purpose can be served effectively. It is therefore necessary when designing an enclosure to find an adequate balance between visitor interest and animal welfare, where much of the enclosure is likely to be utilised by the animal to improve visibility, and where the enclosure allows expression of natural behaviours by the animal and is representative of the usual habitat of the animal. These pre-Islands data will also act as an important baseline comparison for future research exploring the impact of the new exhibit on animal welfare and visitor engagement with the species. Data collection took place between January and May 2015. A pilot study was carried out to categorise the range of behaviours displayed by the animals and thus to form an ethogram for use by data collectors. Collection involved multiple sessions of instantaneous scan sampling, on the minute, over periods of 30 minutes, from public areas only. These data were then imported into SPSS for statistical analysis. Initial analyses suggest significant differences in behaviour, visibility and enclosure-use between individuals of the same species, in both cassowary and hornbills. Multi-variate analyses will be conducted to explore effects of our independent variables on our three dependent variables.

Long term evaluation of enrichment provision: Does our system work?

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All carnivores at West Midland Safari Park are given enrichment based on dynamic enrichment schedules designed by keepers with enrichment devices approved by animal managers. A system to monitor enrichment use was developed over several years involving patrol keepers scoring all enrichment interaction on a predetermined scoring system. For every incidence when enrichment was given, type of enrichment, and interaction score were recorded and evaluation of enrichment time tables was designed to take place each quarter. This study looked at how useful the data is for informing husbandry practices and whether it can be used for more academic research.

Social networks in a band of ring-tailed coatis at ZSL London Zoo

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This study followed the exploits a small band of ring-tailed coatis, *Nasua nasua*, housed at ZSL London Zoo, consisting of six neutered males and two females between March and May 2015. Five individuals of varying ages were born at the zoo and share the same parents, whilst the remaining three were born in Germany in 2013 and were introduced to the exhibit a little over a year ago. This has allowed the animals time to acclimatise and form their distinct social patterns and groups. In the wild, ring-tailed coati females form large bands of between 20-30 individuals on average, with a single male sometimes taking residence. The fact that the ZSL band comprises of such an unusual composition provides a unique opportunity for study. The main aim of the study was to investigate the social behaviour of the coati band using social network analysis. This technique is being increasingly applied to animal behaviour studies to tease apart the social relationships of animal groups (networks) more directly. We were interested to investigate the extent of interactions between all members of the band and the dominance or centrality of individuals in the network.

Three metrics were used in the creation of social networks and their subsequent investigation: association (through nearest neighbour analysis), affiliative behaviour (grooming and play) and aggressive behaviour (displaying, chasing and physical attacks). Patterns of association clearly showed that there are two distinct subgroups within the band, formed on the basis of genetic relatedness. This was also seen in the affiliative data, where neither grooming nor play, were observed between the subgroups. The results obtained from examining aggressive behaviour are less clear cut: although these interactions were more common between subgroups, it was noted that there were periods of infighting within the original ZSL group that were not observed in introduced German one. During the study period, the overall band did not have a clear leader. Coati society is matriarchal and the two females of the band (both from different sub groups) often fought for control; the number of aggressive interactions between these two individuals far exceeded those that occurred between any other individuals. With the assistance of her brothers, the younger female was often able to fend off the older female's attacks.

The study also investigated whether the spread of participation index (SPI) was significantly different between the two subgroups. This metric measures the extent to which captive animals use the available space in their enclosure. Although there was not a statistical difference between the SPIs of the two subgroups, similarities between certain related individuals were noted. These can be correlated with the matching high levels of association, i.e. animals foraging together will likely have similar levels of enclosure usage.

Comparing the pros and cons of maternal and artificial incubation in royal pythons

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This project is an insight into the debate on how eggs should be incubated in captivity; naturally or artificially, linking survivability, ease and the ethical issues involved. It took into account the real views of both professional and hobbyist breeders but did not aim to find a right answer. The aim was to compile relevant information and views to allow for easier choices and perhaps stimulate further study into the most appropriate method. Due to the lack of published work on the success of incubation types most of the project involved online research and contact with large and small breeders to form a small census of opinions and reasons. However, a small experiment was performed where I and a local breeder tested both methods, both having the chance to incubate a clutch of 5 eggs. We plan to continue to monitor the growth and progress of the young to provide further evidence on the methods used.

Among breeders there was resoundingly high support for the use of artificial incubation, with clearly stated benefits. These included the higher control of temperature and humidity, the welfare issue of food refusal from a repeat breeder female maternally incubating, and a very interesting point on how a mother python may not be trusted to appropriately incubate the eggs due to the forcing of a 'false environment' on her, removing the wild chance of looking for a suitable place to lay. The research did not, however discount the use of maternal incubation as a viable method, with many breeders supporting artificial incubation but also stating they had tested and had success with the maternal method. The small experiment also supported the use of artificial incubation; the maternally incubated clutch failed to hatch due to mould growth, whereas the artificially incubated clutch all hatched and survived to date. To conclude, this project does not aim to specify one method as being the right one due to the small size of the experiment and anecdotal nature of the breeder research but to provide greater insight into the pros and cons of each method to allow better informed decisions.

Determining the learning rate of the common octopus (*Octopus vulgaris*) and the giant pacific octopus (*Enteroctopus doflieni*) by providing an enrichment puzzle

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Octopuses are highly intelligent invertebrates that have fast learning rates. The common octopus (*Octopus vulgaris*) and giant pacific octopus (*Enteroctopus dofleini*) at the Sea Life Aquarium Blackpool were provided with an enrichment puzzle that had four stages which increased in difficulty. Both octopuses were presented with identical puzzles constructed to the optimum size needed for the octopuses to interact with it. Baseline behaviours were observed by using continuous sampling with 40 hours of observations being carried out. The baseline observations showed that the most frequently displayed behaviour was resting followed by locomotion and crawling. Feeding days had an effect on how active the octopuses were during the day as both octopuses were observed to be the most active on feeding days. The octopuses were successful in being able to solve the four stages of the enrichment puzzle, each octopus had two attempts to complete each stage of the puzzle. The presented puzzle had four simple stages in order for the octopuses to follow the steps of the puzzle and to slowly introduce the puzzle to the octopuses. The results showed that both octopuses have a fast learning rate with improved solving times after the second attempt when solving each stage of the puzzle. Although the common octopus and the giant pacific octopus both solved the stages of the puzzle in similar times, the common octopus improved in solving times faster than the giant pacific octopus. The stages of the puzzle were created to be simple so that in the future more stages to the puzzle can be added to increase the difficulty of the puzzle.

The activity, behaviour and enclosure use of a solitary male echidna (*Tachyglossus aculeatus*)

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The short-beaked echidna (*Tachyglossus aculeatus*) is a little studied species in captivity, despite being present in collections globally. Previous studies conducted on captive individuals have concentrated on reproduction, neglecting other aspects of captive management and behaviour. This study, investigating the behavioural patterns of one *T. aculeatus*, is the first step in addressing the deficiency of data on short-beaked echidnas. Expanded knowledge and understanding of the behavioural activity patterns and responses to housing and husbandry (H&H) techniques of the echidna can be used to guide evidence-based zoo management (EBZM) and influence decision-making for best husbandry practices. Zoos operating within an EBZM framework, using scientific evidence to understand the relationship between H&H, behaviour, and welfare, increase the likelihood that their decisions will positively impact the welfare of their animals. Paignton Zoo Environmental Park maintains a solitary male echidna and is one of four European institutions currently holding this species. The subject has been housed in an outdoor enclosure since 2009, is assumed to be wild born and is approximately 22 years old. This study aimed to determine possible activity patterns, the time budget, and the enclosure use of the echidna. These data can be used as a baseline against which the effects of changes to current husbandry practices can be measured and evaluated.

Behaviour and location data were collected using instantaneous sampling throughout six days of direct observations. To monitor night activity, camera traps were placed around the enclosure to photograph when the echidna was active. Behaviours were categorised as active or inactive and a 24 hour activity pattern was determined. The data were also used to create a daily time budget and to evaluate enclosure usage. The subject was significantly more active during the day (10:30-16:30) than the night (16:30-10:30), following a similar pattern to one reported for wild echidnas in cold climates. Activity peaked following feeding, however, it is unknown how its activity is influenced by H&H practices. The most common behaviour was locomotion (60.8% of diurnal observations), although average locomotion bouts were short (3:04 minutes +/- 3:24). A smaller proportion of time was spent exploring and interacting with the enclosure (9.2% of diurnal observations). Enclosure use was determined using Spread of Participation Index (SPI) and resulted in an SPI value of 0.43. However, one area (a sheltered area in the back of the enclosure) was utilised more frequently (61.5% of diurnal observations). The large proportion of time spent locomoting may indicate a lack of stimulation and a potential need for expanded foraging and exploration opportunities, which could be satisfied through environmental enrichment. Although wild echidnas live solitarily outside of breeding season, the subject was housed with two females in the past which may have influenced the subject's behaviour as he is unable to perform breeding behaviours. This study, the first to investigate the activity budget and enclosure use of short-beaked echidnas, show further research is needed, involving multiple institutions and observations during various seasons, to properly evaluate the effect of H&H practices on the behaviour of zoo housed echidnas.

Evaluating the effectiveness of current enrichment practices used with three monitor lizard species (*Varanus komodoensis*, *V.salvadorii*, *V.prasinus*) at Chester Zoo.

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Environmental enrichment is an animal husbandry tool that is used to improve the welfare of captive animals by providing particular environmental stimuli. Enrichment encourages greater diversity of natural behaviours, keeps the animals occupied and generally provides more stimulating environments. Previous studies of enrichment have, until recently, been largely focused on mammal species as for a long time it was not believed to be an important aspect of husbandry for captive reptiles. However, the increase in non-mammal enrichment studies has highlighted the benefits of providing a complex and stimulating environment. Most enrichment devices used for reptiles are food or scent based. Historically, changing the way food was presented was thought to be the best

way to enrich reptiles as they were seen as less intelligent than mammals and so less likely to be interested in anything unless there was a food reward. More recently, scent-heavy enrichment has been widely used for monitor lizards in captivity.

This study focuses on the current enrichment methods used at Chester Zoo. Because there are such a wide range of reptiles at the zoo, it was decided to only focus on the enrichment for the monitor lizard species as this would provide a good base study from which to expand in the future. Chester Zoo has three species of monitor lizard – Komodo dragons (*Varanus komodoensis*), Salvador’s monitors (*V. salvadorii*) and emerald tree monitors (*V. prasinus*). Due to time constraints, this study could not focus on all current devices used to enrich the three species. Instead, three categories of enrichment were selected for each. Scent trails, scent piles and furnishings from other animal enclosures were studied with *V. komodoensis*. Similarly, scent trails and furnishings were used with *V. salvadorii* as well as scent trails with a food incentive. Scent trails were also used with *V. prasinus* alongside hanging feeders and terrestrial feeders. Each device was observed on four days with four sessions of twenty minutes per day. It is hoped that this project will successfully evaluate which practices are most effective for monitor lizards and demonstrate the importance of enrichment for reptiles. It will also provide a base from which future studies could develop, looking more in depth at current devices and investigating new ideas and a wider range of species.

“MUNCH-o-tictis de-SLIM-lineata” – Diet analysis of a pair of narrow-striped mongoose

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Mixed species exhibits are a popular way of housing zoo species due to the economic use of space and the exhibit value in terms of ecosystem education. If species occupy similar niches, mixed species exhibits can lead to nutritional problems such as inter-species feed related aggression and obesity of certain species/individuals. Newquay Zoo houses a pair of narrow-striped mongoose, *Mungotictis decemlineata*, in a mixed species with crowned lemurs, *Eulemur coronatus*. The tendency of the male narrow-striped mongoose to gain excess weight is of concern to his keepers. Male weight and/or domination over the female at food resources are suspected to be playing a role in the pair’s lack of breeding success, either directly or indirectly. The mongoose pair has been observed entering the portion of the indoor enclosure intended for the sole use of the crowned lemurs and foraging for food scraps from the floor. The keepers suspect that this behaviour is mainly exhibited by the male mongoose and may be contributing to his weight gain. This study aimed to analyse the diet received by each individual mongoose, and identify steps which might be taken to ensure that each mongoose receives adequate nutrition and remains within a healthy weight range.

To evaluate the diet each mongoose receives a number of components were analysed. First the amount of each food item eaten was analysed for each individual through a 5 day intake/outtake study and nutritional composition of the diet eaten was analysed using Zootrition™ software. In conjunction, behaviour during feeding was recorded for each individual over the 5 days, to determine whether there was marked difference in the proportion of food received by either individual, or whether one individual dominated a food source. Nutritional and behavioural data sets could then be combined to provide a good estimation of the nutrition each individual received from the offered diet. Lastly, to record all instances of mongoose foraging in the lemurs’ area, a camera trap was set up to record 30 second video clips every time movement was detected. The video recordings were used to collate data on which individuals were entering the lemurs’ area, and whether or not they were actively foraging during this time. From this data we hope to ascertain whether, and by how much, the mongooses are supplementing their offered diet with lemur food. Initial results suggest that it is in fact the female who forages most often in the lemurs’ area. Results from this study will directly inform husbandry practice for these individuals, aiming to improve nutrition of both individuals and therefore their welfare and breeding success. Conclusions may be relevant to other institutions housing this species, as little is known about this species’ requirements in captivity.

Visitor impact on the behaviour and use of enclosure of different species of birds in a mixed exhibit

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Visitor effect on animals in captivity is a growing area of study but many have focused on visitor density and the behaviour of primates. Results vary from negative animal responses towards visitors' presence to no response and finally, to visitor presence as enriching for the animals. Examining how animals use their enclosures can be a tool to assess their welfare. Visitors' behaviour has been shown to have a range of effects on the animals behaviour and enclosure use. However, few studies have been conducted on mixed species exhibits. The aim of this study was to assess how visitors can affect birds in a walk-through mixed-species bird enclosure in terms of the birds' behaviour and the areas they use. Five different bird species were observed: Victoria crowned pigeon, *Goura victoria* (n=3), white-naped pheasant pigeon, *Columba albinucha* (n=2), Nicobar pigeon *Caloenas nicobarica* (n=8), Mindanao bleeding heart dove, *Gallicolumba crinigera* (n=2) and roul-roul partridge, *Rollulus rouloul* (n=17). A scan sampling technique was used to record the location and behaviour of the birds. The number of children and adults and a categorisation of the noise level were also recorded. The results show that visitor density, young people's presence and noise affected all the bird species except the Mindanao bleeding heart doves. With higher densities of visitors many of the birds retreated to areas where they were less visible, out of reach or out of sight. The larger birds, Victoria crowned pigeons and white-naped pheasant pigeons, remained visible but their activity levels decreased with higher numbers of visitors, young people or noise. The results have informed some decisions about the layout of pathways in the enclosure. One pathway has been removed to provide more areas of seclusion for the birds.

Digestibility in the brown spider monkey (*Ateles hybridus*)

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The brown spider monkey (*Ateles hybridus*) is a critically endangered species listed as one of the world's 25 most endangered primates. Native to Columbia and Venezuela, it is a frugivorous primate that is threatened by habitat loss and fragmentation, leading to the captive environment becoming increasingly more important in saving this species. Little is known about the brown spider monkey's nutritional requirements, and health issues are apparent in captivity. An intake and faecal collection study was conducted at three zoological institutions (Paignton Zoo Environmental Park, Bristol Zoo Gardens and Twycross Zoo) with faecal samples collected daily, for a week period, at each institution. One group of spider monkeys were used per zoo. Laboratory faecal analysis was performed to determine the digestibility of the three diets provided in terms of protein, energy, ash and dry matter. Digestibility is defined as the extent to which food or its constituents is broken down and used by the body, thus allowing us to see how much of the diet given is useable to the animals/individual studied.

The results of the faecal analysis showed that lower levels of Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) provided in the diet increased digestibility of ash throughout all three zoos. This suggests that the current diets fed contain a fibre level too high for the spider monkeys to digest ash efficiently. This result is supported more so due to the variation between the institutions in amounts given, the nutrient levels and the energy provided. Despite the importance of an *ex situ* population, there are currently no species specific dietary recommendations and the above results points towards a requirement for further, more in-depth research to determine the requirements this species has.

Visitor effects on Humboldt penguins (*Spheniscus humboldti*) during penguin parades

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Penguin parades are rapidly becoming a regular educational display within zoos around the UK. However, there is no current knowledge within the zoo industry about these parades or how captive Humboldt penguins (*Spheniscus humboldti*) are influenced by being within such close contact to the viewing public. Therefore this study was carried out to determine the effects visitors had on captive Humboldt penguins during these penguin parades. Three preliminary studies and 20 observations were carried out on the Humboldt penguins (n=19) located within Twycross zoo, during their 12:30 and 15:30 daily penguin parades. These were studied to see how many penguins made it around the parade or into the destination zone, alongside the estimated visitor numbers who attended the display. The results gathered were then tested for a correlation using either the Spearman's Rank statistical test or the Pearson's PMCC statistical test. The visitor numbers at the end of the parade and the number of penguins to make it all the way around the exhibit were positively correlated ($p < 0.013$). The visitor numbers at the end of the parade and the number of penguins to make it into the destination zone were also positively correlated ($p < 0.001$). The results of this study have shown that regular training sessions can create a positive interaction between an animal and its keeper, as well as the viewing public. This in turn can then go on to improve the overall general welfare of that animal, as they will not see humans as a threat and will therefore have a reduction in their stress levels.

Evaluation of current enrichment for aquatic turtle species at Chester Zoo

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Enrichment for reptiles is an area of research where little has been discovered in comparison to other animal classes such as mammals. The majority of enrichment used in animal husbandry has not been evaluated for its effectiveness but is considered effective based on personal experiences, this is known as folklore husbandry. Previously, enrichment has been viewed as something extra to an animal's husbandry, however it is now seen as an essential requirement for the management of animals in captivity.

This study investigates the effectiveness of enrichment currently used at Chester Zoo, namely whether certain desired behaviours are increased such as locomotive behaviour and feeding. Three types of enrichments were evaluated for the Vietnamese pond turtle (*Mauremys annamensis*) and the golden coin turtle (*Cuora trifasciata*) using behavioural observations in off-show enclosures. The kebab skewer enrichment involves silicon skewers with fruit being hung above the water using hooks, encouraging the turtles to stretch for the fruit. The forage feed enrichment involves the water being removed from the enclosure and replaced by long grasses, the turtles then have to search for the hidden fruit. The floating raft enrichment involves a cork bark raft with skewers protruding out, this encourages the turtles to swim after the raft to reach the fruit. Observations of the regular turtle feeding routine with no enrichment (where the fruit is placed in a bowl upon the land of the enclosure) were used as a control.

This project will provide Chester Zoo with information on how effective these enrichment methods are for aquatic turtles, possibly some recommendations on improving the current enrichment, and investigating future methods. Furthermore, other zoo collections could use this data to expand their enrichment methodology or consider evaluating their own.

An international review of husbandry best-practices for banteng (*Bos javanicus*)

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Maintaining any species of wild animal in captivity requires communication between stakeholders as well as an evidence-based approach relating to husbandry practices. This information is often unavailable however either due to a lack of focused research activities on the species or similarly a lack of published guidelines. The banteng (*Bos javanicus*) is an example of one of these taxa; having been the focus of comparatively little *ex-situ* research or management investigation (no available best practice guidelines) despite elevated *in-situ* conservation threats and also an established global captive population with an apparent increase in holding internationally. With these factors in mind, a husbandry survey was conducted involving all global holders of this species. These questionnaires are considered to be useful methods to assess current regimes of care and indicate existing trends in husbandry and highlight any potential areas for improvement, which will have a direct and positive impact on the husbandry of this species. Completed surveys from 14 collections (54% response rate) provided sufficient data for the analysis of contemporary practice between these institutions. Work focussed specifically upon the demographics of captive herds, exhibit features (including mixed-species exhibition), provision of diet and behavioural management (enrichment and training). All of these aspects of husbandry will be discussed and differences in practice will be identified, with the aim of contributing to the availability of husbandry best-practice for the species. The potential to develop this research by focusing on particular areas of husbandry practice with further empirical investigation will also be highlighted.

Assessing the welfare of captive reptiles: a glimpse into the diversity of stress-related behaviours

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Although numerous reptiles are kept in zoos, labs and private collections, to date very little is published on how to assess their welfare. Non-invasive techniques, like scoring specific stress-related behaviours, can be helpful in evaluating welfare. When observing reptiles in a stressful environment like exotic pet markets, they display a variety of stress behaviours. To investigate whether these behaviours can also be used as a measurement of stress in more familiar environments like zoo-settings we observed three species of the Squamata order and one tortoise before, during and after the exposure to a stressor. The stressor used was a rotating orange light beacon of about 15 cm that illuminated the entire enclosure for five minutes, hence all individuals were equally exposed to this visual stressor. Animals were observed for one hour before (period 1) and one hour after the start of the stressor (period 2). The ethogram included a total of 18 behaviours of which five were signals of stress relating to the captive environment (e.g. interaction with transparent boundaries), eight social (e.g. dew-lap) and five maintenance (e.g. basking) behaviours. Results show that the seven juvenile bearded dragons (*Pogona barbata*) significantly increased the amount of short-distance movements ("stepping"; $p=0.02$) in period 2 when compared to period 1. This may be linked to hyperactivity as a reaction to the stressor, although more data on normal movement activity in this species are needed to interpret this result. Seven juvenile blue spiny lizards (*Sceloporus cyanogenys*) tended to increase the amount of time they were invisible to the observer during period 2 compared to period 1. This trend ($p=0.07$) might reflect a hiding tactic in this species when exposed to a stressor. On the other hand, five juvenile Chinese crocodile lizards (*Shinisaurus crocodilurus*) showed no significant change in any of the observed behaviours when comparing period 1 and 2. The six adult grooved tortoises (*Centrochelys sulcata*) in this study showed a trend towards an increase in positioning their head flat on the ground during period 2 ($p=0.07$). A flattened body posture is categorised as a signal of stress. Overall, our preliminary data suggest that in our study species, no conclusive obvious behaviour signalling stress can be pinpointed. Each of the species observed displayed another strategy when faced with a stressor, suggesting a broad diversity in the repertoire of stress-related behaviours. Alternatively, much more subtle stress behaviours might still be present in all species. The reactions to stress in reptiles and the use of non-invasive welfare indicators, will be further investigated in *Anolis carolinensis*. The results shown here are part of a two year project that aims to evaluate

non-invasive welfare indicators in captive reptiles and amphibians (the AWARE-project), combining forces from the academic (University of Antwerp and Odisee) and the zoo world (Royal Zoological Society of Antwerp) and funded by the Belgian government.

Comparison of the behaviour of seven giraffe between a yard and a large drive through exhibit

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This pilot study estimates the activity budgets of seven captive giraffe and whether the behaviour of each individual differs between two environments. Of particular interest was whether the giraffe were more likely to display behaviours which could be regarded as abnormal behaviour in a small enclosure compared to a larger more complex enclosure. Giraffe at WMSP normally have the run of the large African Reserve during park opening hours. If the weather is very bad they have to remain in their smaller holding yard for all or part of the day. Therefore behaviour can be compared between two different environments using each individual as its own control without altering normal husbandry procedures. Data collection was carried out over a period of ten months (Oct-July) using continuous, focal sampling at set periods of time for eight days for each location, for four hours per data collection day (totalling 64 hours of data). Each giraffe was studied for a half hour time slot before moving on to the next individual. Once the study was completed, each giraffe had been observed for a total of one day with data collected from each time slot, at each location.

Results suggest that the animals display almost no abnormal behaviour in their usual exhibit but most exhibit some oral stereotypy in their smaller yard. To determine whether there was a significance difference between the observed amounts of abnormal behaviour between enclosures Mann-Whitney U test was run on each individual comparing the two locations. Six out of the seven giraffe displayed significantly more abnormal behaviour in the smaller enclosure than in the larger, complex enclosure ($p < 0.05$). Results of this study imply that larger, complex enclosures may reduce the likelihood of abnormal behaviours in this species. Future work will collect more data on these animals in both situations and examine in more detail whether the size of these enclosures or other differences between them are responsible for differences in giraffe behaviour between the areas.

Assessing the behavioural and physiological impacts of housing changes in Bornean orangutans (*Pongo pygmaeus*) at Chester Zoo

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Bornean orangutans (*Pongo pygmaeus*) are an endangered species found in Indonesia and Malaysia. They are the world's largest arboreal primate, leading semi solitary lives. The main threat to this species is habitat destruction, with a large percentage of orang-utan territory being utilised for palm oil plantations and unsustainable logging. Wild populations live in fission-fusion societies, whereby individuals regularly come together and separate. Captive orangutan populations are often housed in groups with limited opportunity for individuals to move away from their conspecifics. Previous research has suggested that wild Bornean orangutans may express heightened stress levels in response to visiting tourists and there is some evidence for an increased stress response in larger captive groups. Chester Zoo has a group of six Bornean orangutans housed in on-show and off-show enclosures in the Realm of the Red Ape exhibit. Sumatran orangutans are also currently housed in the same exhibit but housed in neighbouring enclosures to the Bornean species. In summer 2015 the Sumatran orangutans are due to move to a new Islands exhibit and consequently the Bornean orangutans will gain access to all enclosure spaces within Realm of the Red Ape. In order to assess the potential impact of the housing changes, observations of behaviour and enclosure use have been made non-invasively from public viewing areas and from video recordings in off-show areas. Faecal glucocorticoid concentrations have also been recorded with a view to compare to concentrations following access to the new areas of the exhibit. The findings from this study will provide vital evidence for the management of Bornean orangutans and form part of the long-term assessment of species involved in the new Islands development at Chester Zoo.

Cuttlefish in captivity: an investigation into housing and husbandry for improving welfare

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The European cuttlefish (*Sepia officinalis*) is often kept in public aquaria, is becoming more common in aquaculture, and is also the most frequently used cephalopod in European research. In captivity, juveniles can easily become damaged by impacting with tank walls when startled. These injuries rarely heal and can have a major impact on growth and survival. Six experiments were performed, using juvenile cuttlefish, in which exhibition of thigmotaxis in different environments, responses to simulated husbandry in different scenarios, and responses to typical and novel forms of enrichment (e.g. photographs of substrates) and refuges was investigated. Refuge use by both adults and juveniles was also investigated, including response to husbandry when different refuges were provided. In addition to thigmotaxis, the frequency of negative behaviours (such as those likely indicating stress or preceding damaging behaviours), were recorded. The results suggest that certain environments, clothing/equipment and refuges/enrichment can significantly reduce the frequency of negative behaviours which are indicative of stress. It was also found fake seaweed and photographs of substrates placed in tanks may be beneficial without the issues of localised pollution. We conclude by providing an evidence based guide to improving husbandry practices, which could improve the lives of captive cuttlefish.

Activity patterns and use of space of a group of ring-tailed lemurs (*Lemur catta*) and black lemurs (*Eulemur macaco*) in a mixed species enclosure

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When zoos design new enclosures, post occupancy evaluations can be a useful tool to see whether the animals use the new exhibit as expected. Long term monitoring can also show changes of animals' use of the space. More and more zoos are constructing walk-through exhibits for lemur species. We set up a project to monitor the effects of visitors on lemur behaviour in such an exhibit, opened in spring 2015 in Planckendael Wild Animal Park, which houses seven ring-tailed lemurs, three male black lemurs, two purple swamphens (*Porphyrio porphyria*) and one Madagascar teal (*Anas bernieri*). Here we report on the preliminary data of the first months after the lemurs have been introduced into their new enclosure. We collected data during 2 rounds: In April 2015 the first five days were observed after the ring-tailed lemurs had been introduced in the enclosure. In May 2015 we observed for another five days after the black lemurs were introduced to the enclosure and to the ring-tailed lemurs. In each round we collected data on the 5 adult ring-tailed lemurs (1 male, 2 females with infants, 2 younger females), in the second round we also collected data on the black lemurs. For each day we collected 4 focal follows of 15 minutes for each individual, randomly spread throughout the day, scoring social interactions, individual behaviours. Between each focal we used instantaneous sampling to score the location of every individual within the enclosure. Preliminary analysis showed that the five ring-tailed lemurs show bold behaviour at the onset of the introduction to the new enclosure. The females and male showed slightly different activity patterns, with the females spending more time on actively scanning the environment as opposed to the male. The SPI data show that the ring-tailed lemurs did not stay in a small part of the enclosure. The lemurs showed little negative response to the visitors walking through the enclosure, or to the bird species. We will continue this research project during the busy summer holiday season to see whether the presence of visitors has any negative influence on welfare or behaviour of the lemurs. Implications of this research could potentially lead to a better understanding of mixed species enclosures and correspondent to this the use of space.